



LUND UNIVERSITY

Comparison of hygrothermal measurements and calculations in a single family wooden house in the Swedish municipality of Upplands-Bro

Mundt Petersen, Solof

2013

[Link to publication](#)

Citation for published version (APA):

Mundt Petersen, S. (2013). *Comparison of hygrothermal measurements and calculations in a single family wooden house in the Swedish municipality of Upplands-Bro*. (Report TVBH; Vol. 3058). Byggnadsfysik LTH, Lunds Tekniska Högskola. http://www.byfy.lth.se/fileadmin/byfy/files/TVBH-5000pdf/TVBH-3058SOMP_web.pdf

Total number of authors:

1

General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Comparison of hygrothermal measurements and calculations in a single-family wooden house in the Swedish municipality of Upplands-Bro

S. Olof Mundt-Petersen

Report TVBH-3058, Lund 2013
Building Physics, LTH



LUND
UNIVERSITY

Comparison of hygrothermal measurements and calculations in a single-family wooden house in the Swedish municipality of Upplands-Bro

S. Olof Mundt-Petersen
Licentiate thesis

Building Physics LTH
Lund University
P.O. Box 118
SE-221 00 Lund
Sweden

ISRN LUTVDG/TVBH--13/3058--SE(149)
ISSN 0349-4950
ISBN 978-91-88722-49-2
©2013 S. Olof Mundt-Petersen

Preface

This report was compiled at the Department of Building Physics, Lund University, Sweden, as part of the “Framtidens trähus” (Wood framed buildings of the future) project and my doctoral studies.

The study was carried out in cooperation with SP Technical Research Institute of Sweden and the Swedish wooden house company Willa Nordic. I would specially like to thank Lars Olsson, Per-Anders Fjellström and Simon Dahlquist at SP and Willa Nordic for their valuable cooperation while carrying out the measurements. I would also like to thank my supervisor Jesper Arfvidsson and co-supervisors Lars-Erik Harderup and Petter Wallentén who have supported me while working on this project and for reviewing the report.

Lund 2013-02-12

S. Olof Mundt-Petersen

Summary

This report presents measurements of relative humidity, temperature and moisture content carried out in a two floor wooden framed house in the society Upplands-Bro on the Swedish east coast during the period September 2008 to December 2011. The report also presents blind WUFI 5.0 calculations using the same measurement positions and carried out during the same period under as similar boundary conditions as possible.

Measurements and calculation results of relative humidity in the studied positions are also evaluated and compared to the risk conditions for mould growth by using the Folos 2D visual mould chart.

The measurement results, calculated results and comparisons between the measurements and calculations have been evaluated using Folos 2D visual mould charts which show the deviations between measured and calculated values. These are briefly discussed at the end of the report. The results from measurements, calculations and comparisons between measured and calculated values will be used and further evaluated in future studies and research projects.

Contents

Preface.....	3
Summary	5
1 Introduction.....	9
1.1 Background.....	9
1.2 Aim.....	9
1.3 Limitations	9
1.4 Intended readers	9
2 Method	10
2.1 Blind comparison between measured and calculated values	10
3 Materials.....	10
4 Measuring and calculation periods	11
5 Boundary and initial conditions for calculations	11
5.1 Outdoor climate boundary condition data.....	11
5.2 Indoor climate boundary condition data.....	16
5.3 Air change rate/ Ventilation in air gap behind the cladding	16
5.4 Roof and attic boundary conditions	16
6 Studied house and positions	17
7 Results	25
7.10 Position 10	25
7.13 Position 13	33
7.16 Position 16	41
7.19 Position 19	49
7.22 Position 22	57
7.25 Position 25	65
7.28 Position 28	73
7.36 Position 36	81
7.39 Position 39	91
7.42 Position 42	101
7.45 Position 45	111
7.48 Position 48	121
7.51 Position 51	131
7.54 Position 54	139
8 Discussion and analysis of the results	147

8.1 Walls	147
8.2 Attic.....	147
9 Conclusions.....	148
10 References.....	149

1 Introduction

This report presents measurements of relative humidity (RH), temperature (T) and moisture content (MC) in a number of positions in the studied house. Measurements of relative humidity and temperature are also compared with blind WUFI 5.0 calculations. Measured moisture contents have also been compared with blind WUFI 5.0 calculated values in positions where this was possible. The risk of mould growth has also been evaluated in the studied positions.

This study is part of the Swedish research project “Framtidens trähus” (Wood framed buildings of the future) and was mainly carried out in a cooperation between Lund University, SP Technical Research Institute of Sweden and the Swedish wooden house company Willa Nordic.

The report only includes a brief discussion based on the results. The results of measurements, calculations and comparisons between measured and calculated values will be used and further evaluated in future studies and research projects.

A separate report (Mundt-Petersen, S.O., 2013) has been compiled which includes a broad analysis, discussion and conclusions with regard to the comparisons between measured and blind WUFI 5.0 calculated values. This report also discusses the possibility of using WUFI 5.0 in the Swedish design process for Swedish constructions and Swedish climate conditions (Mundt-Petersen, S.O., 2013).

1.1 Background

The project “Wood framed buildings of the future” started in November 2007. In 2008 and 2009 several wireless sensors were installed in five differently designed wood framed houses during the construction process. The sensors measured temperature, RH and MC in order to make it possible to evaluate the climate conditions and risk of mould growth in different positions in different wood framed constructions (Framtidens trähus, 2012).

1.2 Aim

The aim of this report is to present the measurement results for temperature, RH and MC in the studied positions in the studied house. The report also aims to present comparisons between measurements and blind calculations of temperature and RH, and MC where possible, carried out using the transient heat and moisture calculation tool WUFI 5.0 (Mundt-Petersen, S.O., 2013). Furthermore, the report aims to evaluate the risk of mould growth in the studied positions.

1.3 Limitations

There are a number of limitations and sources of error with regard to the measurements, comparisons of measured and calculated values and evaluations of the mould growth risk. These limitations are described in a separate report (Mundt-Petersen, S.O., 2013).

1.4 Intended readers

This report has been written for the Swedish wooden house companies that participated in the “Wood framed buildings of the future” project and whose wooden framed constructions were studied.

2 Method

The comparisons between measured and calculated values were blind comparisons, i.e. they were verified without knowing the measurement results before the comparisons with the unadjusted calculated results were made. More detailed descriptions of the measurement method, the construction of the calculation model and the method of comparison between the measured and calculated values are provided in a separate report (Mundt-Petersen, S.O., 2013).

Measurements of temperature, RH and MC are presented in Folos 2D visual mould charts and additional charts together with comparisons with the blind WUFI 5.0 calculations and evaluations of the risk of mould growth. The Folos 2D visual mould chart is described in more detail in a separate report (Mundt-Petersen, S.O., 2012). Additional charts also show measured moisture content and, if it was possible, calculated moisture content. Vapour contents were calculated from measured and calculated values and compared. If there was a lack of measured values, the vapour content is shown as zero. There are also additional charts showing the magnitude of deviation between measured and calculated temperature and relative humidity.

Results from positions where the measuring sensor initially failed are not presented and consequently there are gaps in the numbering sequence of the measurement positions.

2.1 Blind comparison between measured and calculated values

Initially, measuring sensors for temperature, relative humidity and moisture content were mounted at different depths and locations in the walls during the construction phase. The construction phase was monitored to establish any possible deviations between the drawings and the real conditions in the built walls. Hourly measurements of temperature, relative humidity and moisture content for each specific position were then separately stored by a measurement collector, inaccessible to the persons involved in evaluating the calculation tool.

When the measurements were carried out, calculation models of each studied position were made. The calculation models were based on drawings and photos from the construction phase with the intention of reflecting as real conditions as possible. In 2012, blind calculations were carried out for each studied position without knowing the measured results. After the blind calculations had been completed and sent to the measurement collector, the previously inaccessible measurements were retrieved and compared to the calculated values.

Note that it was possible to make adjustments to the calculation models to achieve better correlation between the measured and calculated values in almost all the studied positions. However, this was not done since this was a blind verification.

3 Materials

The presented measurements, comparisons of measurements and calculations and evaluations of the risk of mould growth were carried out in a wooden framed single-family house in the society Upplands-Bro built by the Swedish wooden house company Willa Nordic. The building was a two-floor single-family house with a construction area of 115.8 m² and a living area of 158.4 m². The house was built on a concrete ground slab with wooden walls, a wooden slab and a wooden roof frame. An under floor heating system was installed in the concrete slab. Walls, slab and roof elements were constructed at Willa Nordic factory in Stockaryd during March and April 2008. The

house was then constructed in Upplands-Bro with starting in April 2008 and was occupied nearly a year later.

4 Measuring and calculation periods

Most of the measurements started on 9 September 2008. Calculations were carried out from 1 July 2008 in all positions since this was the day from when reliable outdoor climate data were available. The comparison starts at the time when measuring data were available. Indoor climate measurements started 10 June.

Measuring sensors were mounted by SP Trä Skellefteå that also has collected measuring data. During some periods there were problems regarding local transmission of measuring data from the measuring sensors to the local measurement data collector (Sandberg, K., 2011). Some measuring positions therefore lack long periods of measured data.

5 Boundary and initial conditions for calculations

The climate boundary conditions and initial conditions aim to reflect as real conditions as possible during the measuring period. Specific parameters and initial set values are presented in a separate report (Mundt-Petersen, S.O., 2013). The materials used are also listed separately (Mundt-Petersen, S.O., 2013). However, the materials used are briefly presented in connection with the WUFI 5.0 model for each separate position.

The in- and outdoor climate boundary conditions used are presented below. This is done together with a comparison and check against other available climate data in the area. The methods for finding additional climate data during periods when this is lacking, in order to provide complete in- and outdoor climate boundary conditions, are described in a separate report (Mundt-Petersen, S.O., 2013). Comparisons and checks regarding other available climate are also described in the same report (Mundt-Petersen, S.O., 2013).

5.1 Outdoor climate boundary condition data

The boundary conditions data used for each parameter are presented below. The charts also include a comparison with other available climate data. The amount of supplemented data, which were the same amount of lack of data, is given in percent for each year for each climate parameter.

Outdoor short-wave radiation absorption, dependent on color, is assumed to be 0.2 (white) on walls and 0.7 on roofs (light grey).

Note that hourly climate data was used in the calculations and three-hourly data was used in order to check the hourly data. In some cases the three-hourly data was also used to supplement periods of lacking data, as described in a separate report (Mundt-Petersen, S.O., 2013). Micro climate data available from own mounted sensors was only used in order to check possible deviations and defects in the hourly data.

The hourly outdoor climate used and three hourly data was, as far as possible, captured from climate stations on the island Adelsö in the lake Mälaren. However, there were a lack of air pressure and global radiation data and this data were therefore captured from the climate station in Stockholm.

The air pressure is carried out from 6 hourly values since no hourly data were available. Since there were more or less a constant lack of air pressure data, and the air pressure have a small effect on the calculation results, this parameter were excluded from black line that indicate lack of climate data in the chart presenting the results result. Diffuse radiation data readings were created from a model based on global radiation (Mundt-Petersen, S.O., 2013).

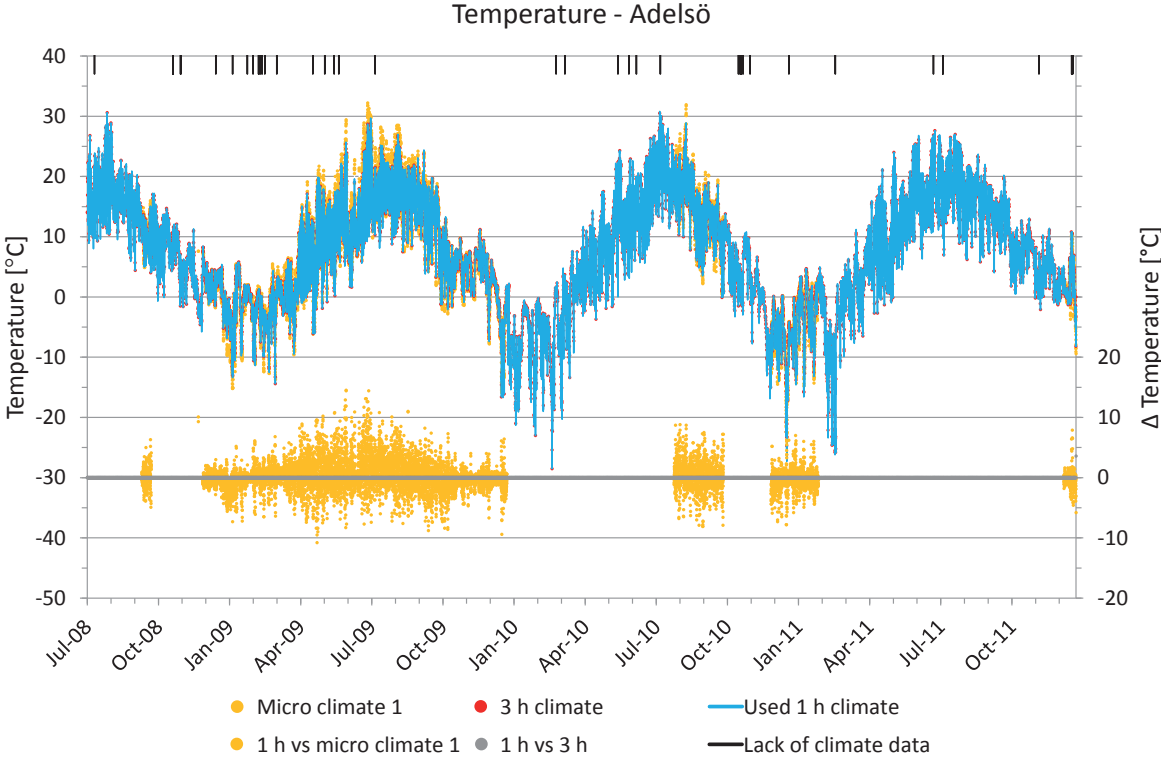


Figure 5.1.1. Used temperature data compared with other available climate data. Lack of data, in percent, that was supplemented: 2008 – 0.15 %, 2009 – 0.16 %, 2010 – 0.15 %, 2011 – 0.39 %.

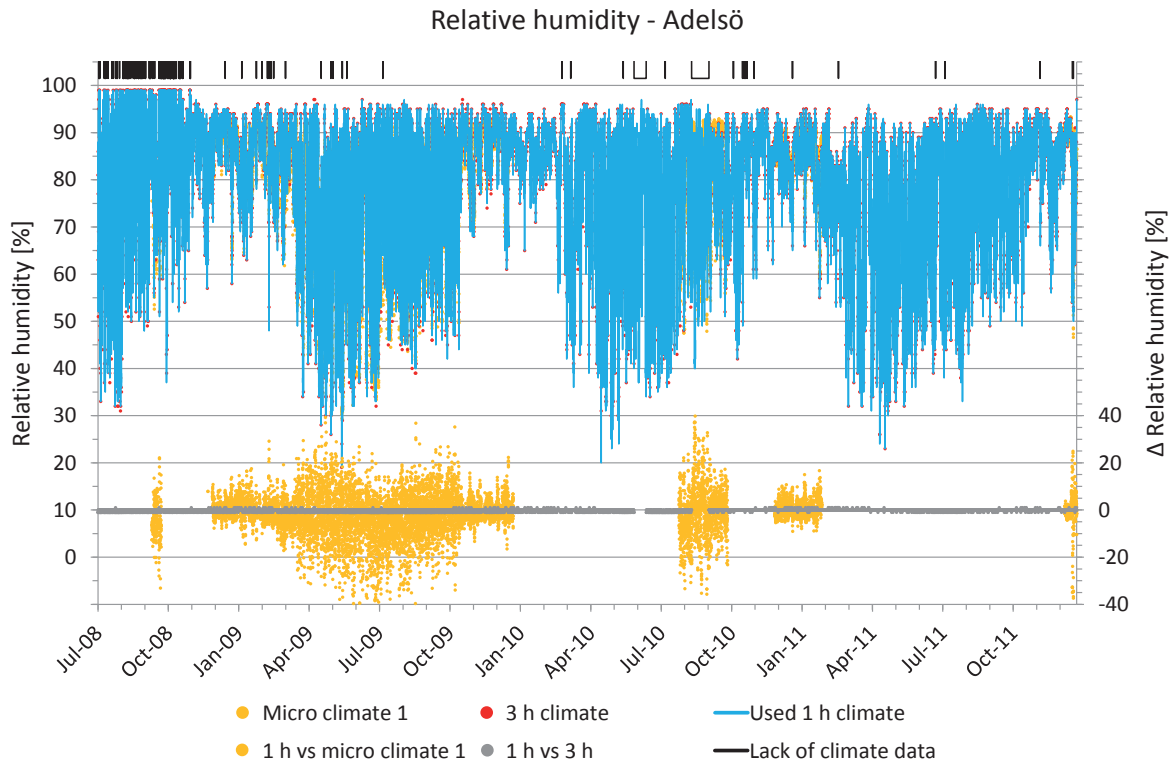


Figure 5.1.2. Used RH data compared with other available climate data. Lack of data, in percent, that was supplemented: 2008 – 2.83 %, 2009 – 0.17 %, 2010 – 10.72 %, 2011 – 0.45 %.

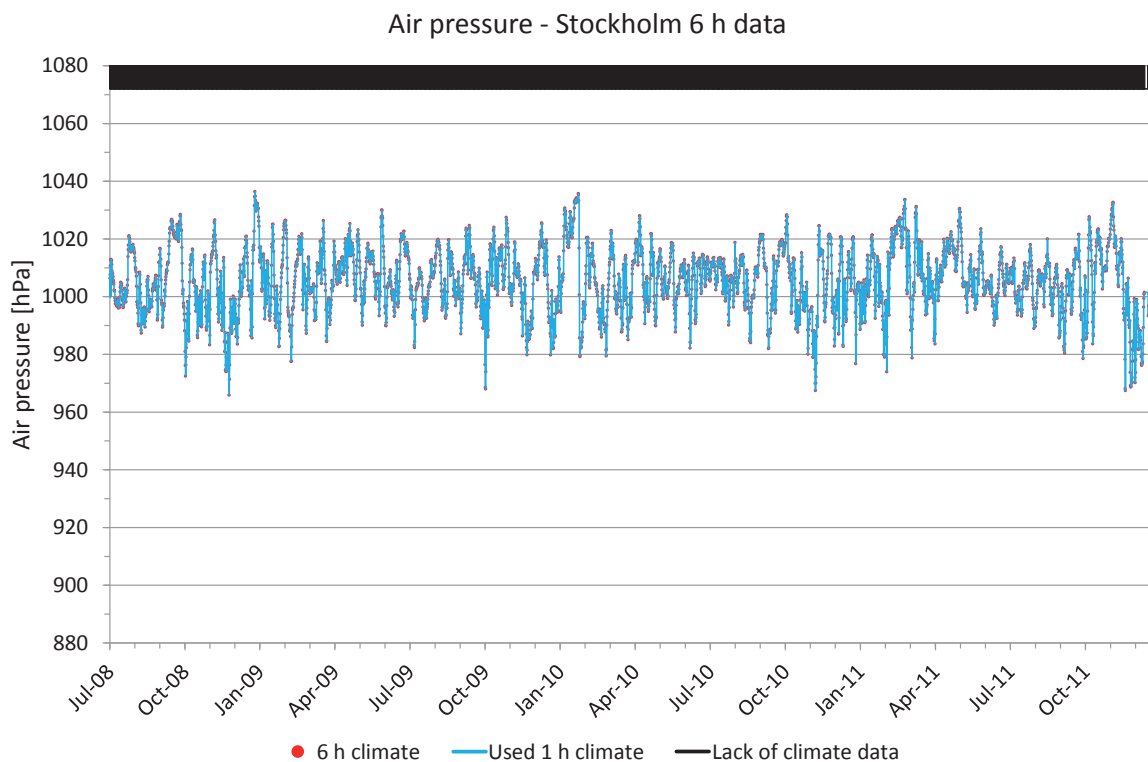


Figure 5.1.3. Used air pressure data at weather station height above sea level. Lack of data, in percent, that was supplemented: 2008 – 12.60 %, 2009 – 25.00 %, 2010 – 25.00 %, 2011 – 26.51 %.

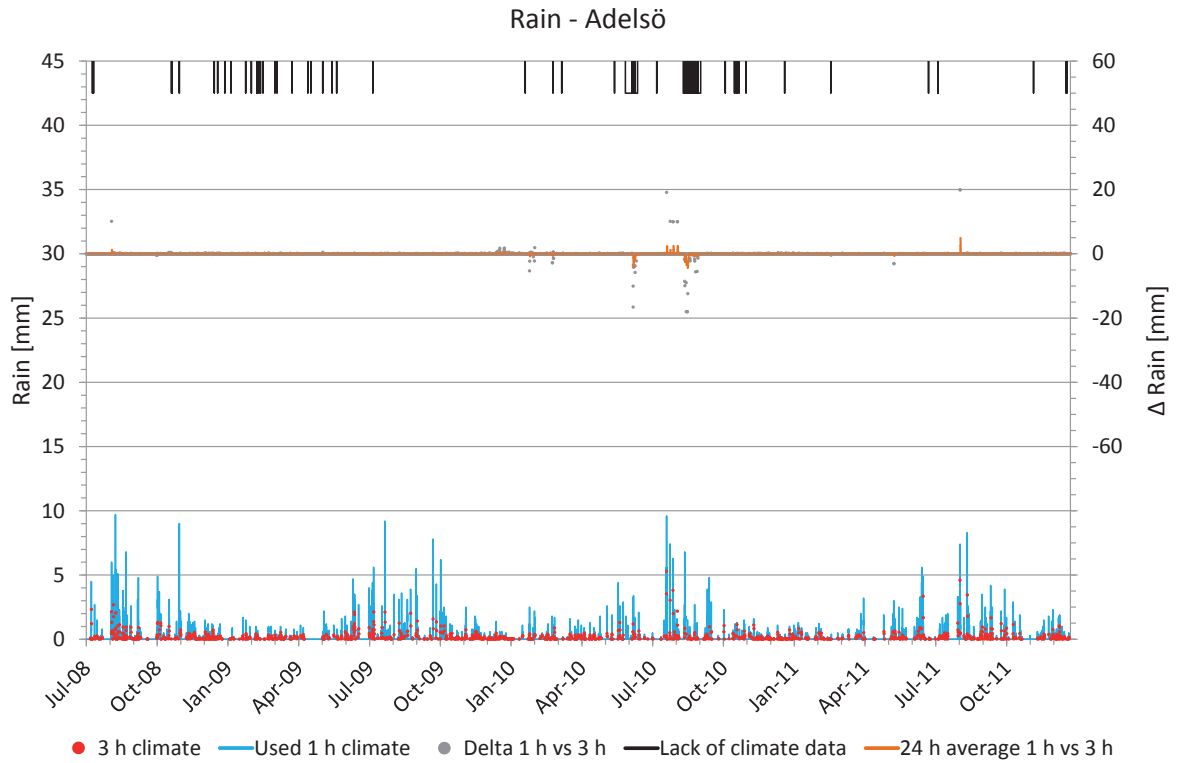


Figure 5.1.4. Used rainfall data compared with other available climate data. Lack of data, in percent, that was supplemented: 2008 – 0.21 %, 2009 – 0.19 %, 2010 – 9.81 %, 2011 – 0.43 %.

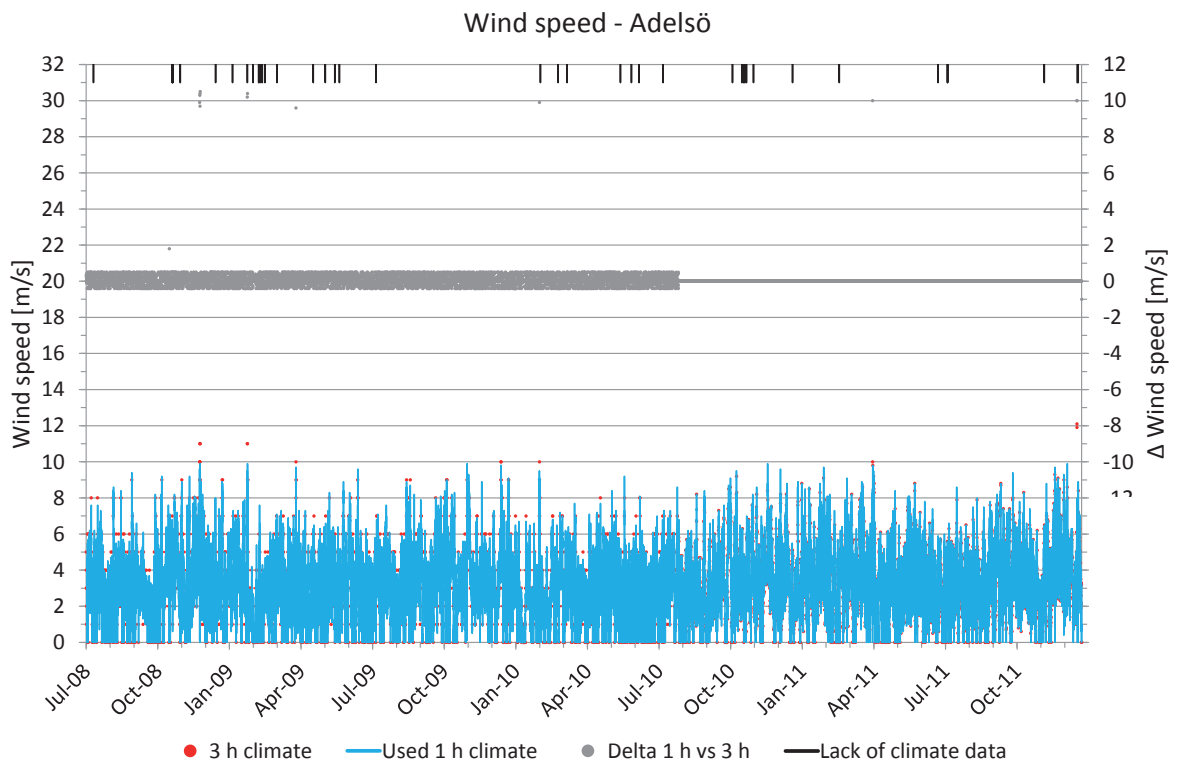


Figure 5.1.5. Used wind speed data compared with other available climate data. Lack of data, in percent, that was supplemented: 2008 – 0.16 %, 2009 – 0.16 %, 2010 – 0.18 %, 2011 – 0.45 %.

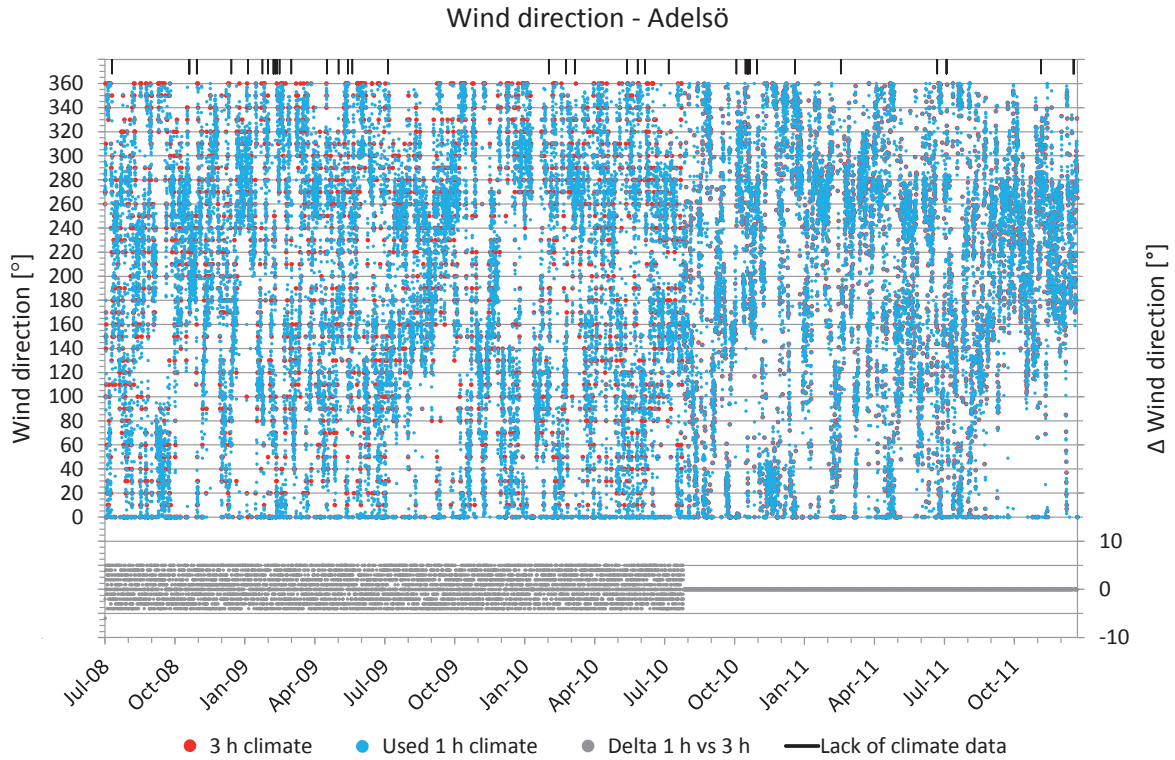


Figure 5.1.6. Used wind direction data compared with other available climate data. Lack of data, in percent, that was supplemented: 2008 – 0.16 %, 2009 – 0.16 %, 2010 – 0.18 %, 2011 – 0.45 %.

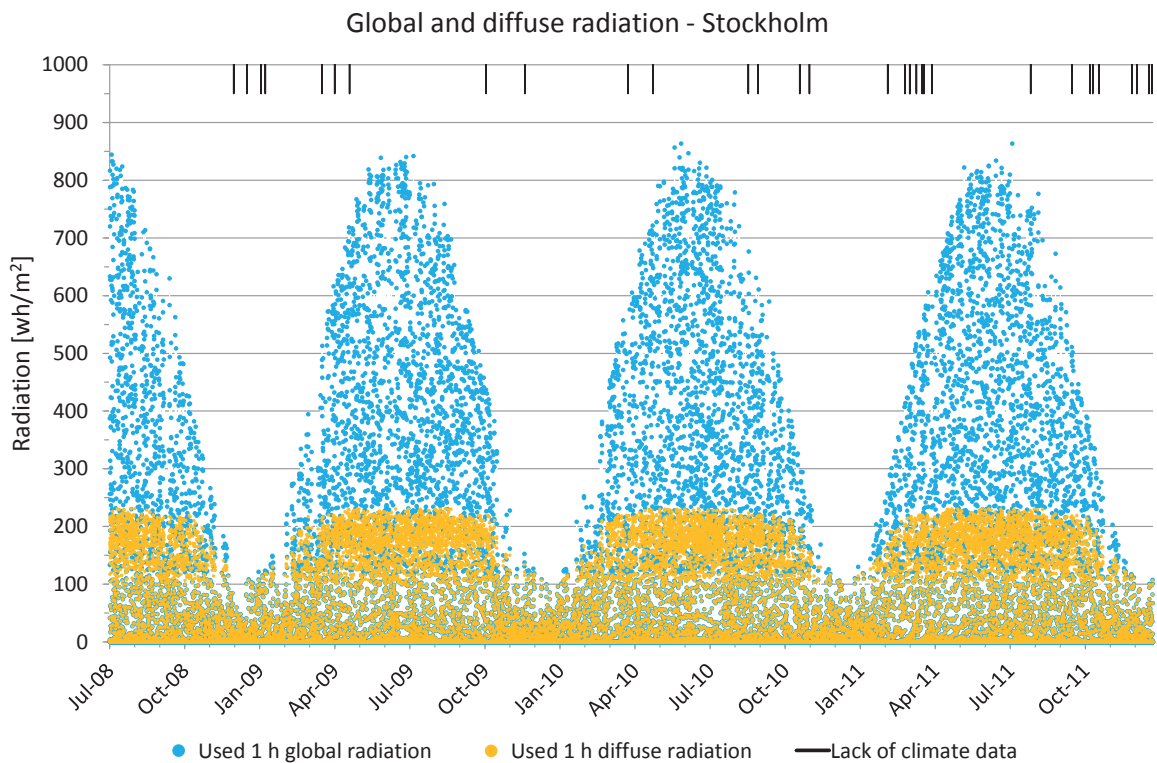


Figure 5.1.7. Used global and diffuse radiation data. Lack of global radiation data, in percent, that was supplemented: 2008 – 0.02 %, 2009 – 0.08 %, 2010 – 0.07 %, 2011 – 0.23 %. Diffuse radiation data was created from global radiation data (Mundt-Petersen, S.O., 2013).

5.2 Indoor climate boundary condition data

The indoor climate boundary conditions used are presented below. Used indoor climate is captured from one of three indoor sensors. Periods with lack of data have been supplemented as described in a separate report (Mundt-Petersen, S.O., 2013). No measurements and calculations in this house are carried out in bathrooms walls. This makes further specific adjustments of indoor climate parameters for bathroom walls calculations unnecessary.

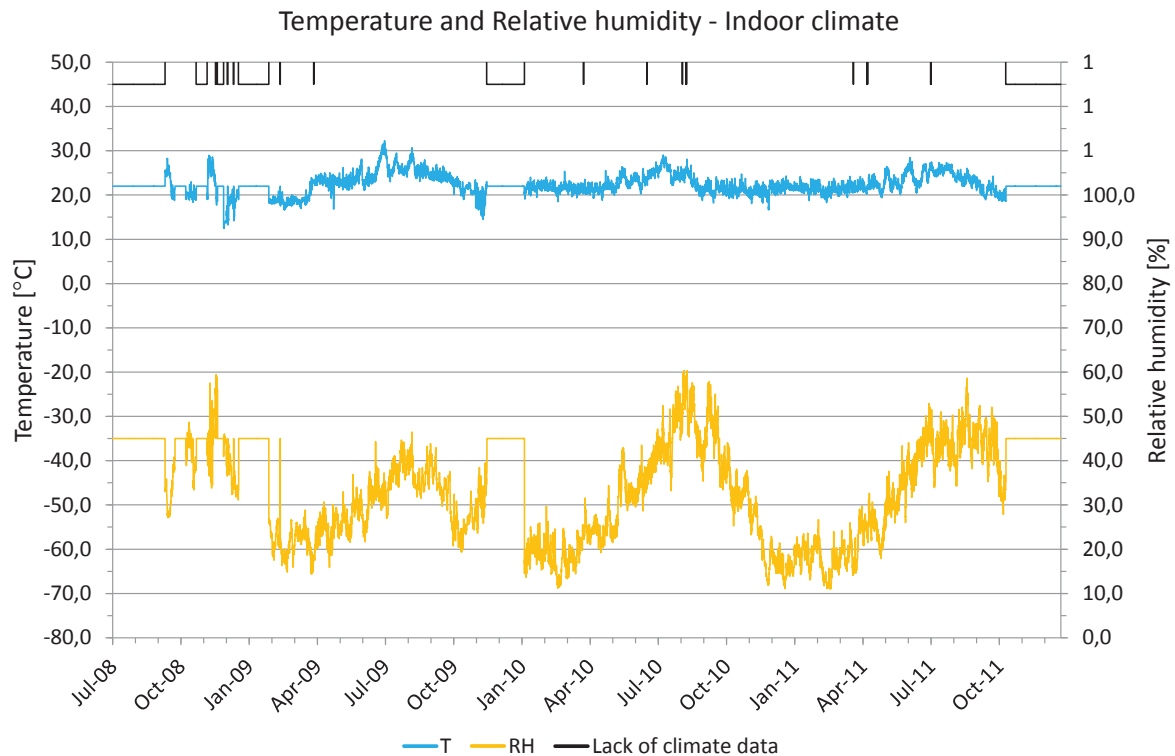


Figure 5.2.1. Used indoor temperature and relative humidity data. Lack of data, in percent, that was supplemented: 2008 – 30.34 %, 2009 – 19.65 %, 2010 – 1.91 %, 2011 – 20.64 %.

5.3 Air change rate/ Ventilation in air gap behind the cladding

Previous studies show that the air flow in the air gap varies depending on several of factors (Falk 2013). However, if the air change rate (ACH) in the air gap is high enough to handle all potential moisture in the gap, the influence of a higher ACH in the air gap is negligible (Hägerstedt 2010A, Hägerstedt 2011). Previous studies show that an air flow of 30 ACH in the air gap is reasonable in the case of ventilated air gaps behind the cladding. An air flow of 30 ACH has therefore been used in the walls studied in this report (Hägerstedt 2010A, Hägerstedt 2010B).

5.4 Roof and attic boundary conditions

The roof construction was built with two different kinds of attics that are connected to each other. The roof has a roof angle of 14 degrees and was directed towards north. One part of the roof was full insulated with a ventilated air gap close to the outer tongued and grooved wood located below the roof membrane. The other part has the same construction besides that the air gap is bigger and looks like a cold attic space. No specific assumptions and attic model have therefore been made in the calculations model. The air gap in the full insulated part with an air gap is treated as a ventilated air gap in the façade with an air change rate of 30 ACH. The part with a big air gap like a cold attic space

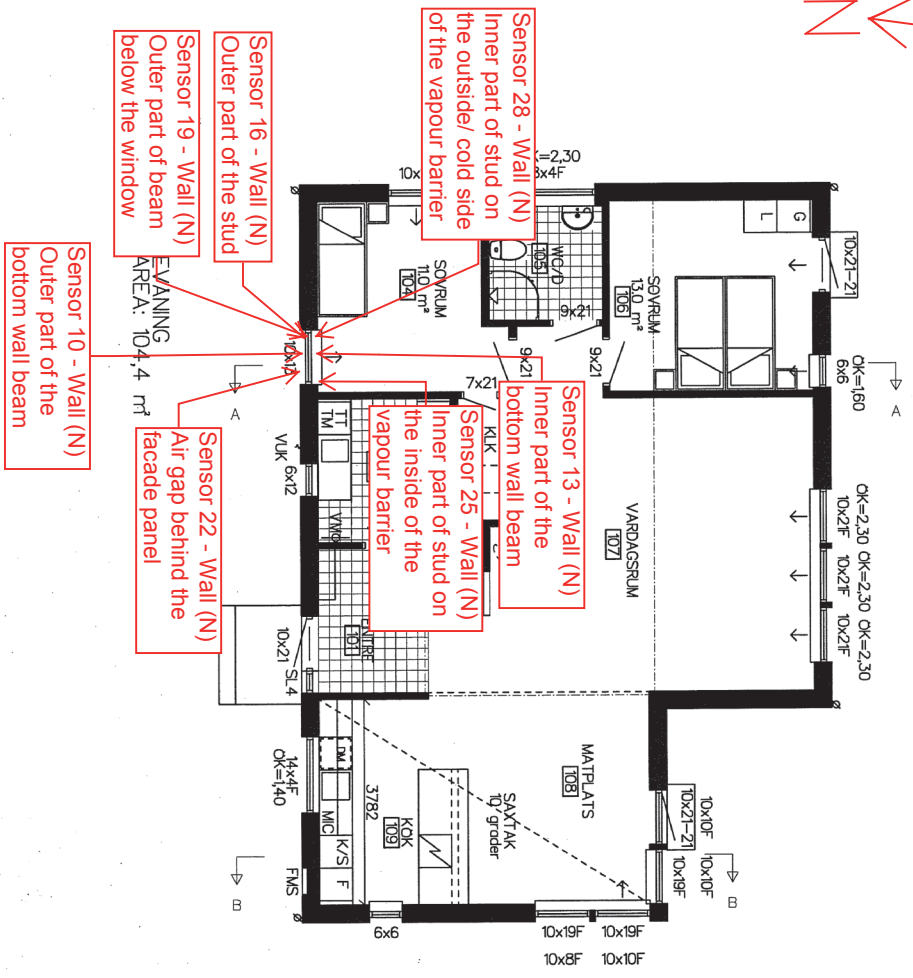
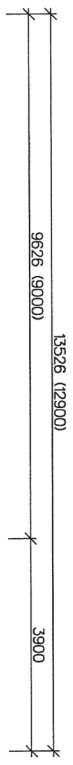
has an air layer of the same thickness, 50 mm, and the same ACH, 30 ACH, as the full insulated part and two 70 mm non-ventilated air layers on each side of the ventilated air gap.

6 Studied house and positions

The locations of the studied positions are shown in the figures on the following pages. In connection with each studied position a more detailed specification and drawing of the position is also given. In some cases photos, showing the sensor, are provided in the results chapter in connection with the part in which each studied position is presented in detail.

The locations of the studied positions were mainly chosen for two reasons. One was to study the positions where previous knowledge and experience had shown a high frequency of damage. The second was to have a couple of positions in a row at different depths in the wall in order to obtain purer measurements and more reliable conditions in order to verify the WUFI 5.0 calculation tool.

The choice of the studied house and its location was governed by the potential for new-build houses from the housing company participating in the study.



Sensor 16 - Wall (N)
Outer part of the stud

Sensor 19 - Wall (N)
Outer part of beam
below the window

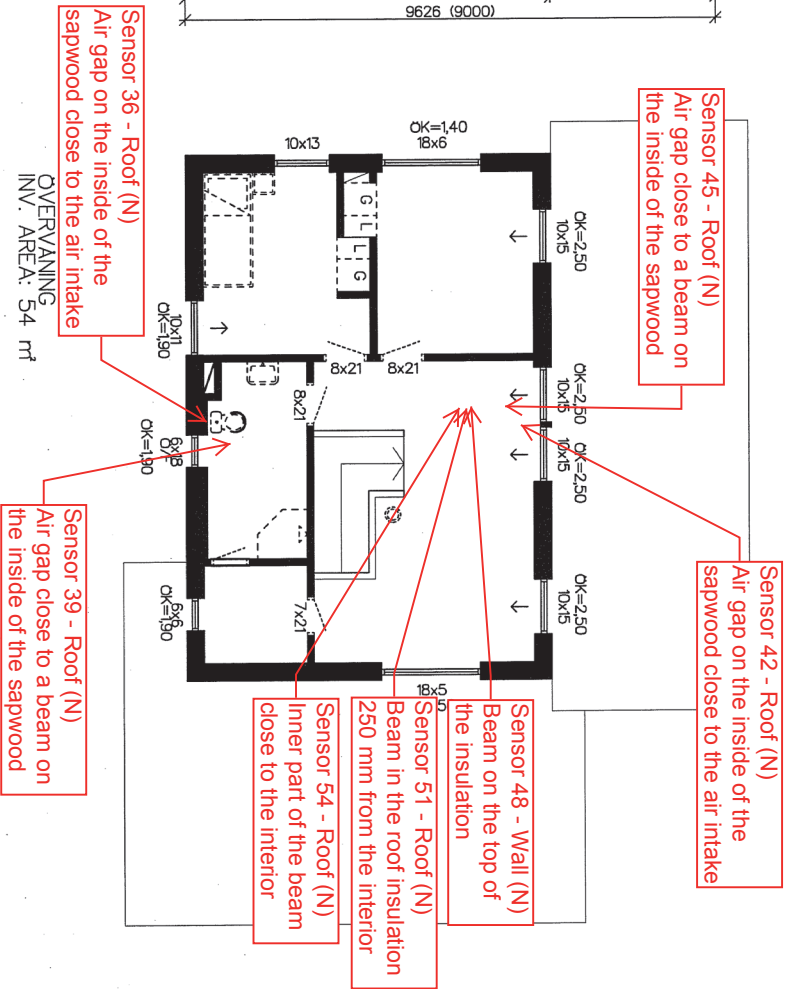
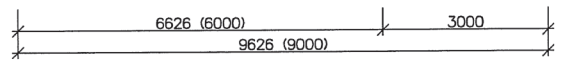
Sensor 10 - Wall (N)
Outer part of the
bottom wall beam

Sensor 28 - Wall (N)
Inner part of stud on
the outsider cold side
of the vapour barrier

Sensor 13 - Wall (N)
Inner part of the
bottom wall beam

Sensor 25 - Wall (N)
Inner part of stud on
the inside of the
vapour barrier

Sensor 22 - Wall (N)
Air gap behind the
facade panel



Sensor 36 - Roof (N)
Air gap on the inside of the
sapwood close to the air intake

OVERVÄNNING
INV. AREA: 54 m²

Sensor 45 - Roof (N)
Air gap close to a beam on
the inside of the sapwood

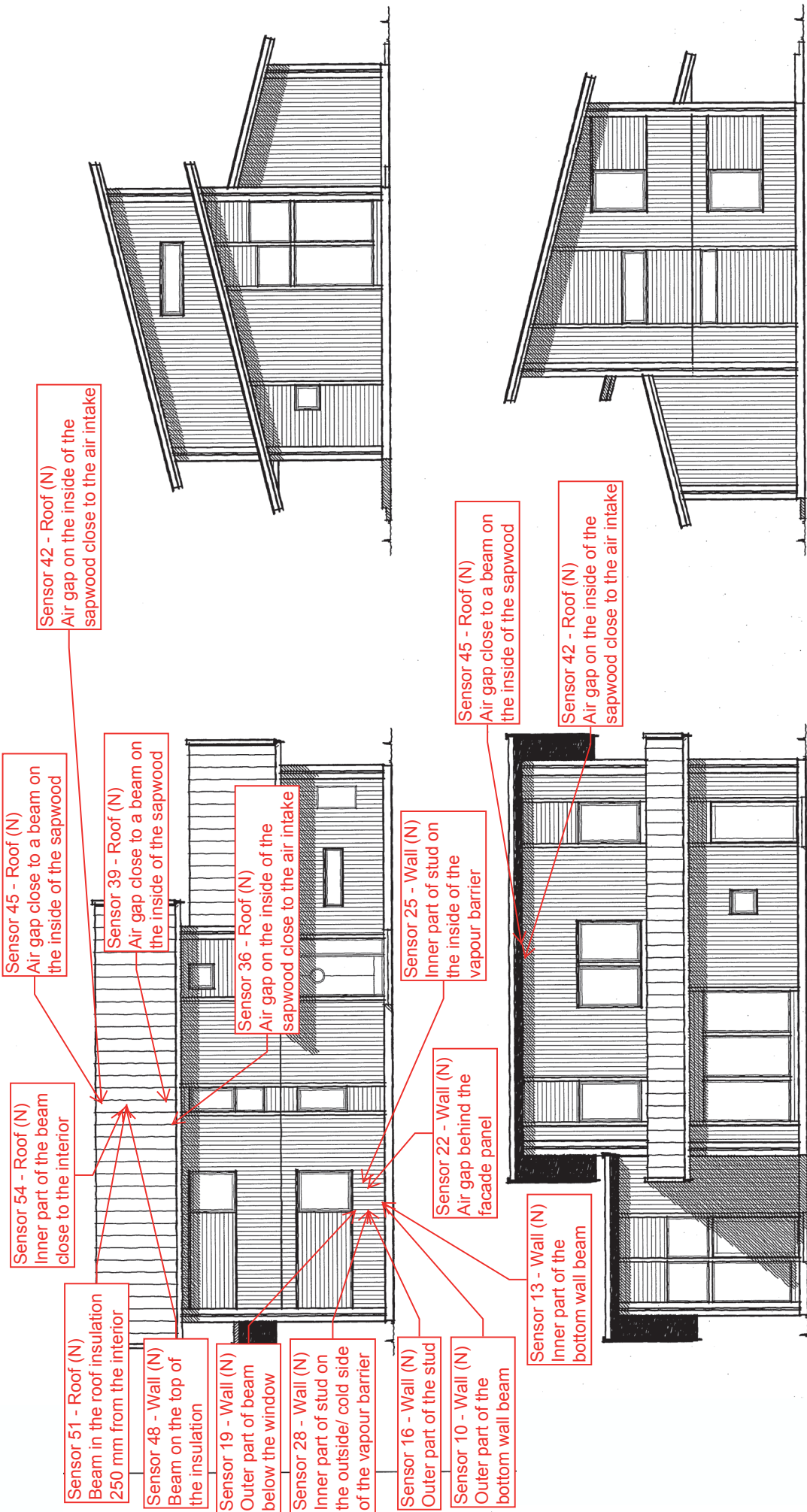
Sensor 42 - Roof (N)
Air gap on the inside of the
sapwood close to the air intake

Sensor 48 - Wall (N)
Beam on the top of
the insulation

Sensor 51 - Roof (N)
Beam in the roof insulation
250 mm from the interior

Sensor 54 - Roof (N)
Inner part of the beam
close to the interior

Sensor 39 - Roof (N)
Air gap close to a beam on
the inside of the sapwood



Sensor 42 - Roof (N)
Air gap on the inside of the sapwood close to the air intake

Sensor 45 - Roof (N)
Air gap close to a beam on the inside of the sapwood

Sensor 39 - Roof (N)
Air gap close to a beam on the inside of the sapwood

Sensor 36 - Roof (N)
Air gap on the inside of the sapwood close to the air intake

Sensor 54 - Roof (N)
Inner part of the beam close to the interior

Sensor 51 - Roof (N)
Beam in the roof insulation 250 mm from the interior

Sensor 48 - Wall (N)
Beam on the top of the insulation

Sensor 19 - Wall (N)
Outer part of beam below the window

Sensor 28 - Wall (N)
Inner part of stud on the outside/ cold side of the vapour barrier

Sensor 16 - Wall (N)
Outer part of the stud

Sensor 10 - Wall (N)
Outer part of the bottom wall beam

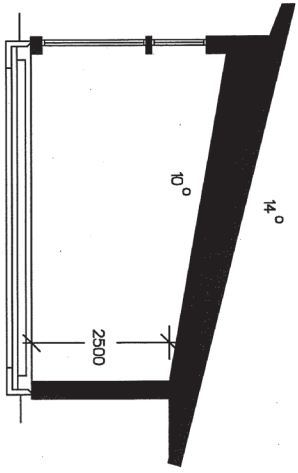
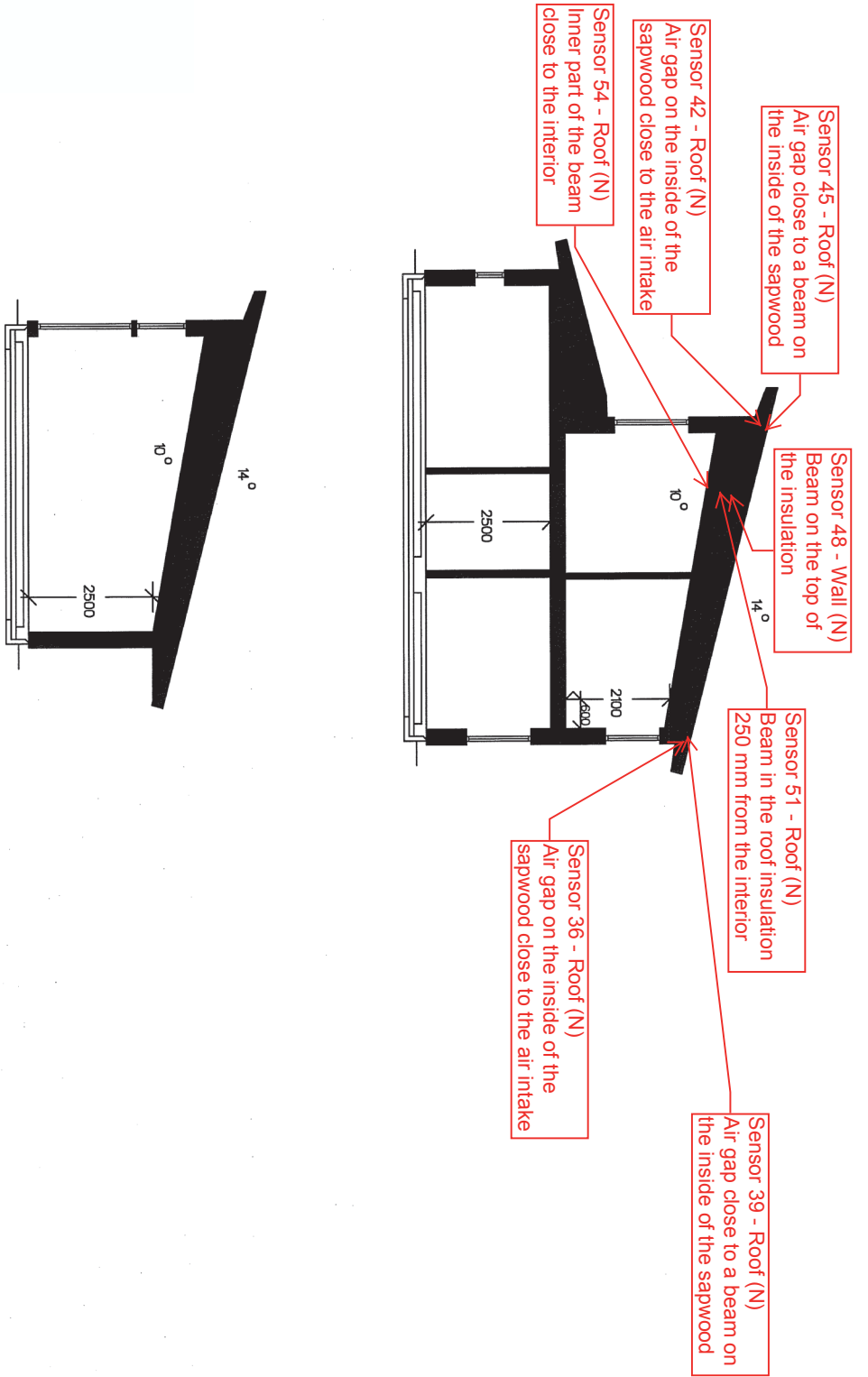
Sensor 25 - Wall (N)
Inner part of stud on the inside of the vapour barrier

Sensor 22 - Wall (N)
Air gap behind the facade panel

Sensor 13 - Wall (N)
Inner part of the bottom wall beam

Sensor 45 - Roof (N)
Air gap close to a beam on the inside of the sapwood

Sensor 42 - Roof (N)
Air gap on the inside of the sapwood close to the air intake



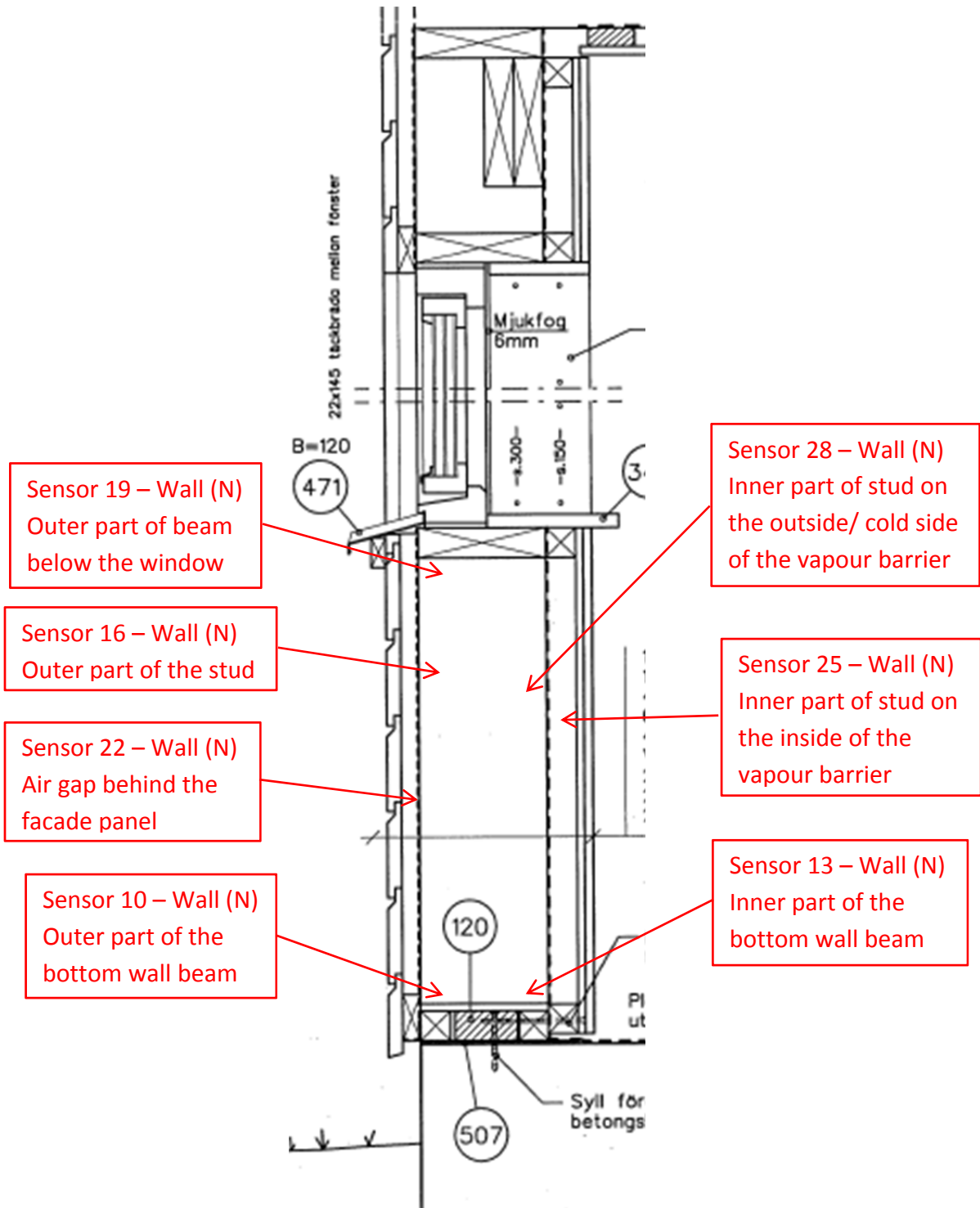


Figure 6.4. Location of studied positions in the wall.

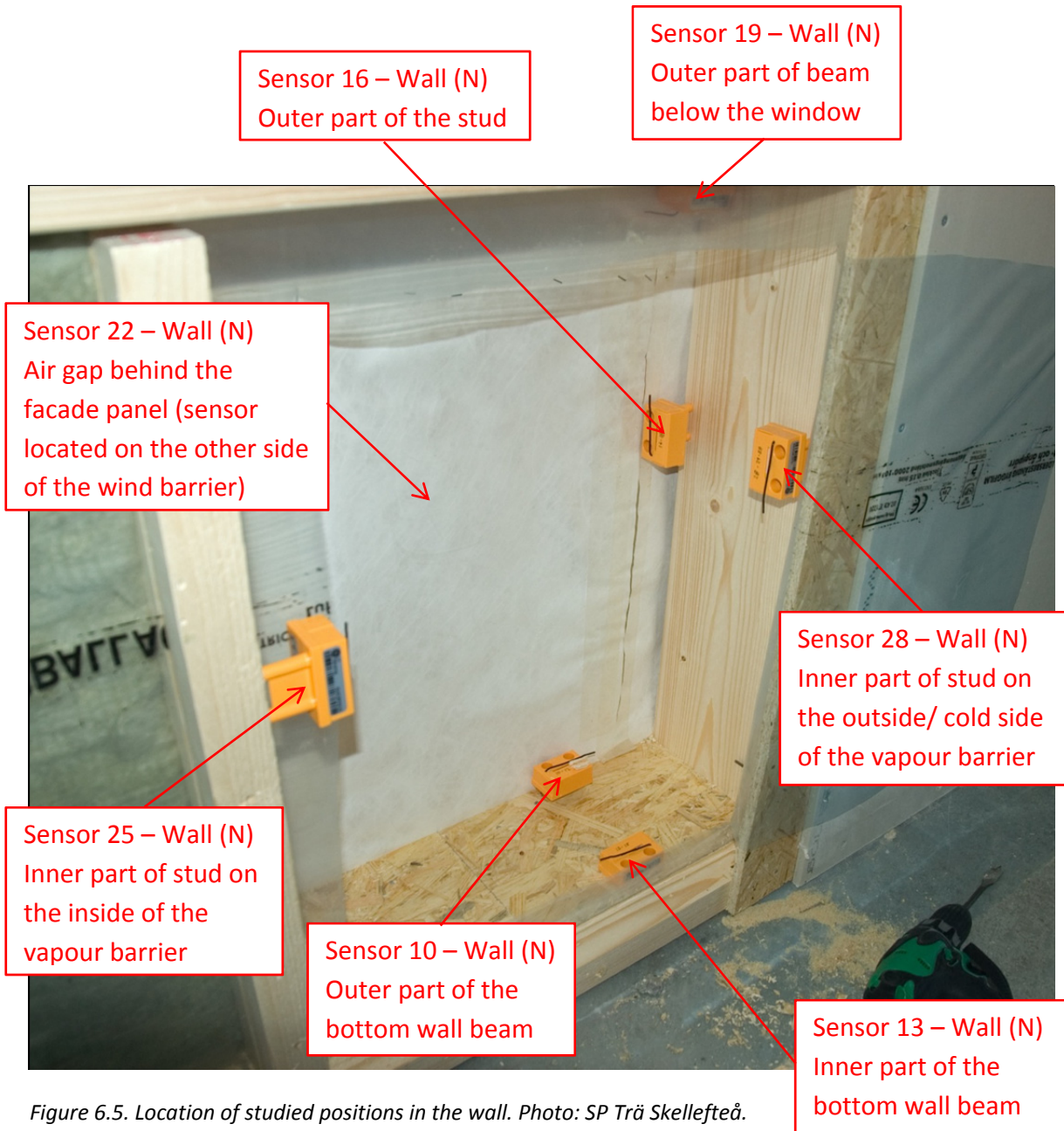


Figure 6.5. Location of studied positions in the wall. Photo: SP Trä Skellefteå.

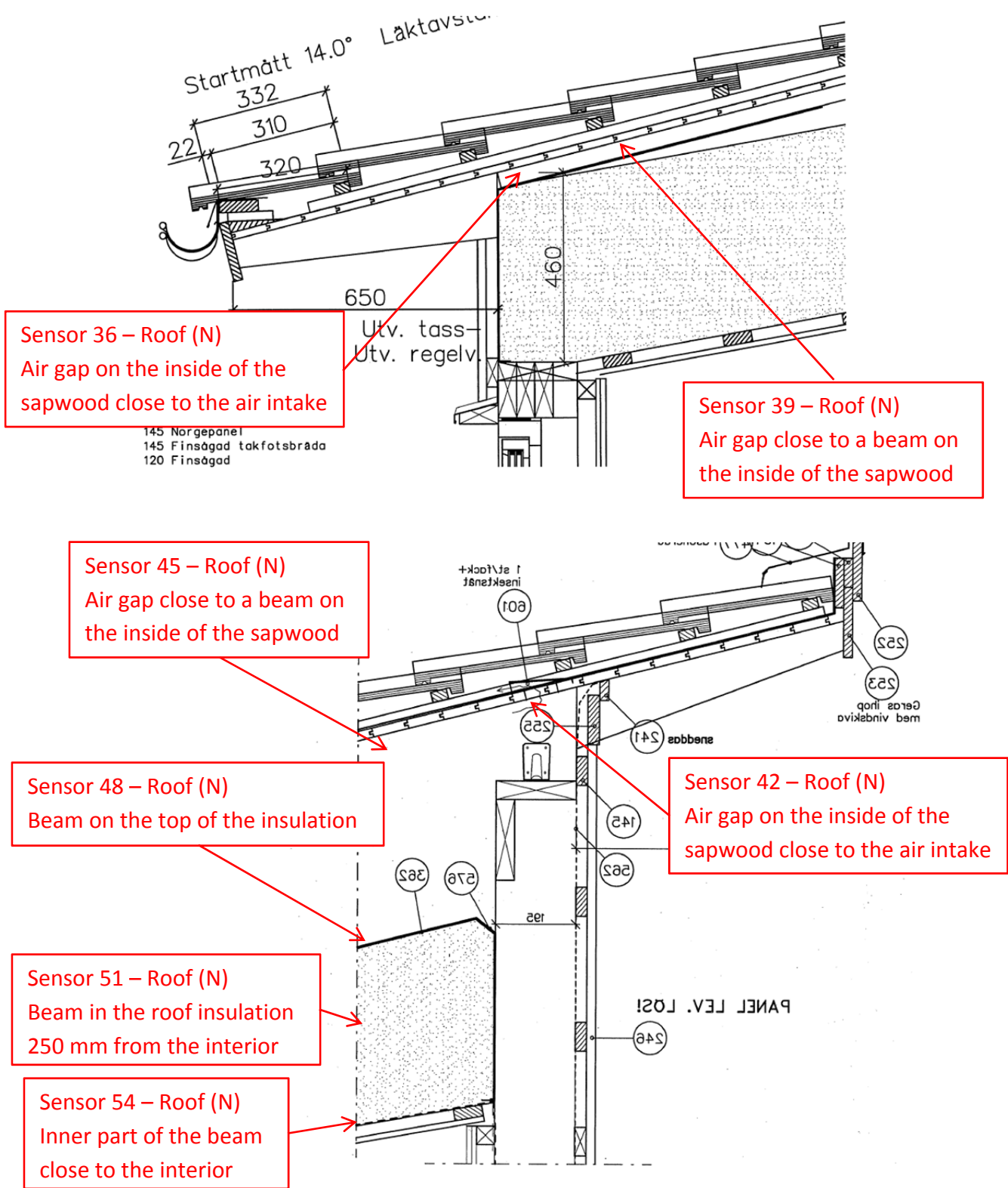


Figure 6.6. Location of studied positions in the roof.

7 Results

7.10 Position 10

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

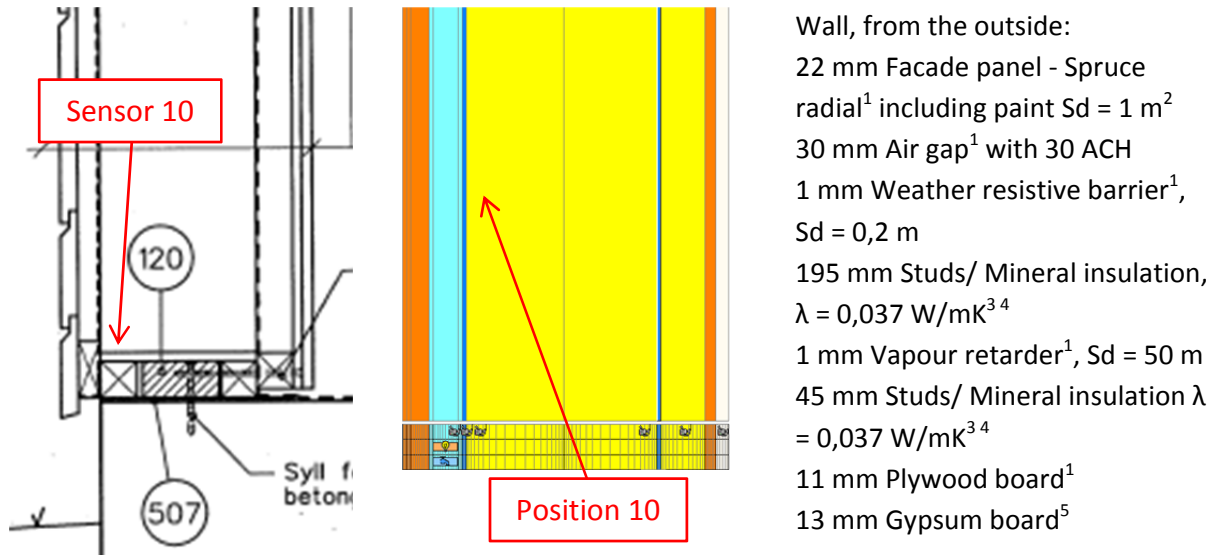


Figure 7.10.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

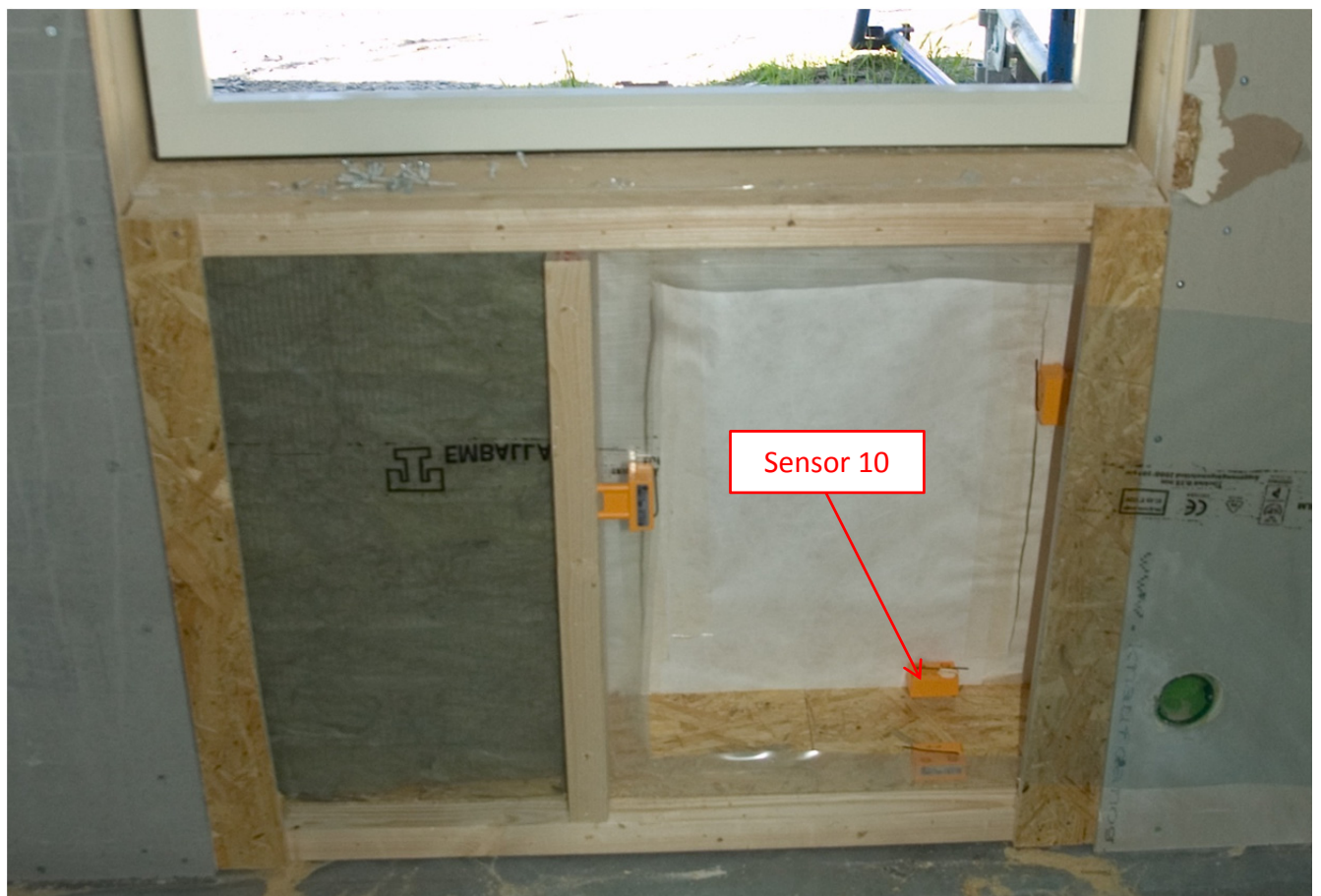


Figure 7.10.2. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.10.3. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors. The measured values of moisture content were unreliable as the measurements were carried out in OSB-board which do not have the same properties as ordinary wood.

Year 2008

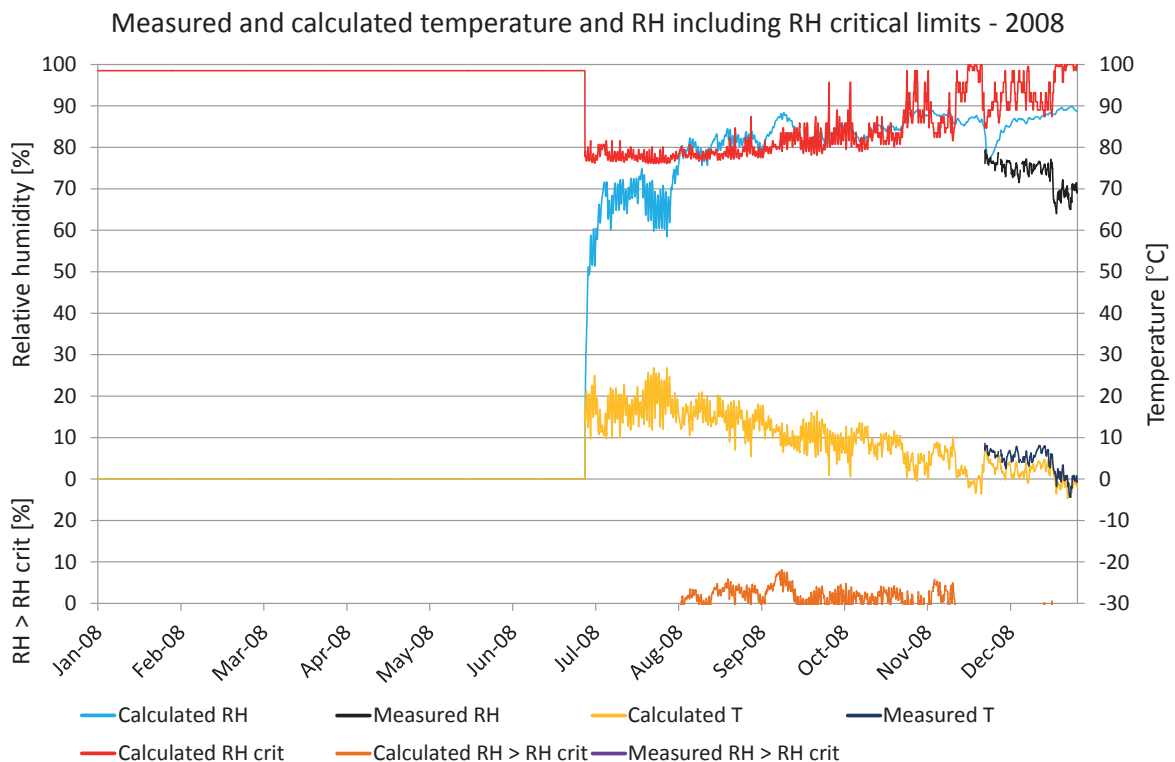


Figure 7.10.4. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

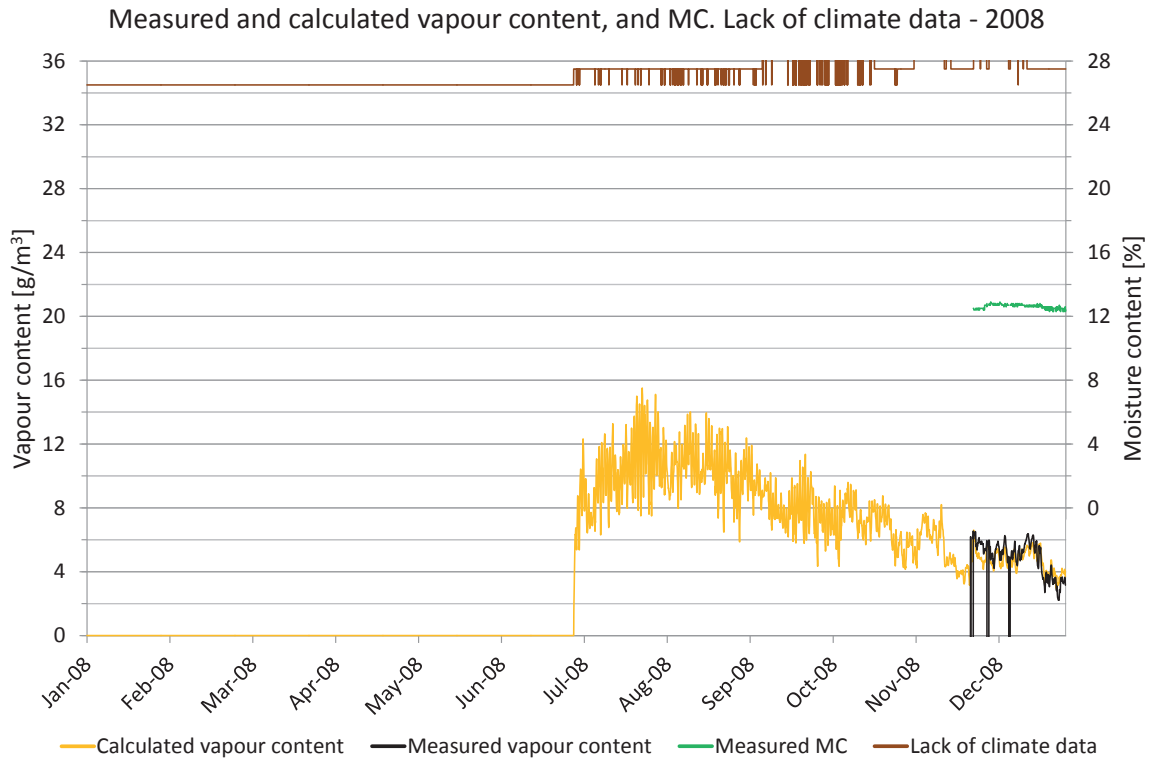


Figure 7.10.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

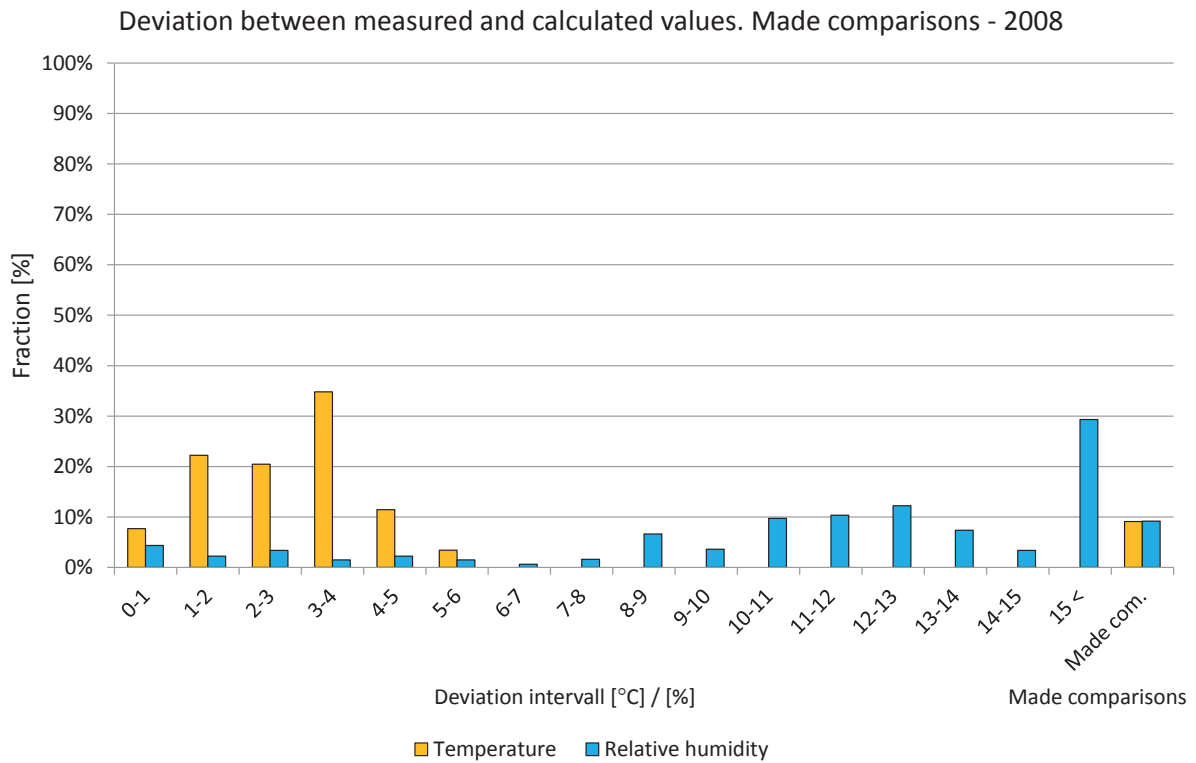


Figure 7.10.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

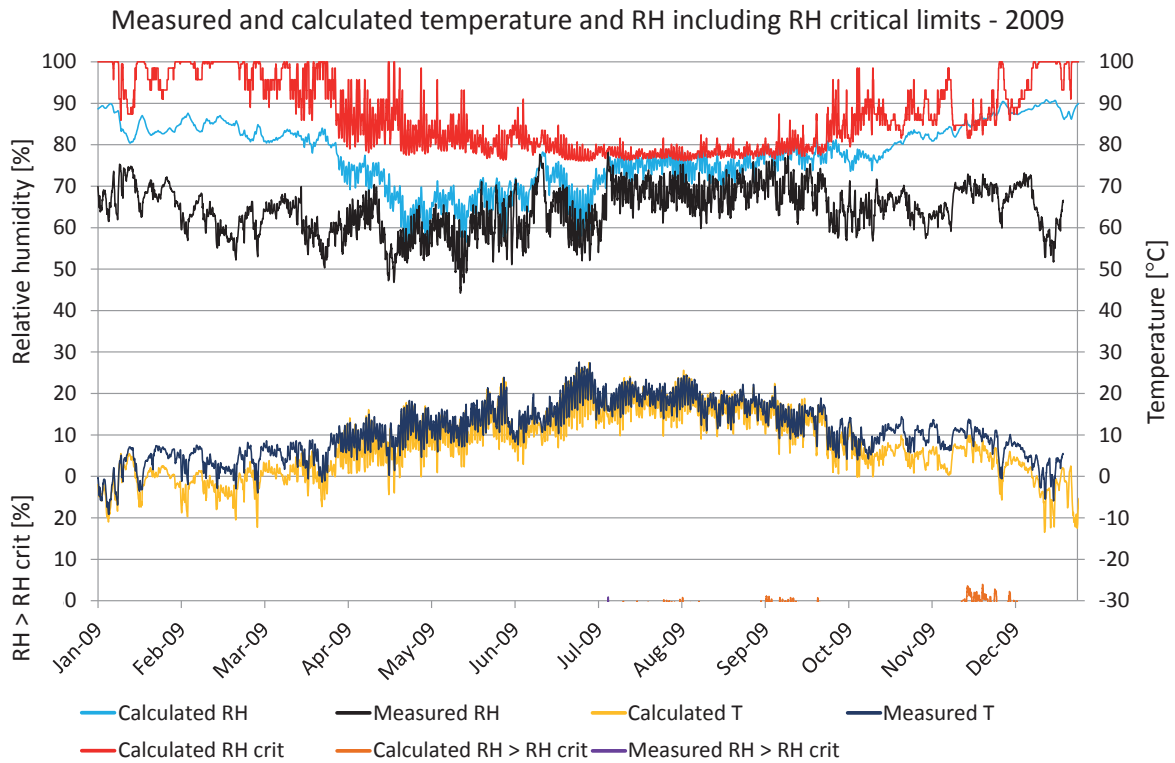


Figure 7.10.7. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

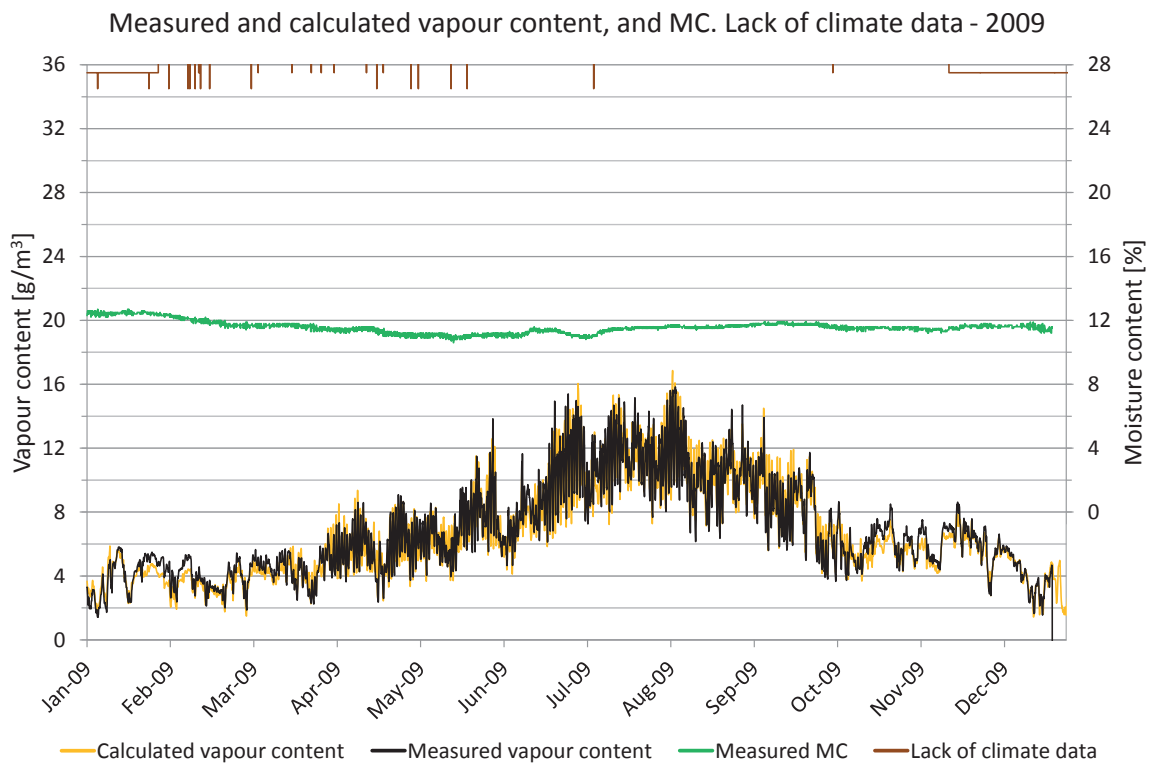


Figure 7.10.8. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

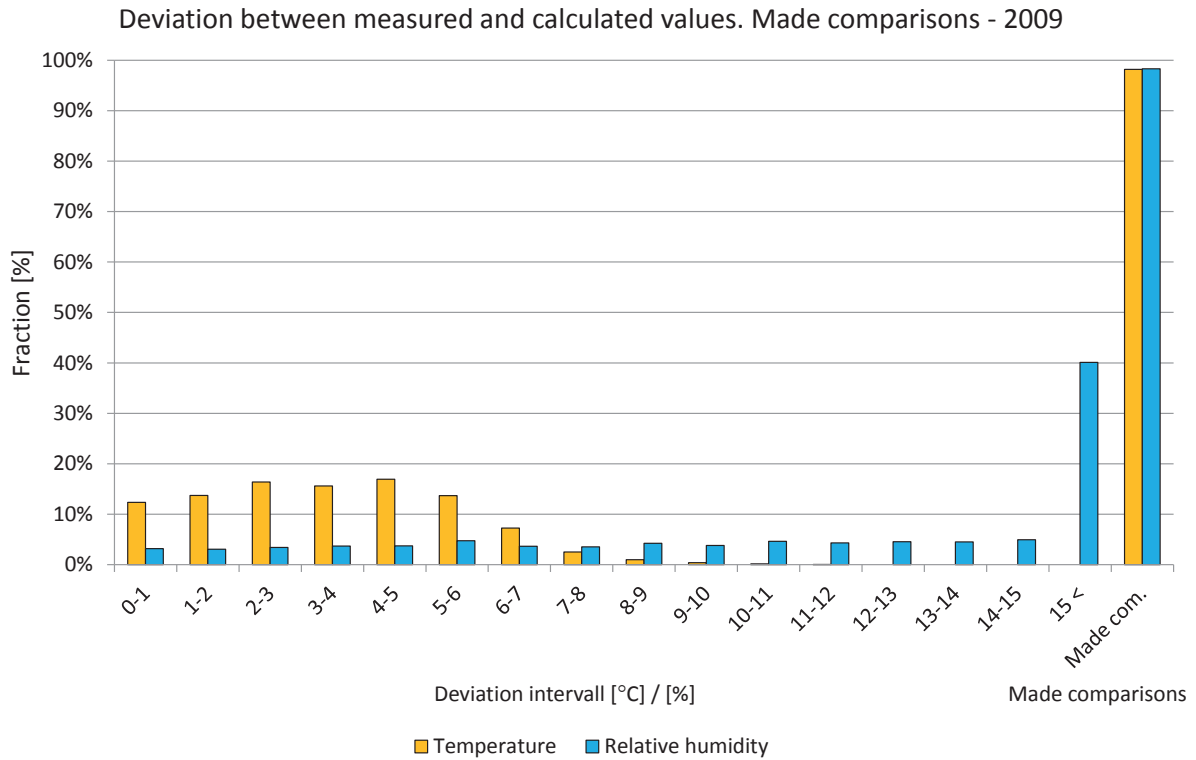


Figure 7.10.9. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

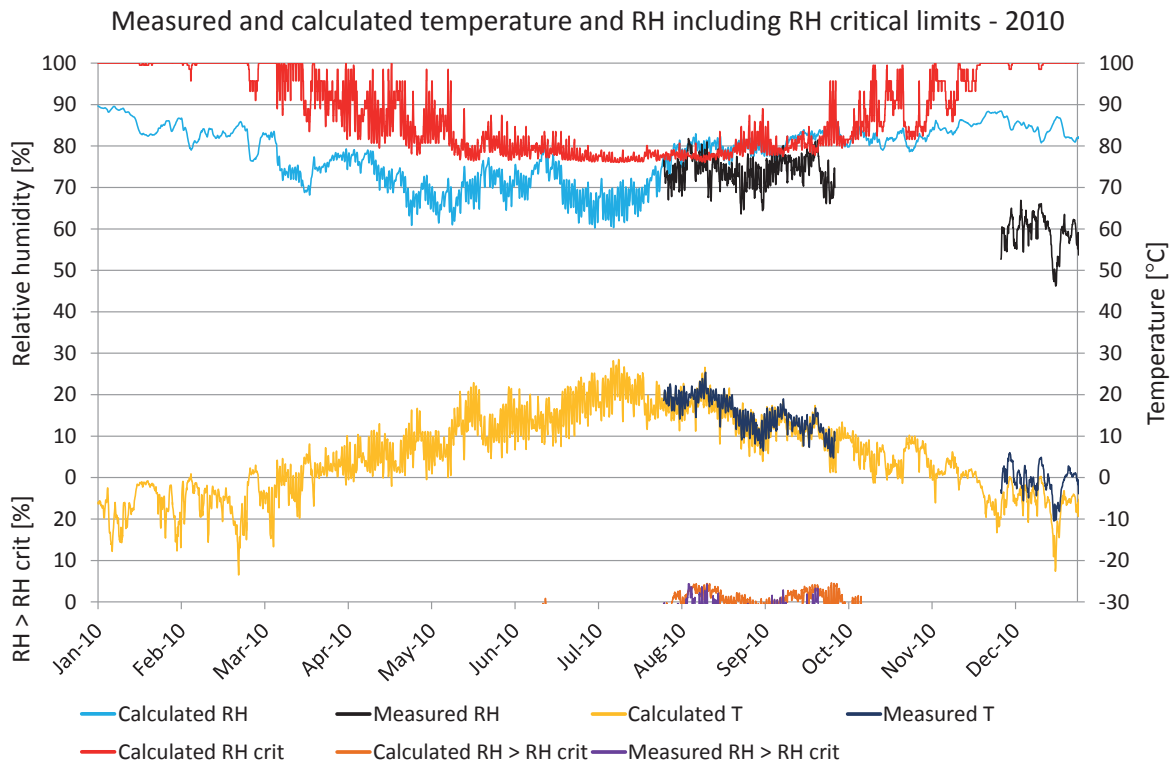


Figure 7.10.10. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

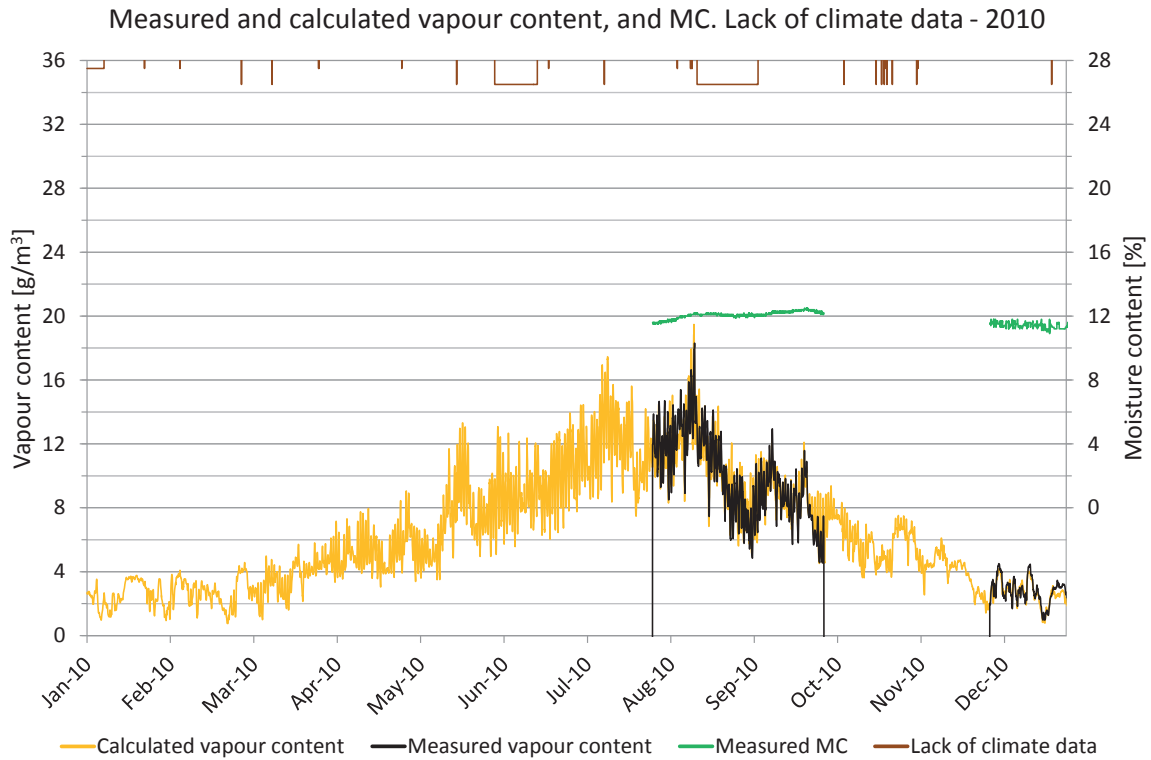


Figure 7.10.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

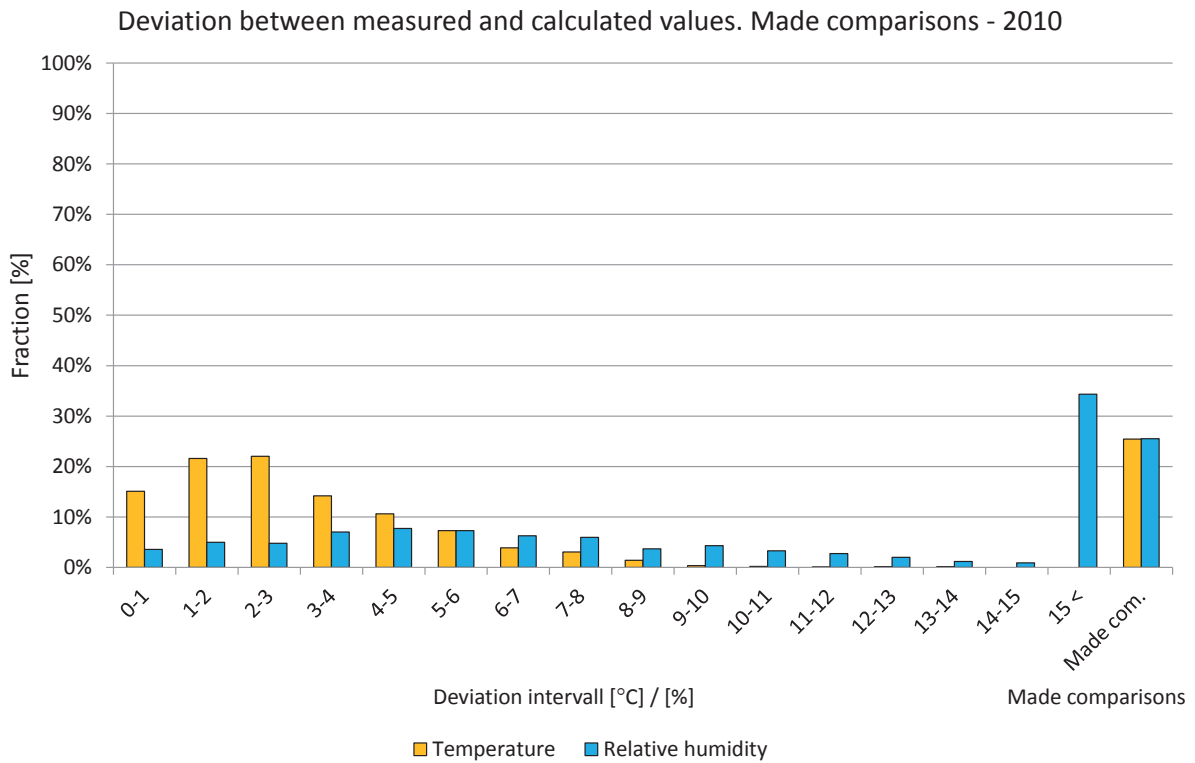


Figure 7.10.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

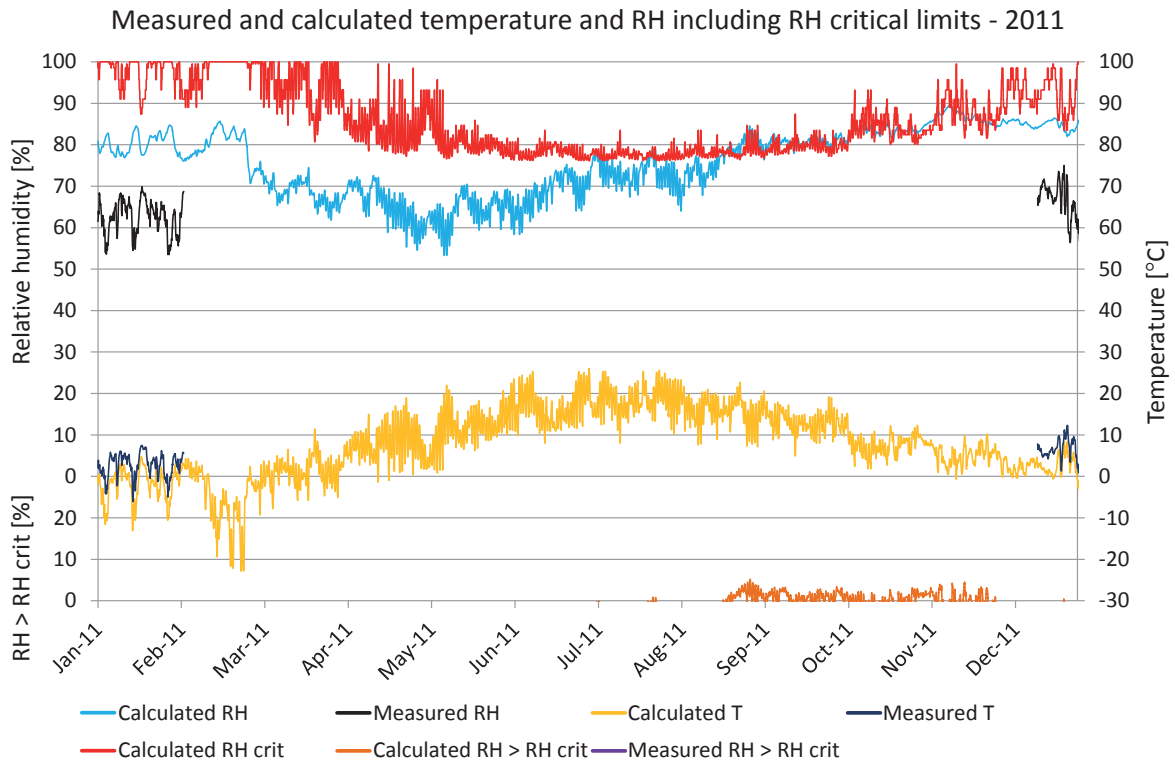


Figure 7.10.13. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

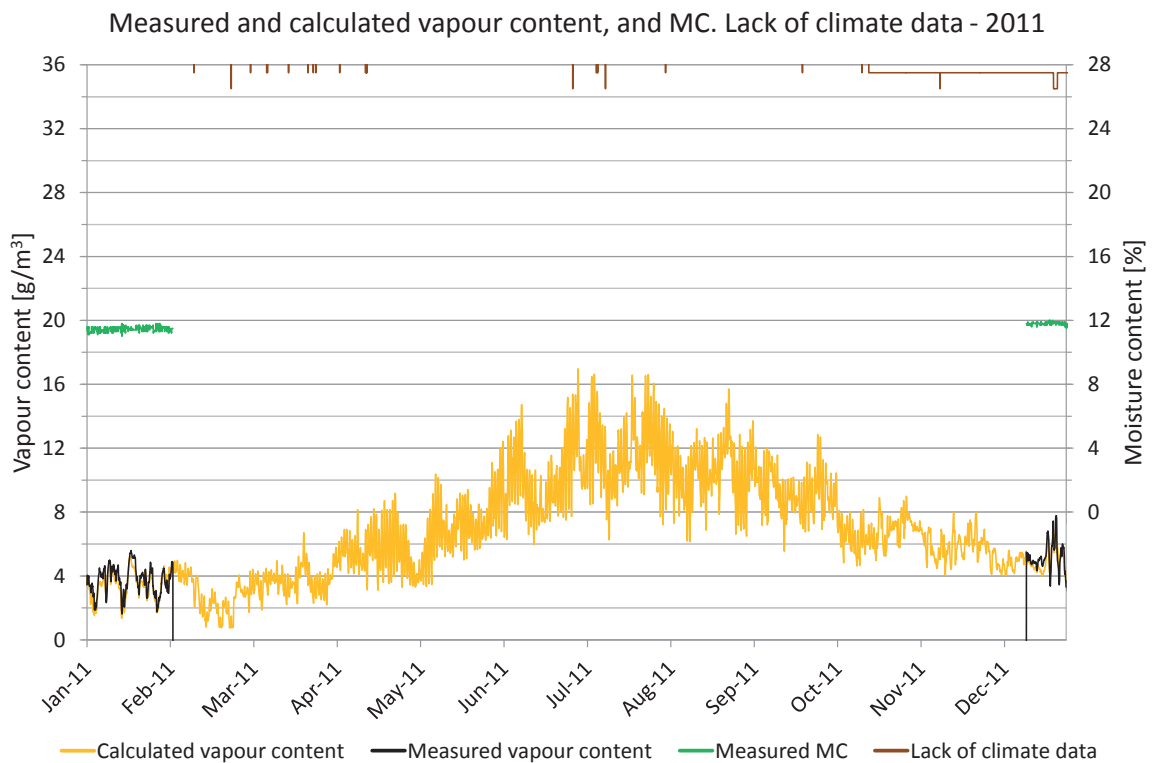


Figure 7.10.14. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

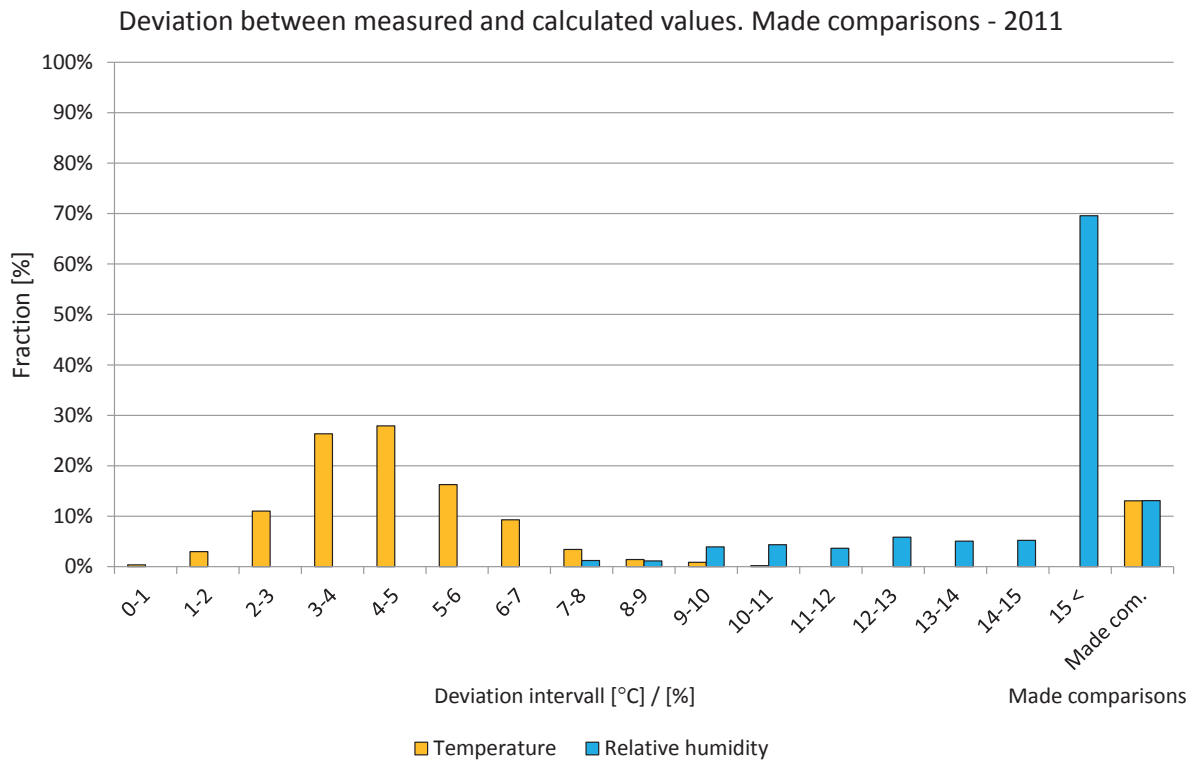


Figure 7.10.15. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.13 Position 13

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

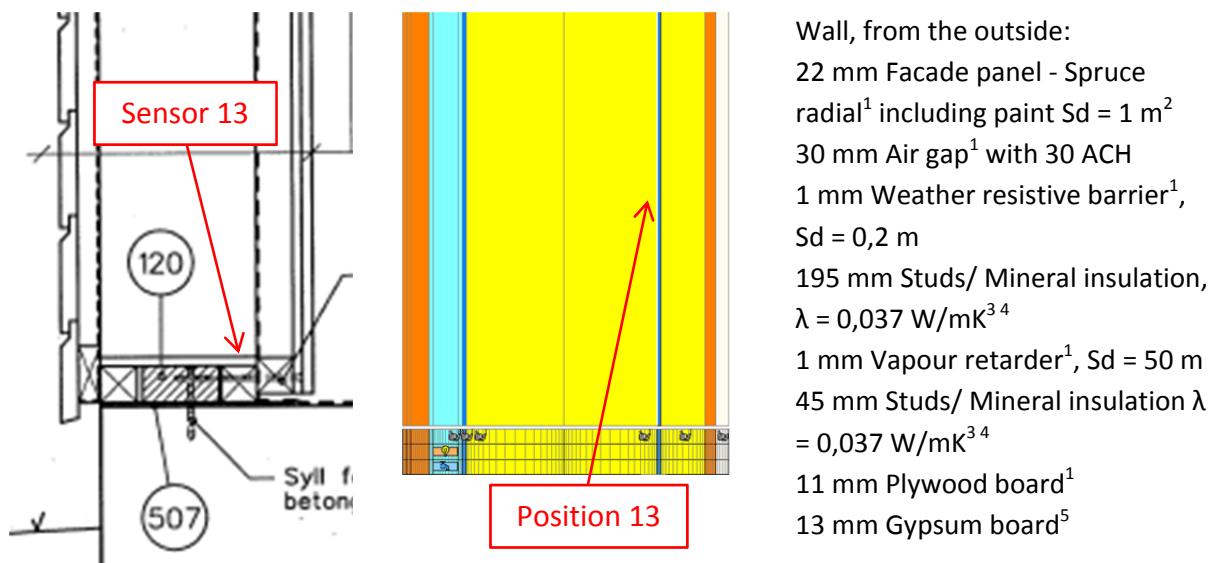


Figure 7.13.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.13.2. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.13.3. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.13.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors. The measured values of moisture content were unreliable as the measurements were carried out in OSB-board which do not have the same properties as ordinary wood.

Year 2008

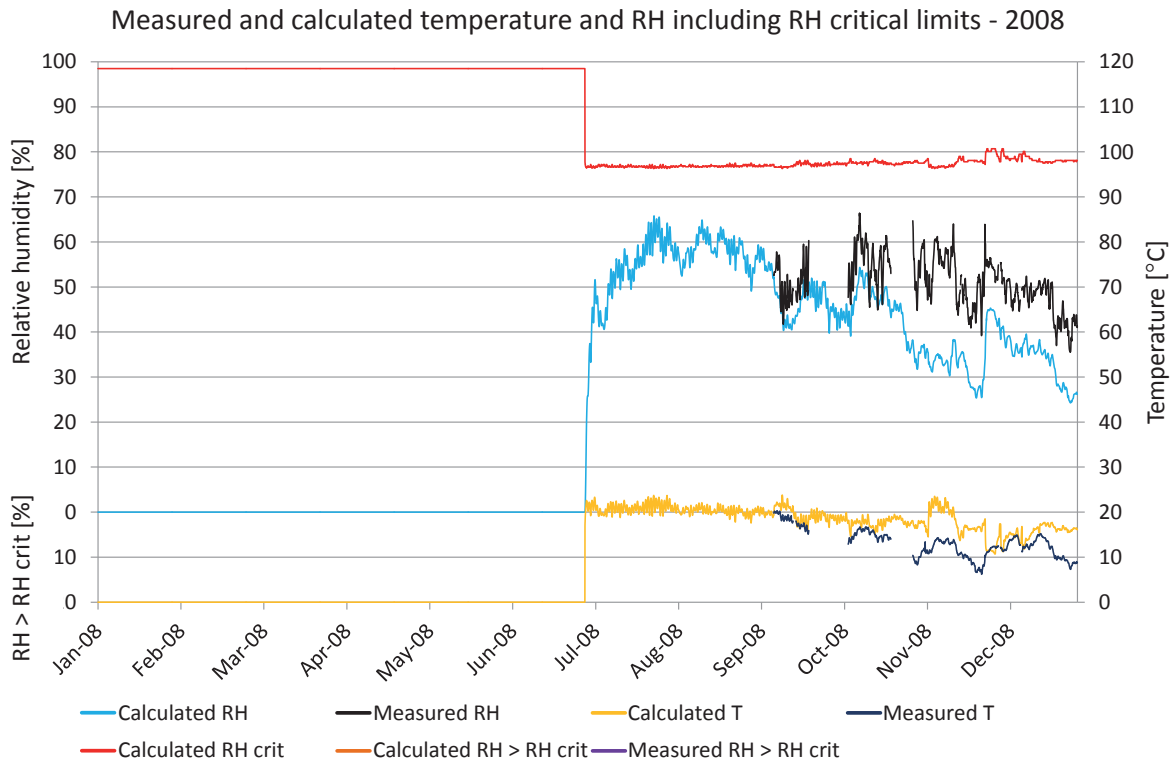


Figure 7.13.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

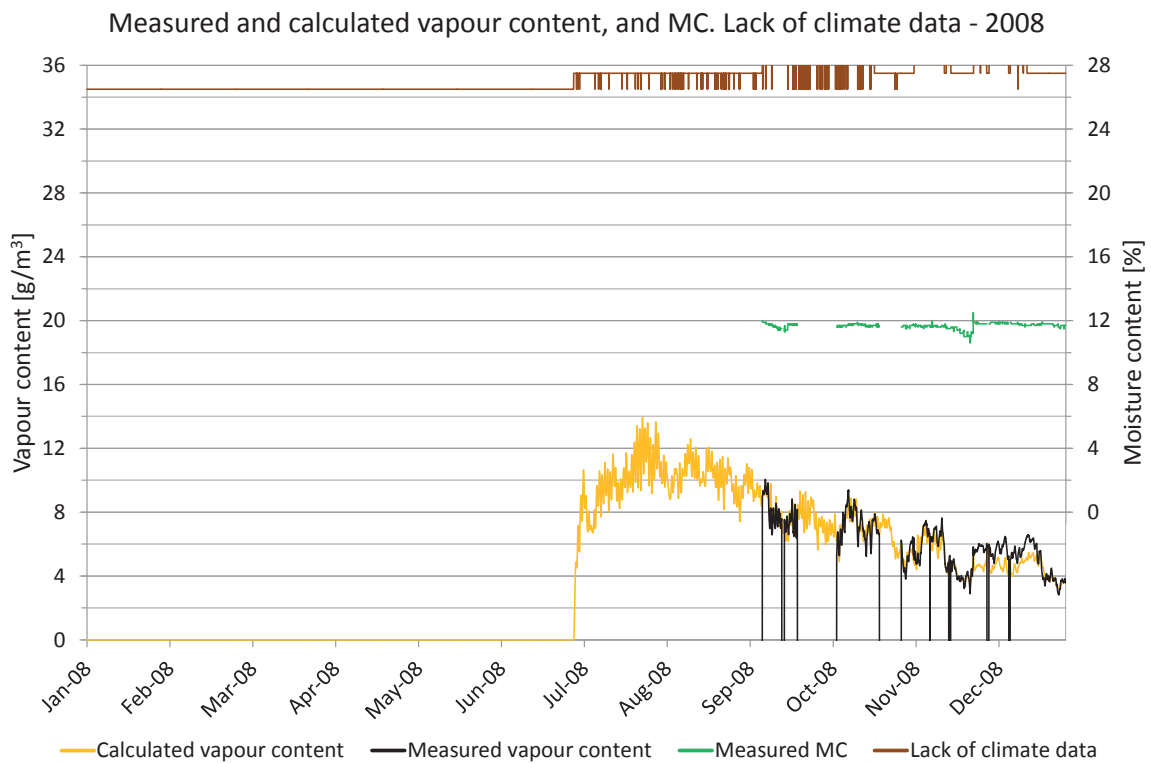


Figure 7.13.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

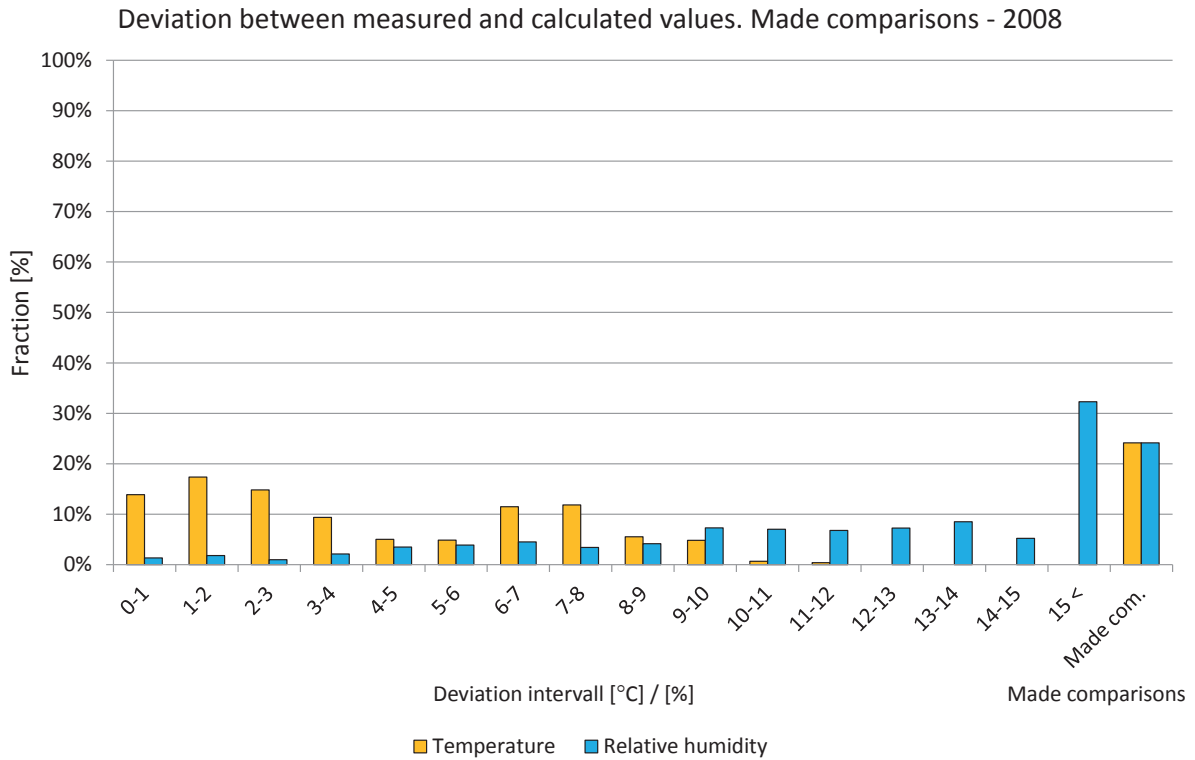


Figure 7.13.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

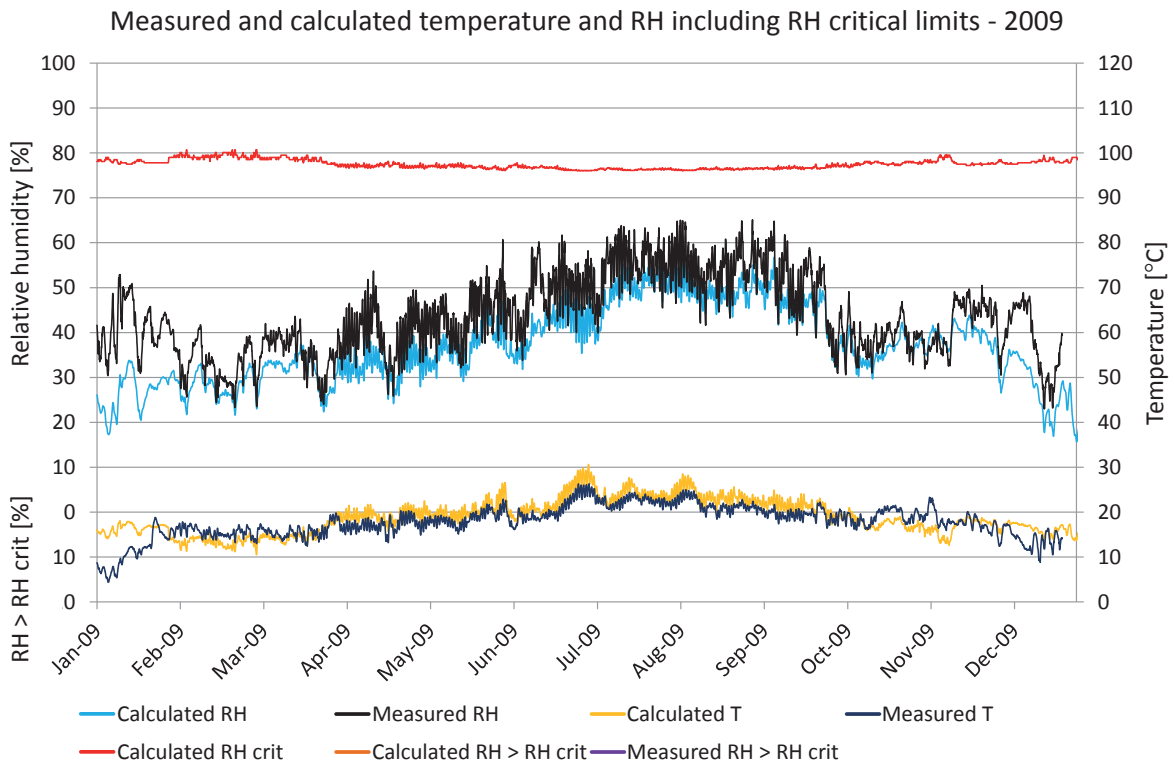


Figure 7.13.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

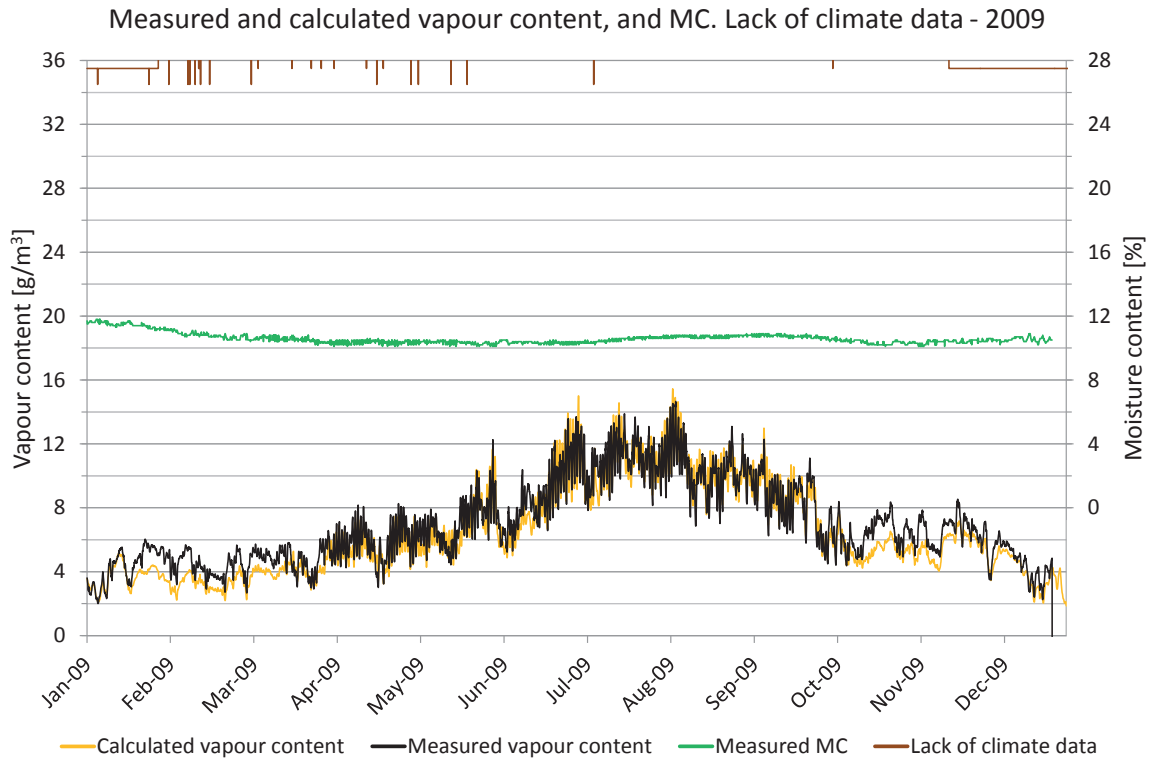


Figure 7.13.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

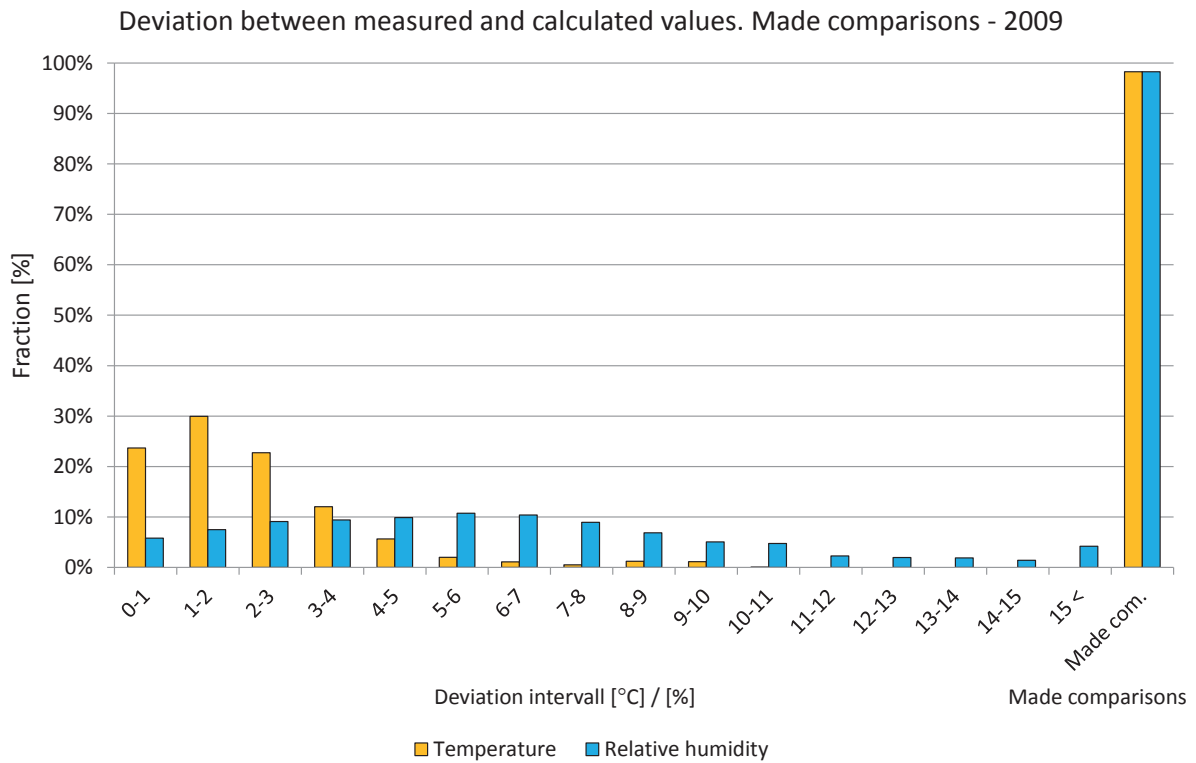


Figure 7.13.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

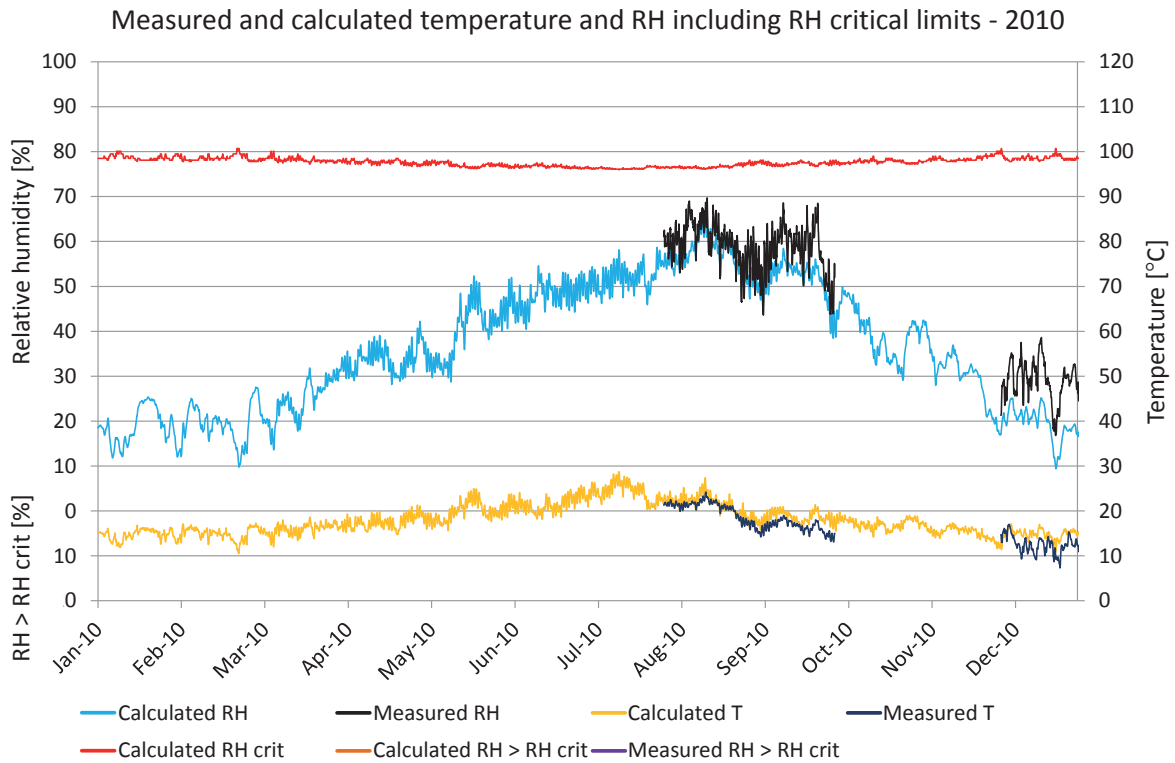


Figure 7.13.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

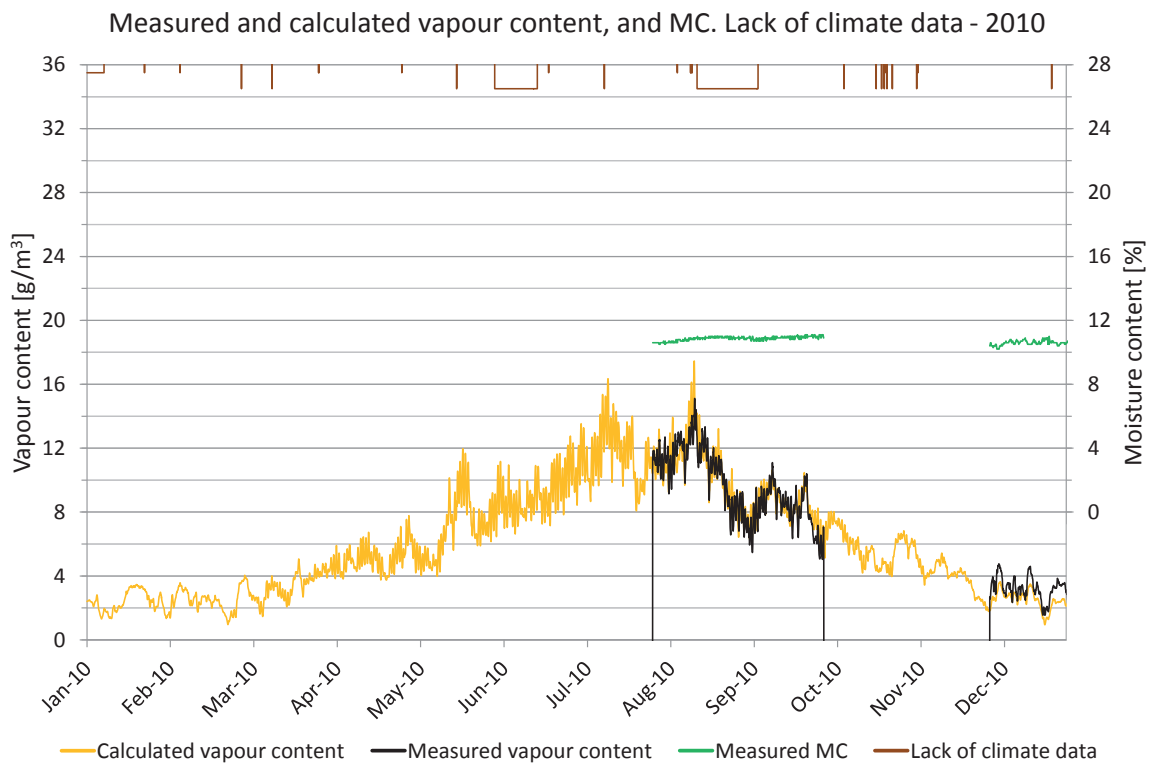


Figure 7.13.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

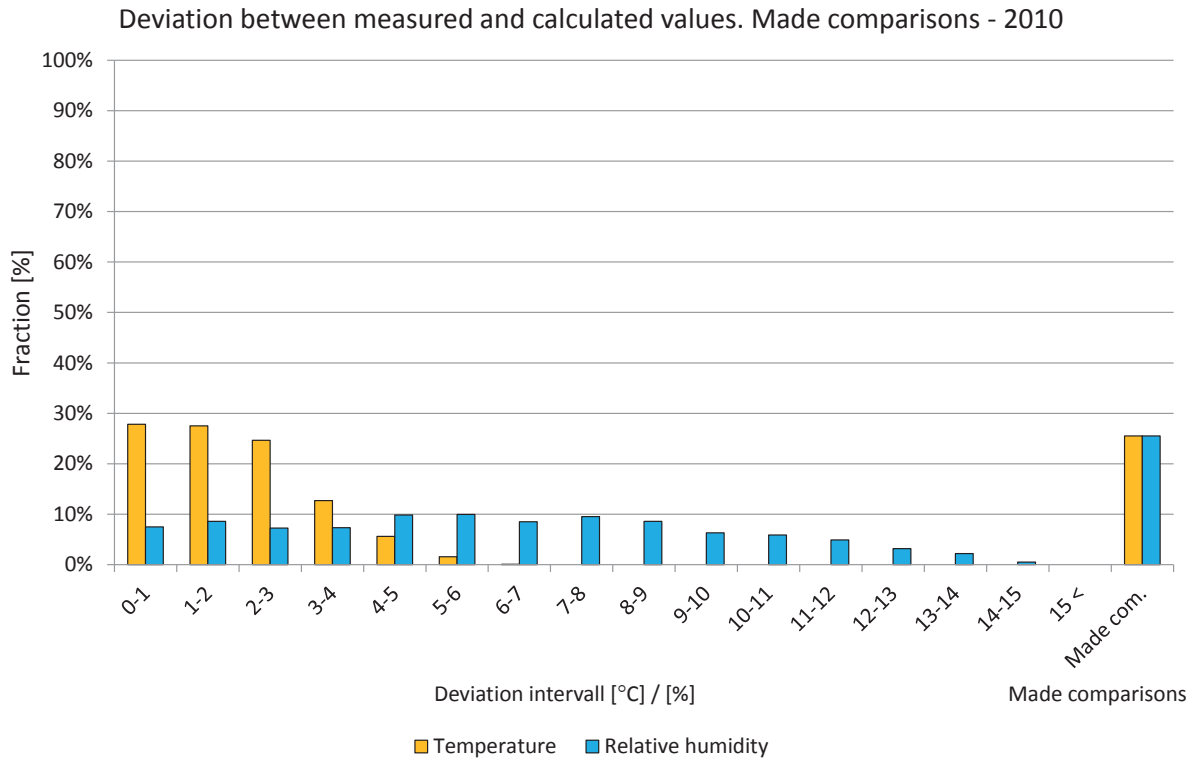


Figure 7.13.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

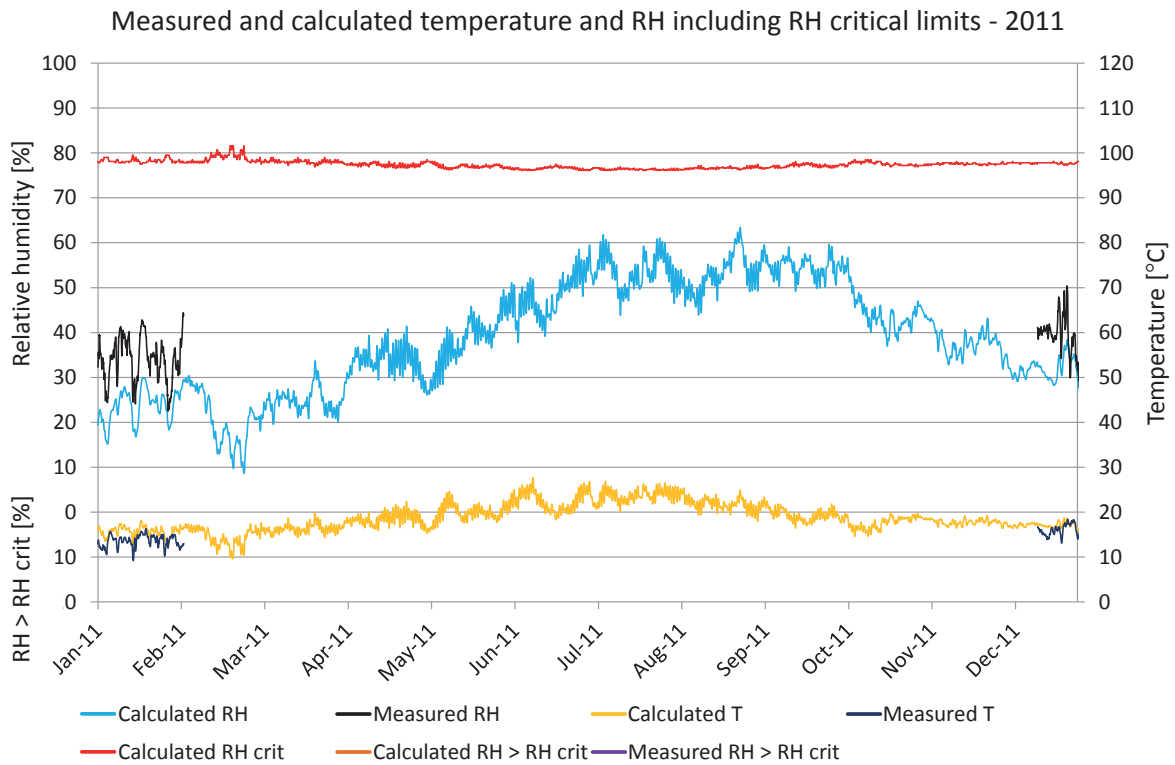


Figure 7.13.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

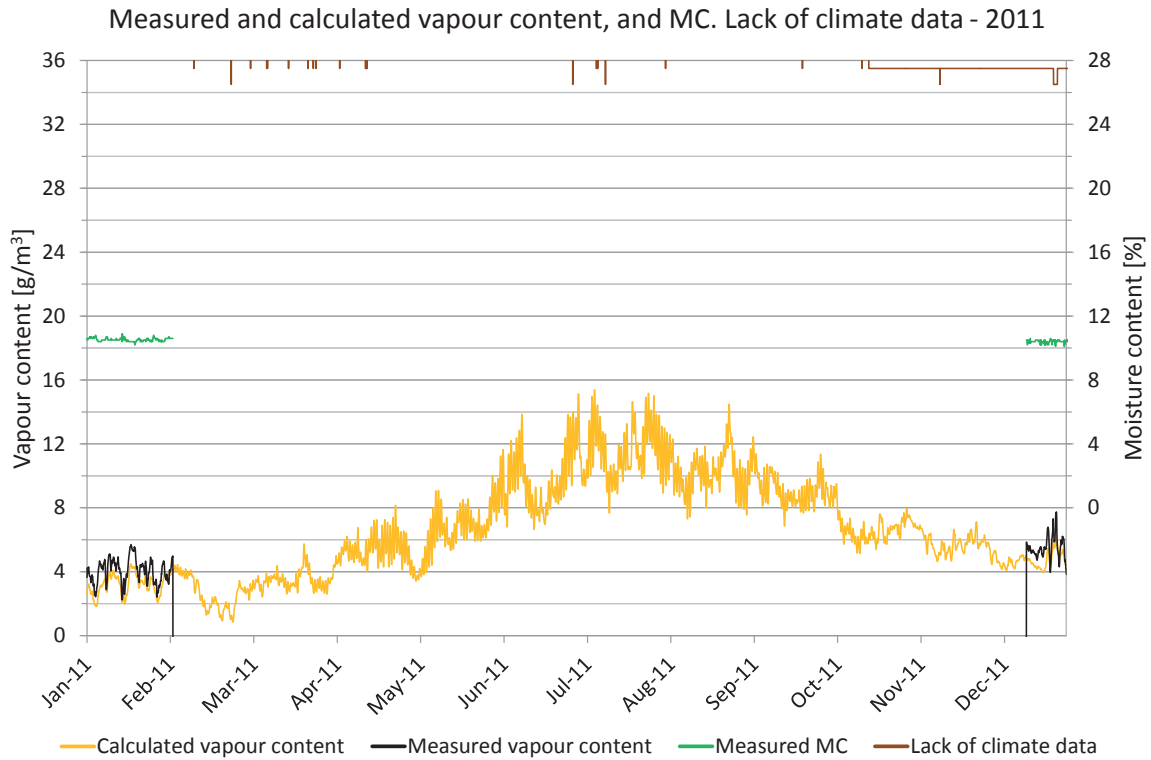


Figure 7.13.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

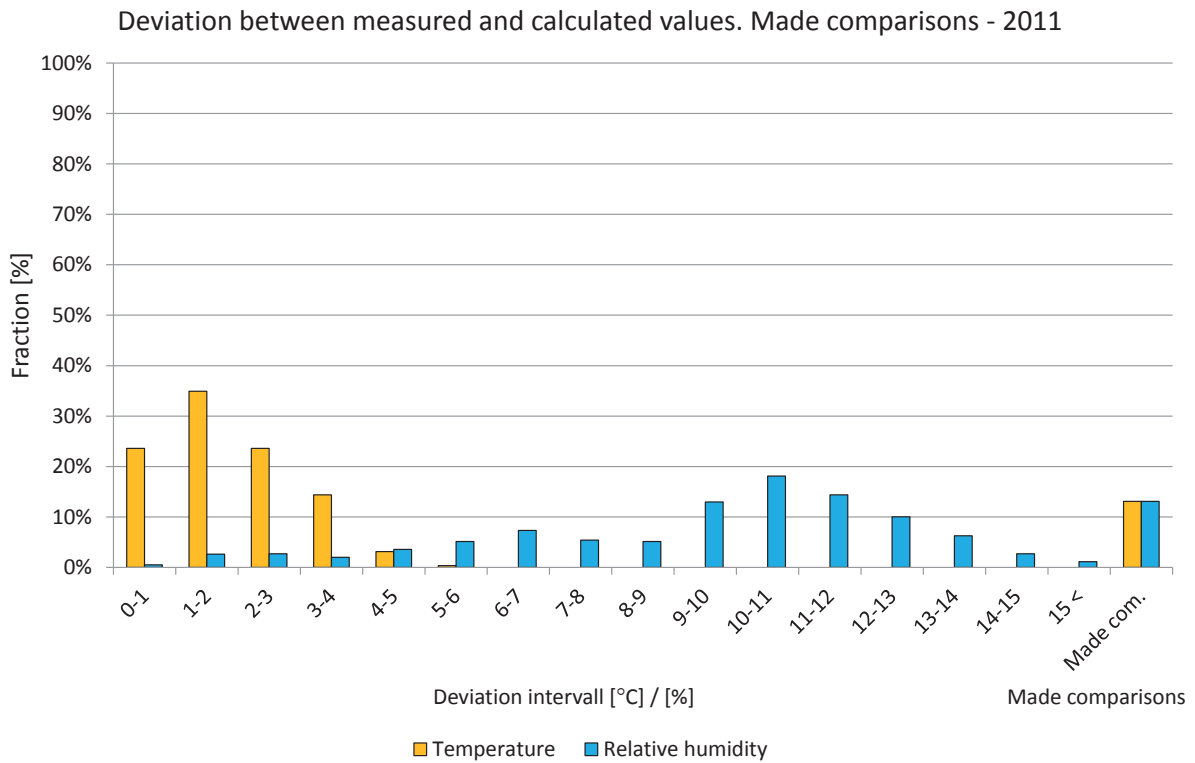


Figure 7.13.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.16 Position 16

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

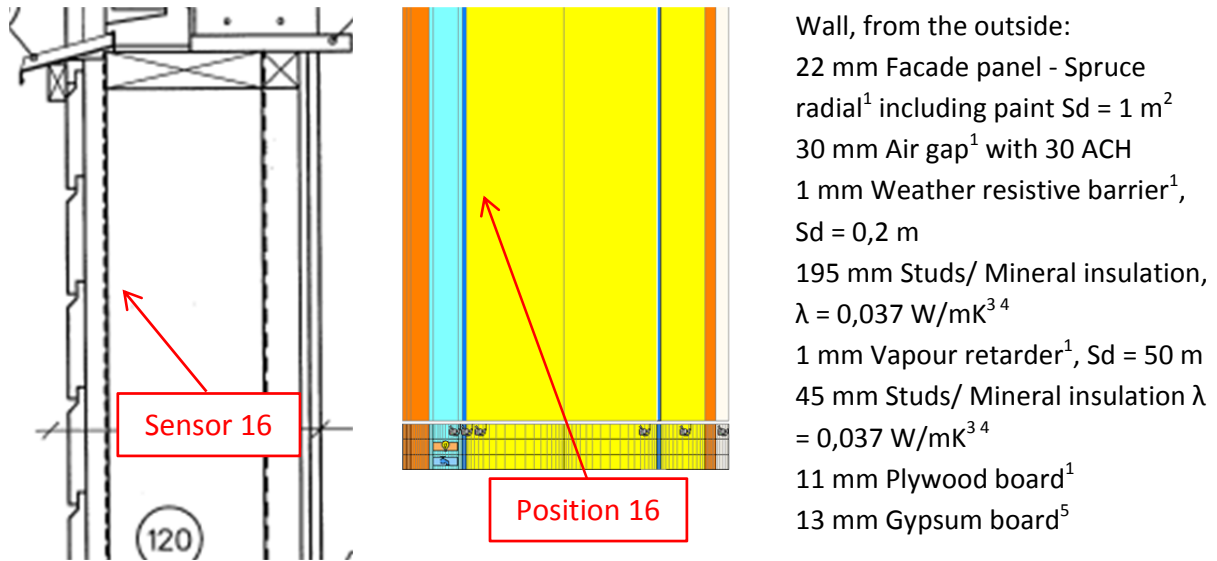


Figure 7.16.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.16.2. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.16.3. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

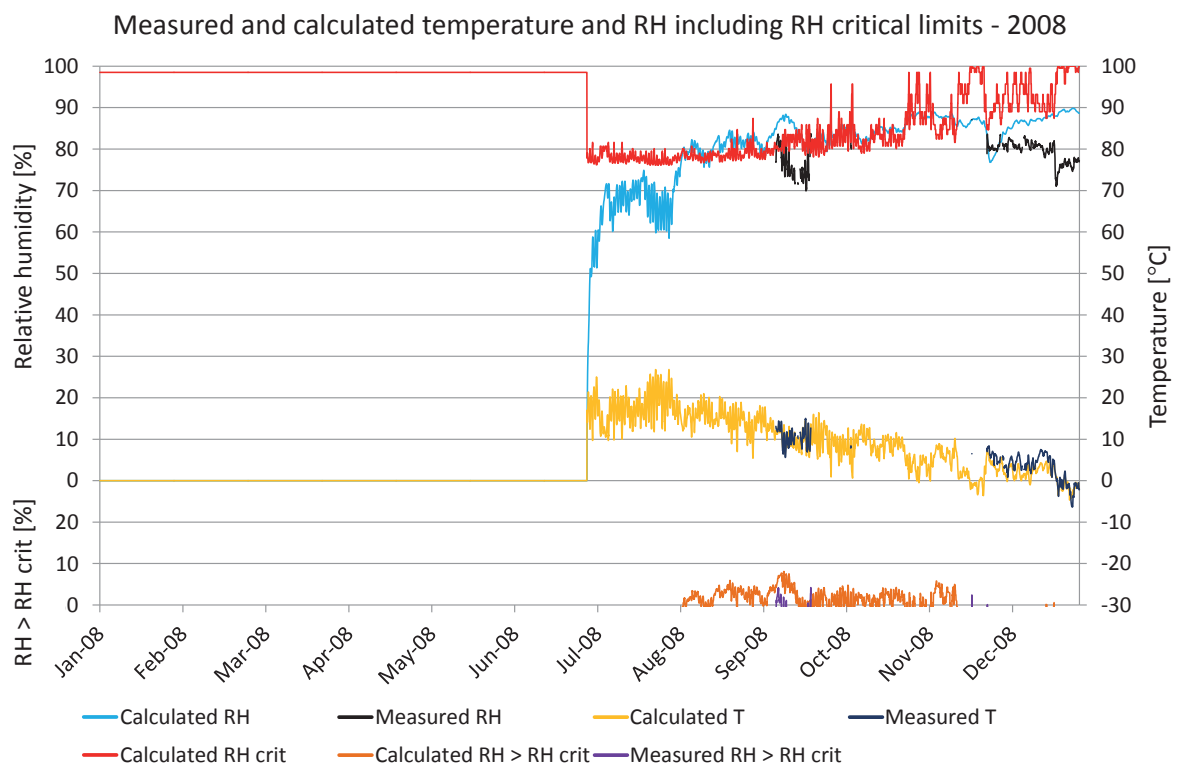


Figure 7.16.4. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

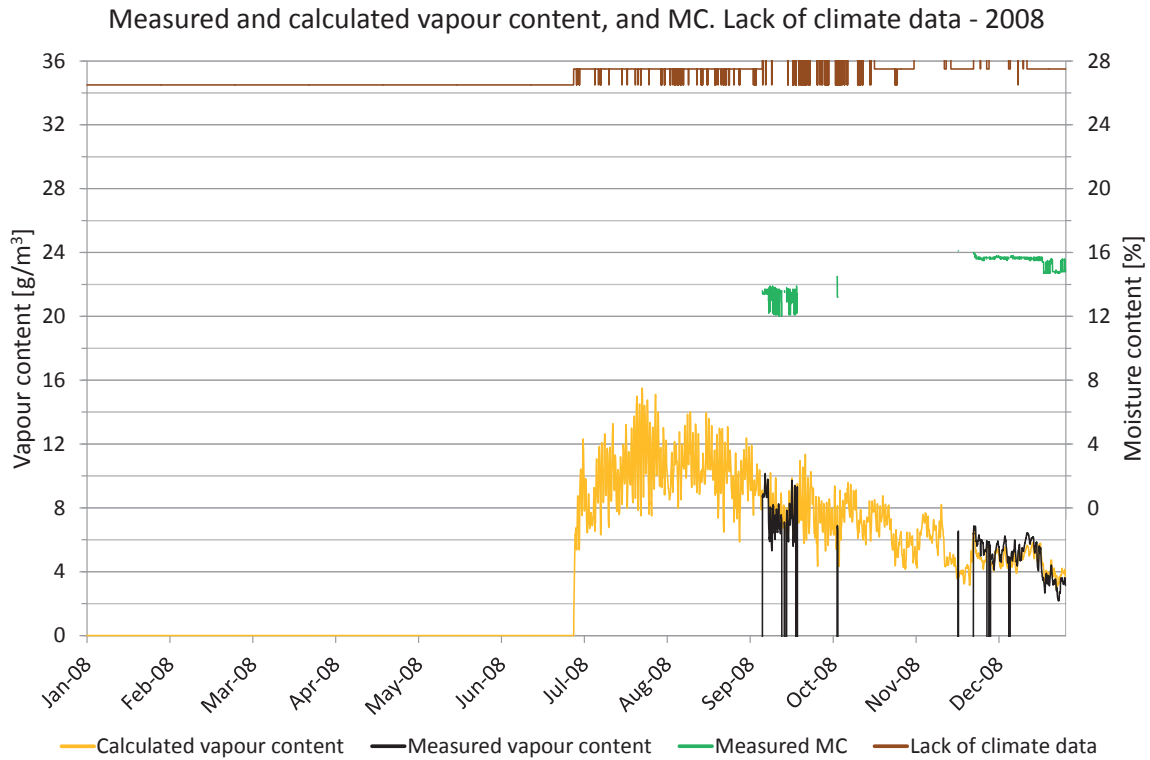


Figure 7.16.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

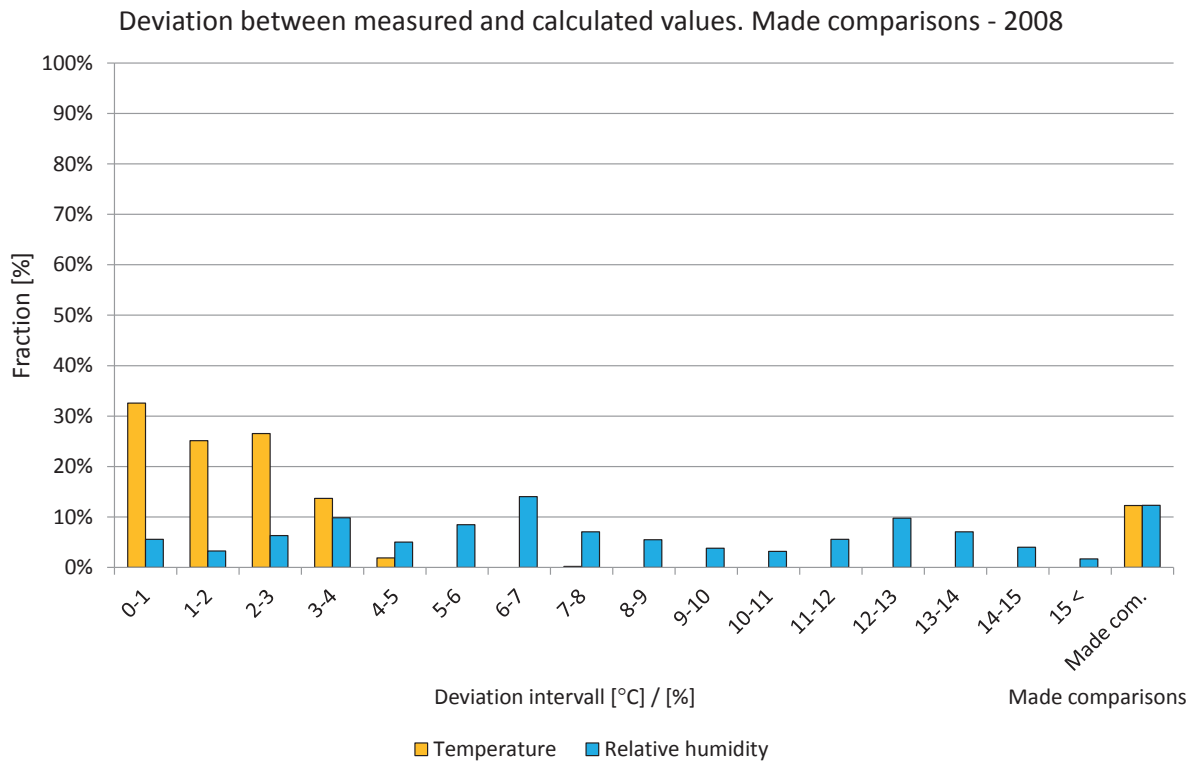


Figure 7.16.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

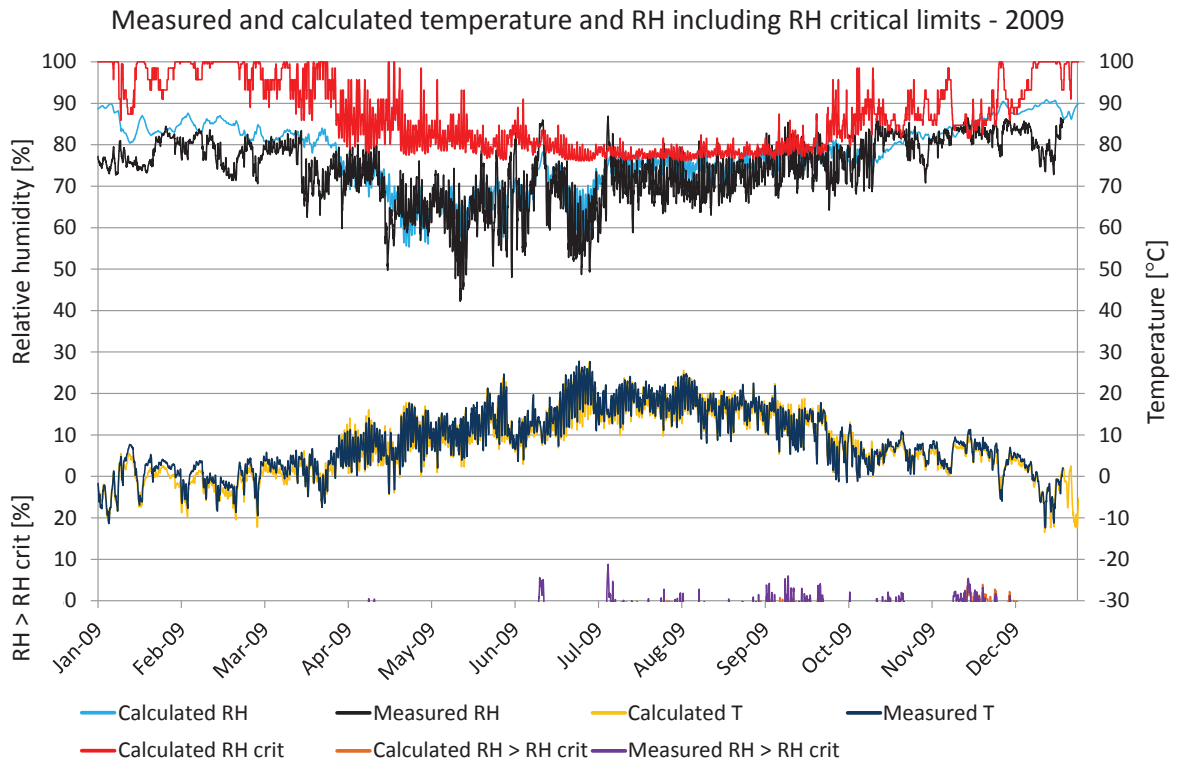


Figure 7.16.7. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

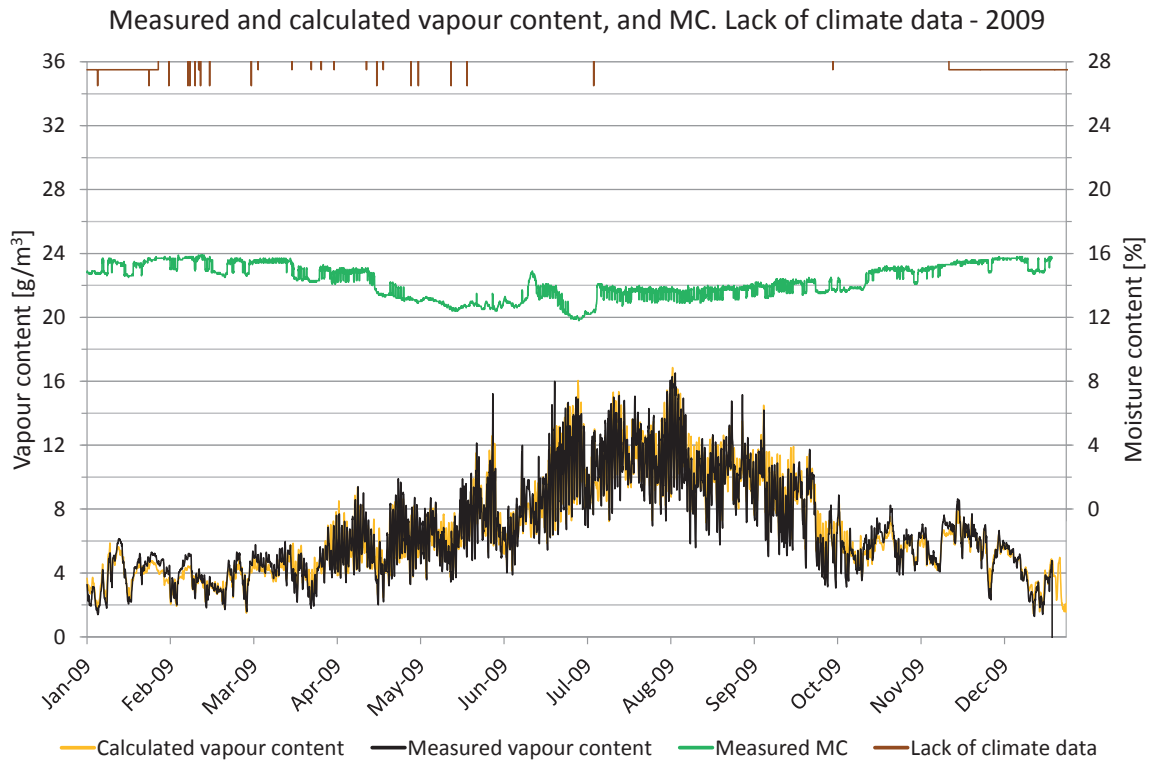


Figure 7.16.8. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

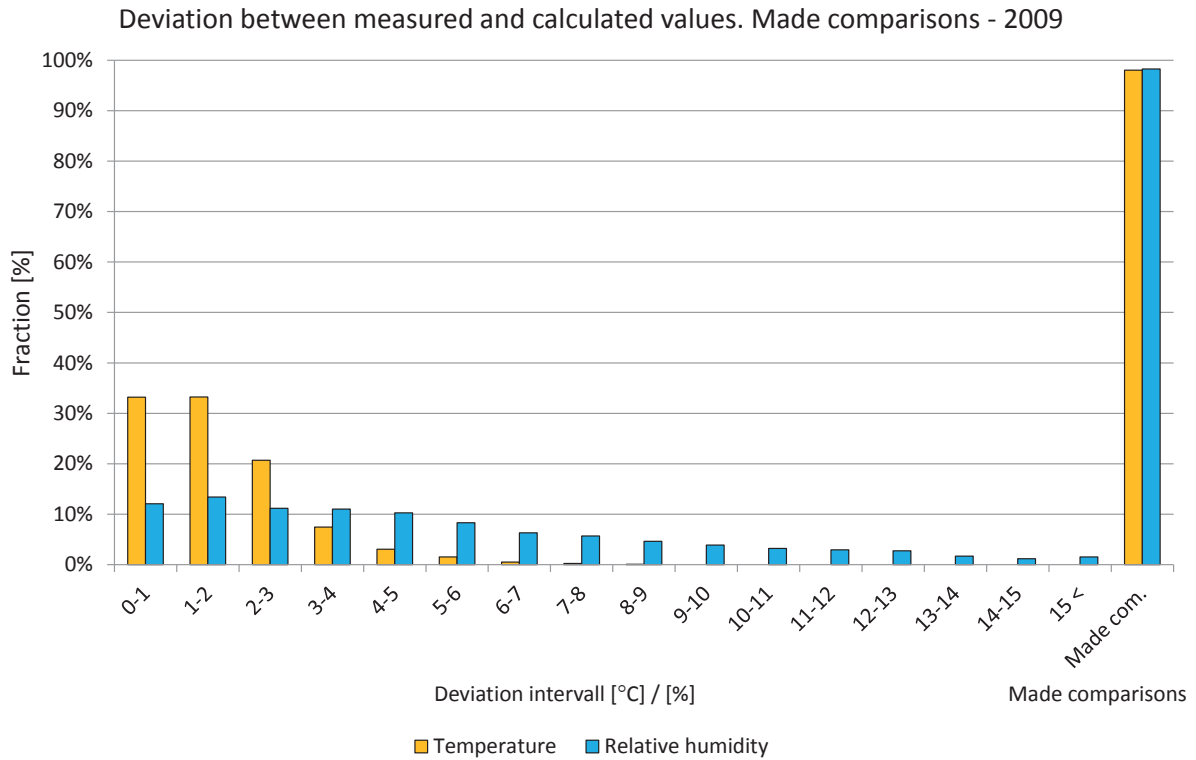


Figure 7.16.9. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

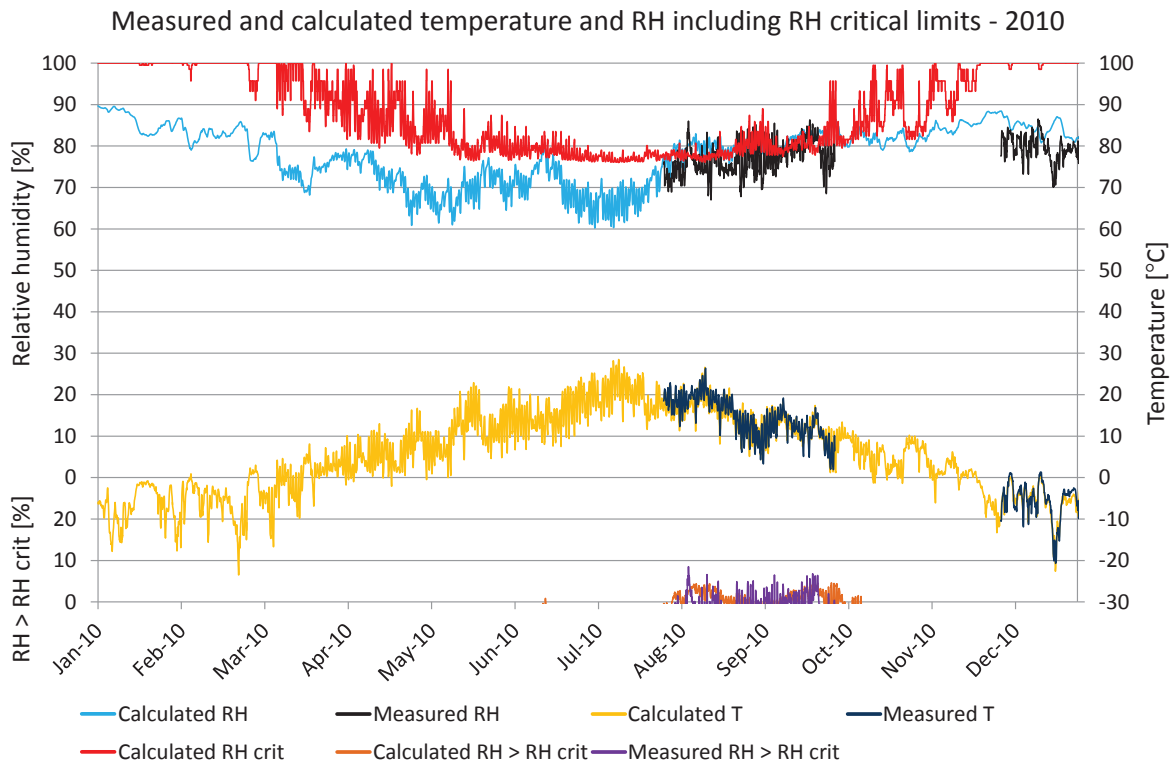


Figure 7.16.10. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

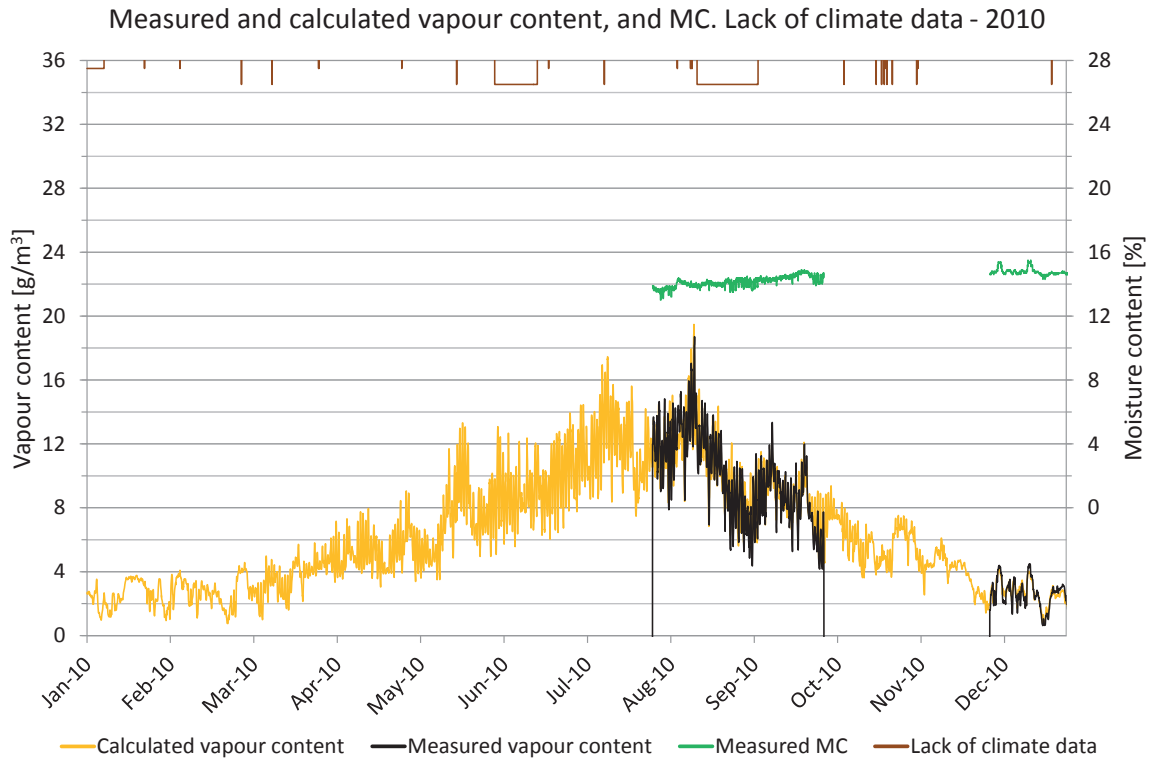


Figure 7.16.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

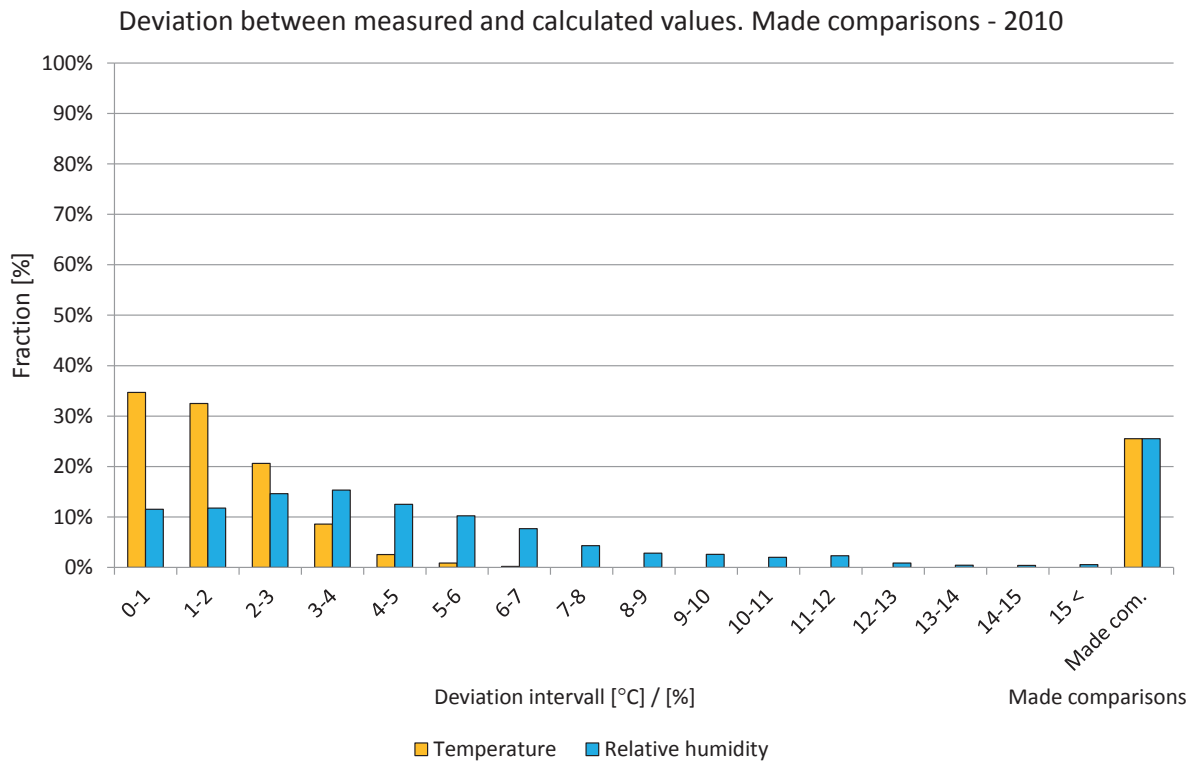


Figure 7.16.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

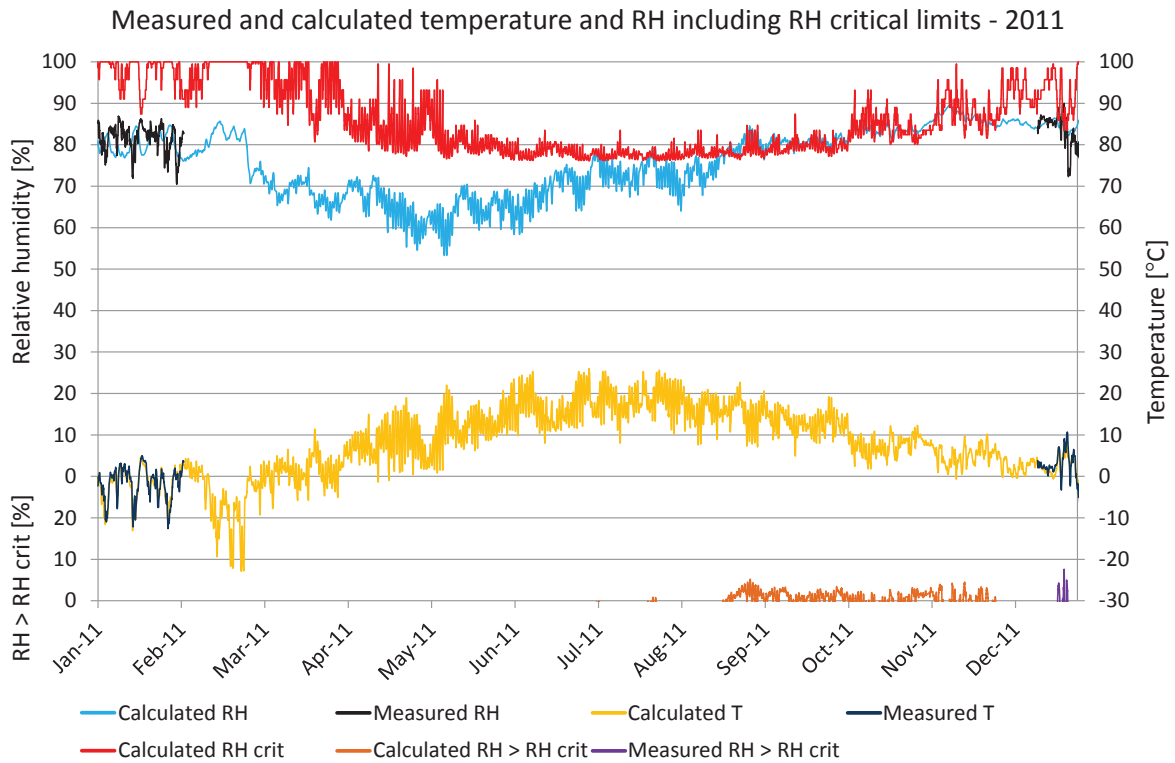


Figure 7.16.13. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

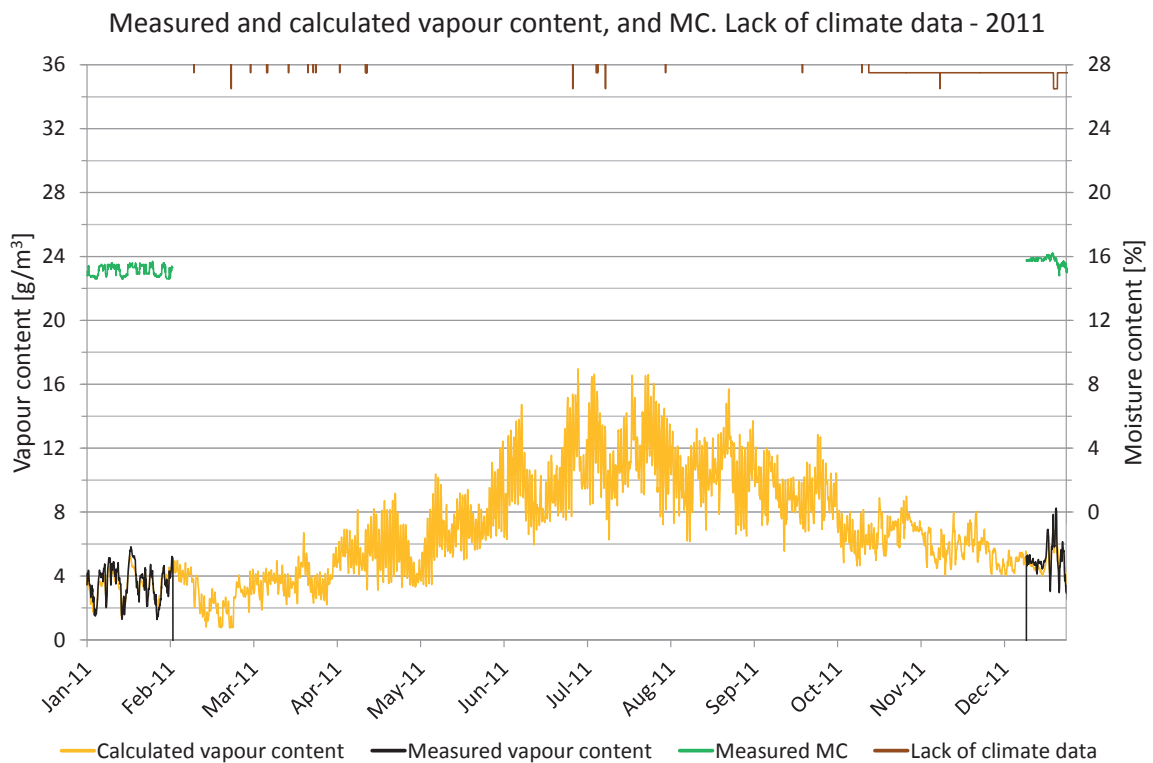


Figure 7.16.14. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

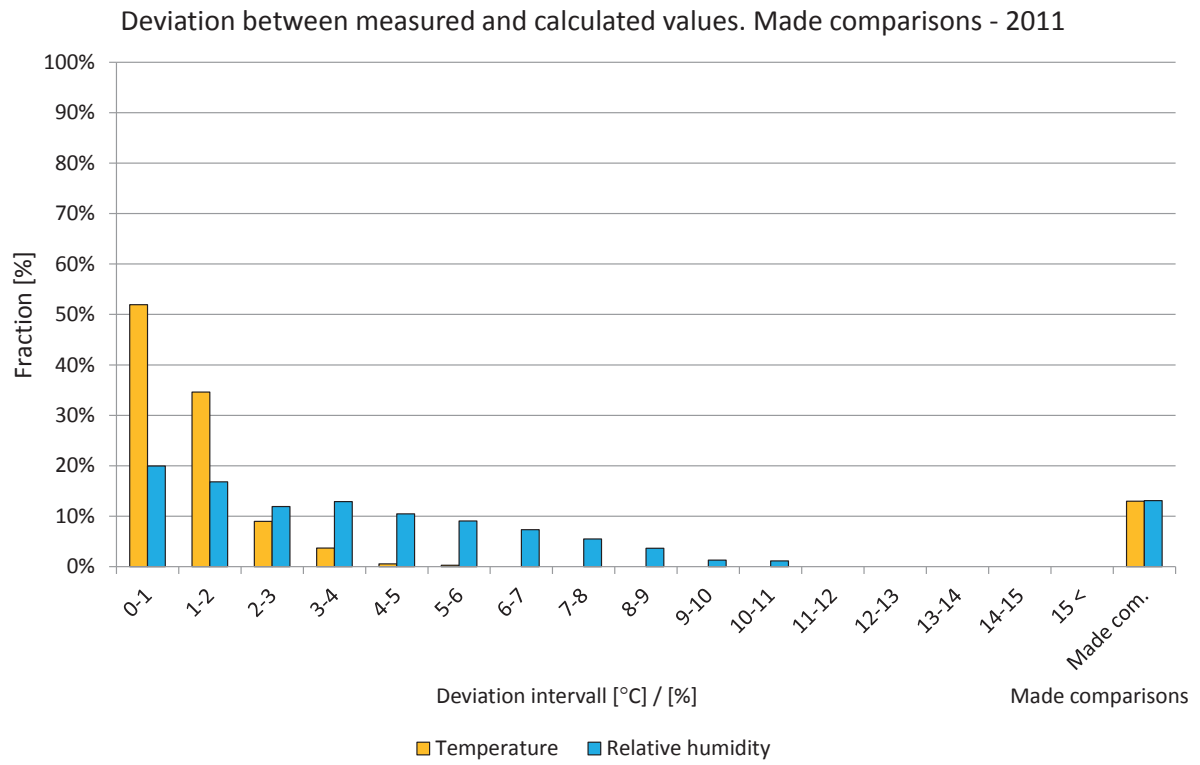


Figure 7.16.15. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.19 Position 19

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

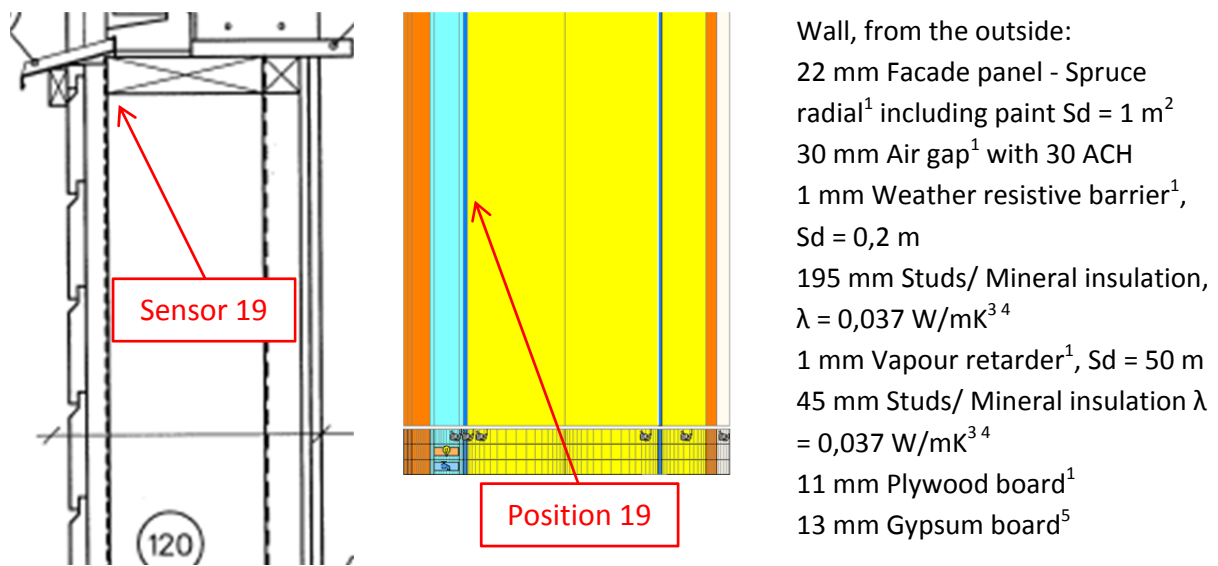


Figure 7.19.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.19.2. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.19.3. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.19.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

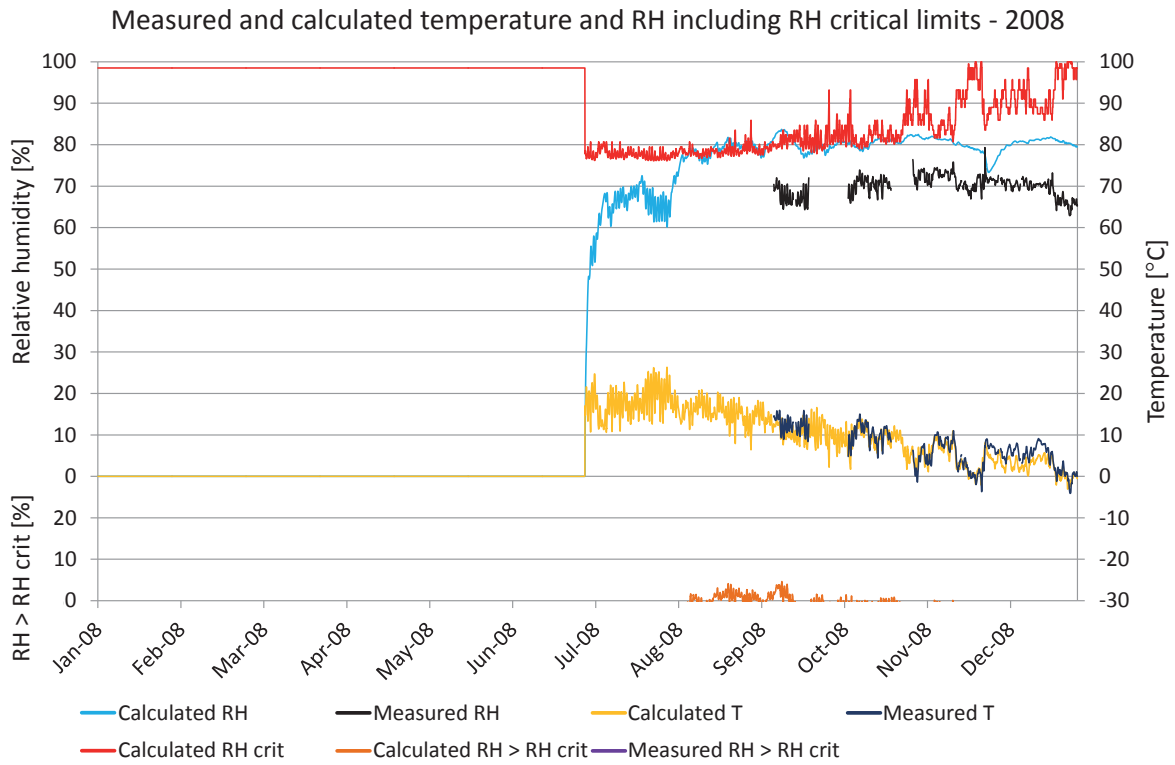


Figure 7.19.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

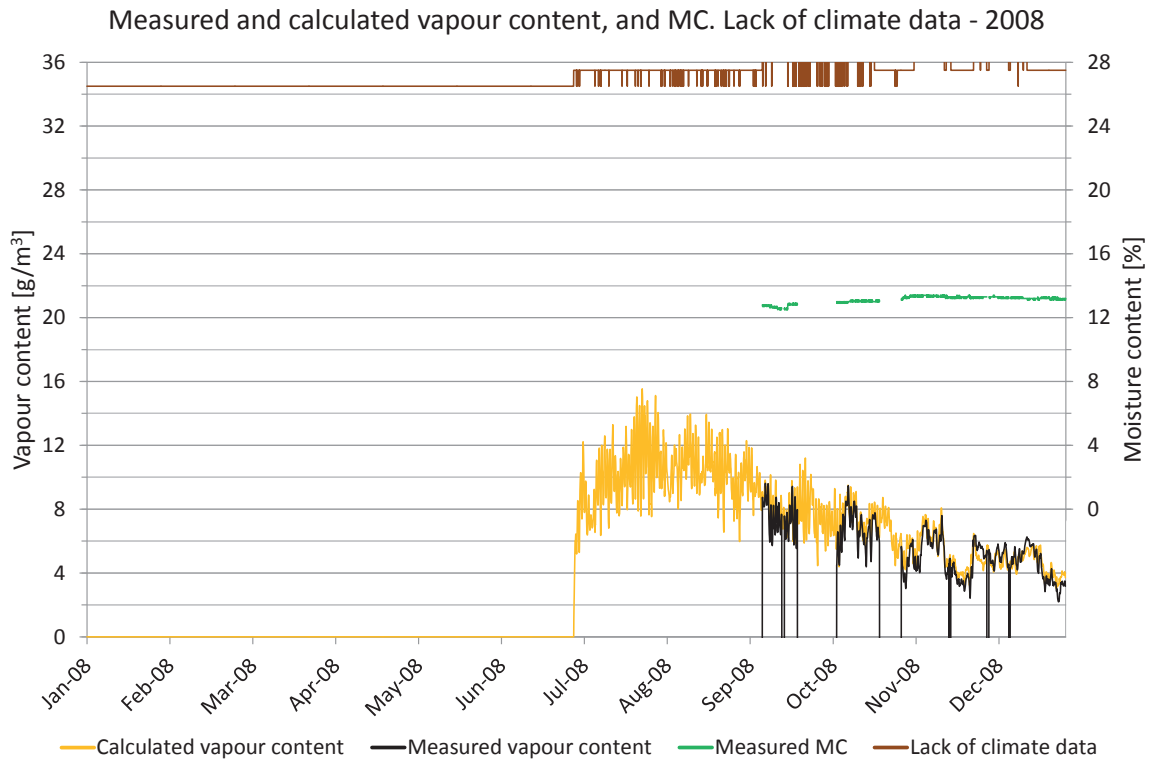


Figure 7.19.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

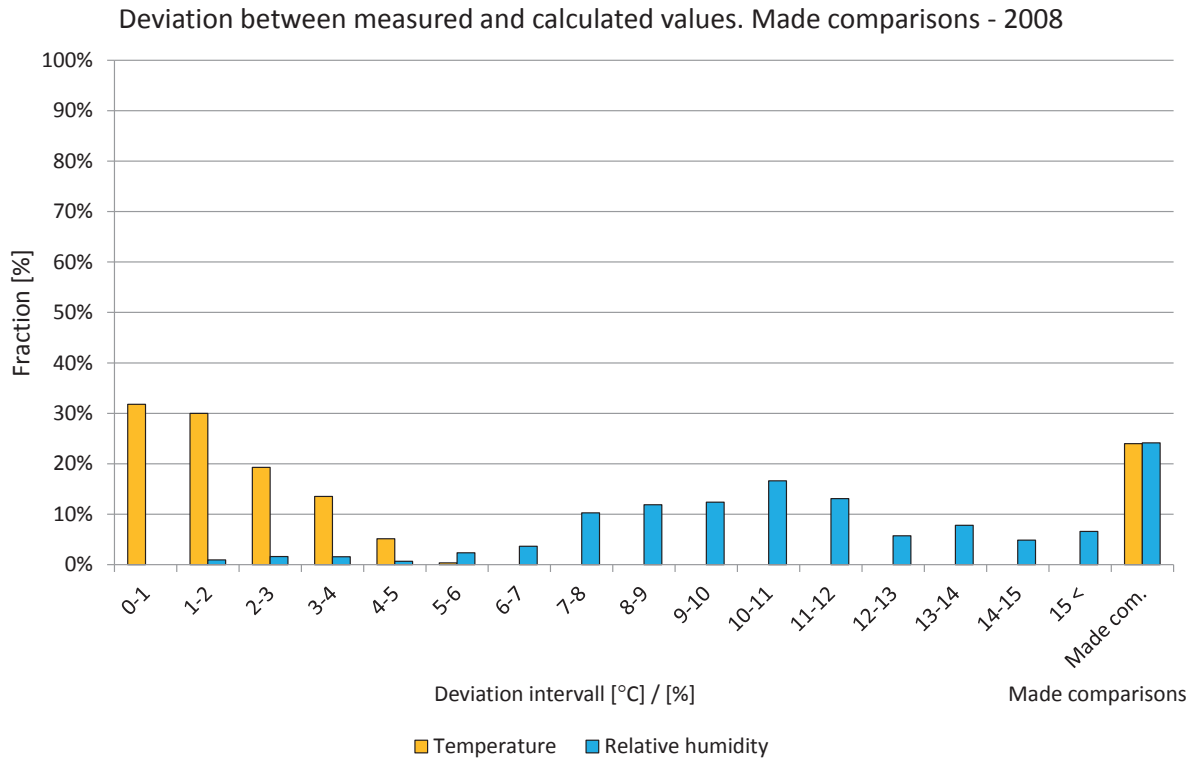


Figure 7.19.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

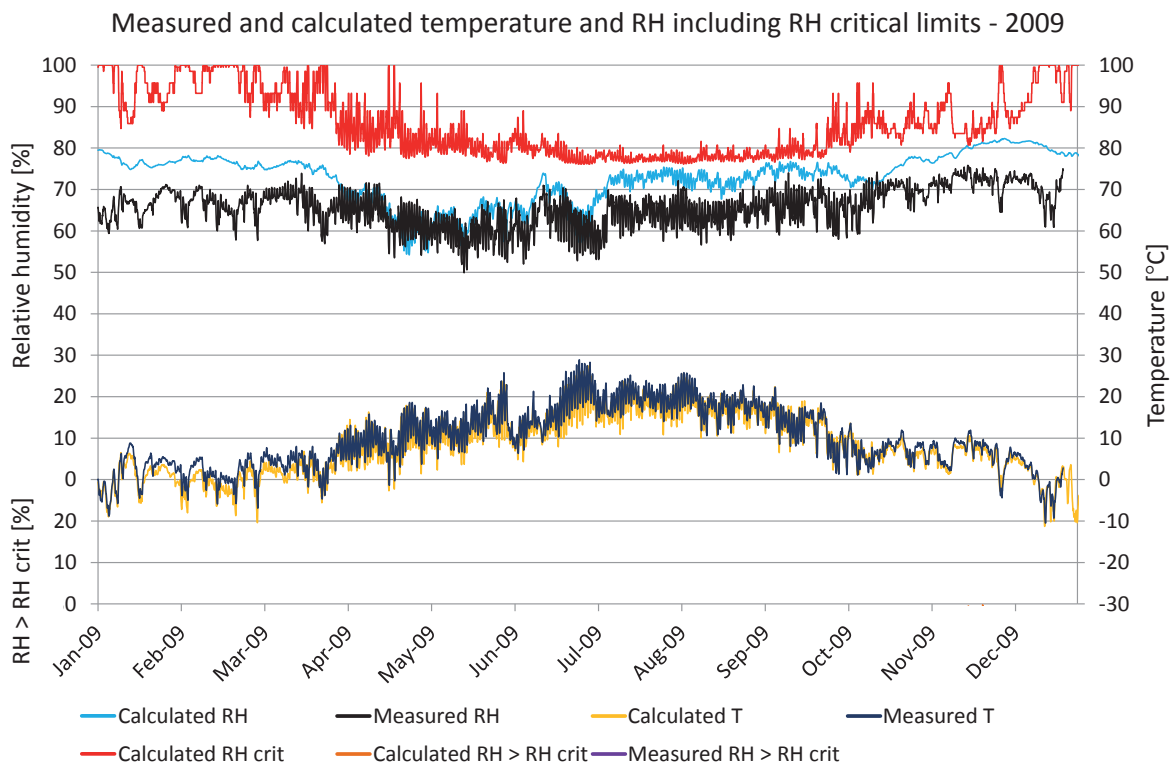


Figure 7.19.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

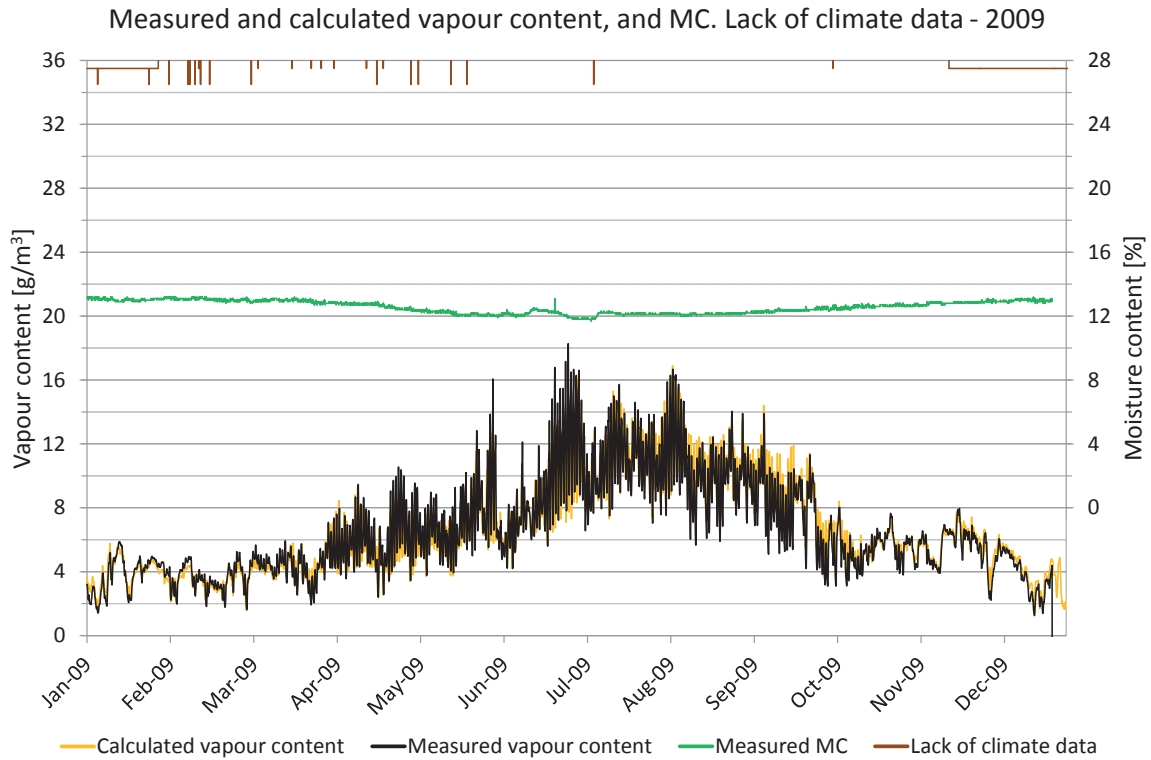


Figure 7.19.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

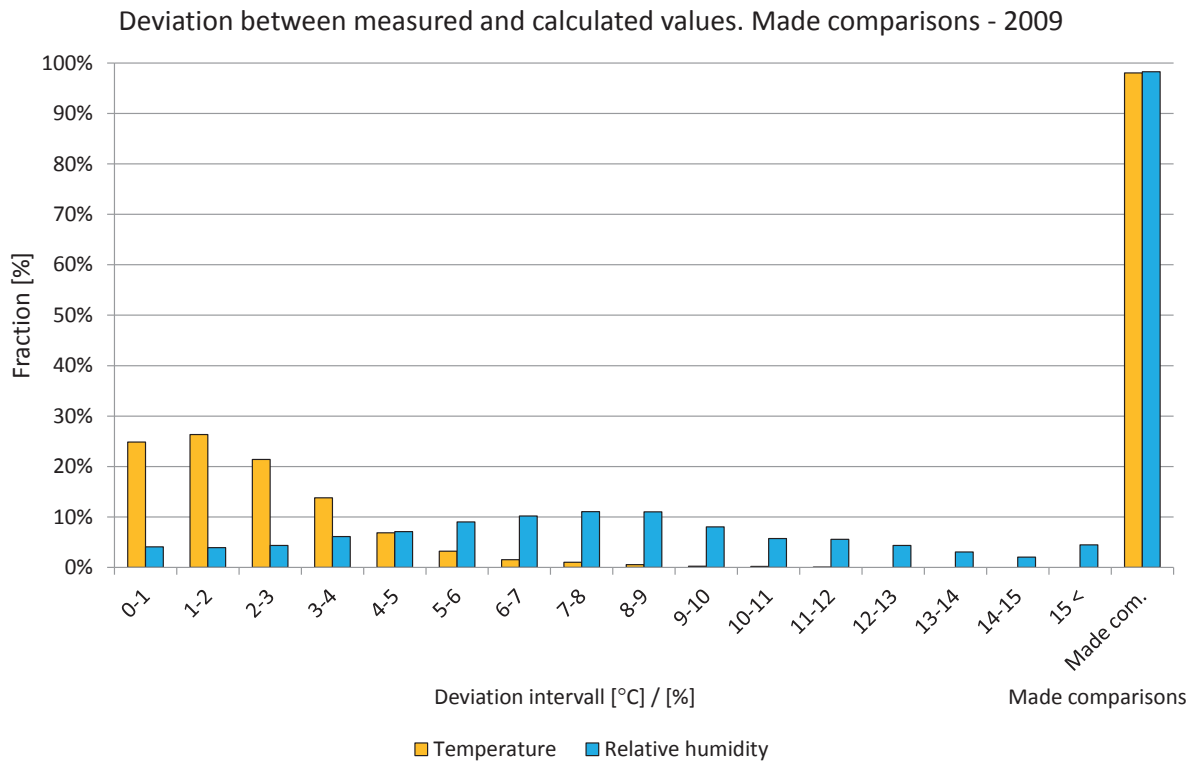


Figure 7.19.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

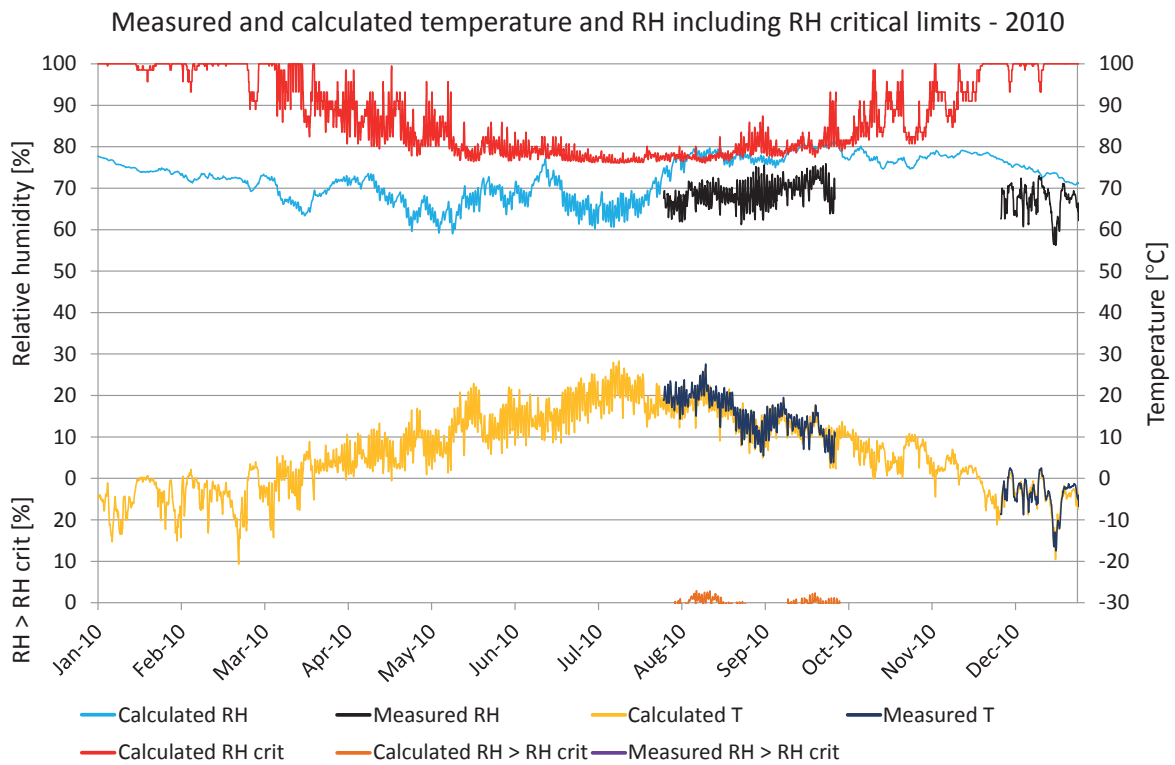


Figure 7.19.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

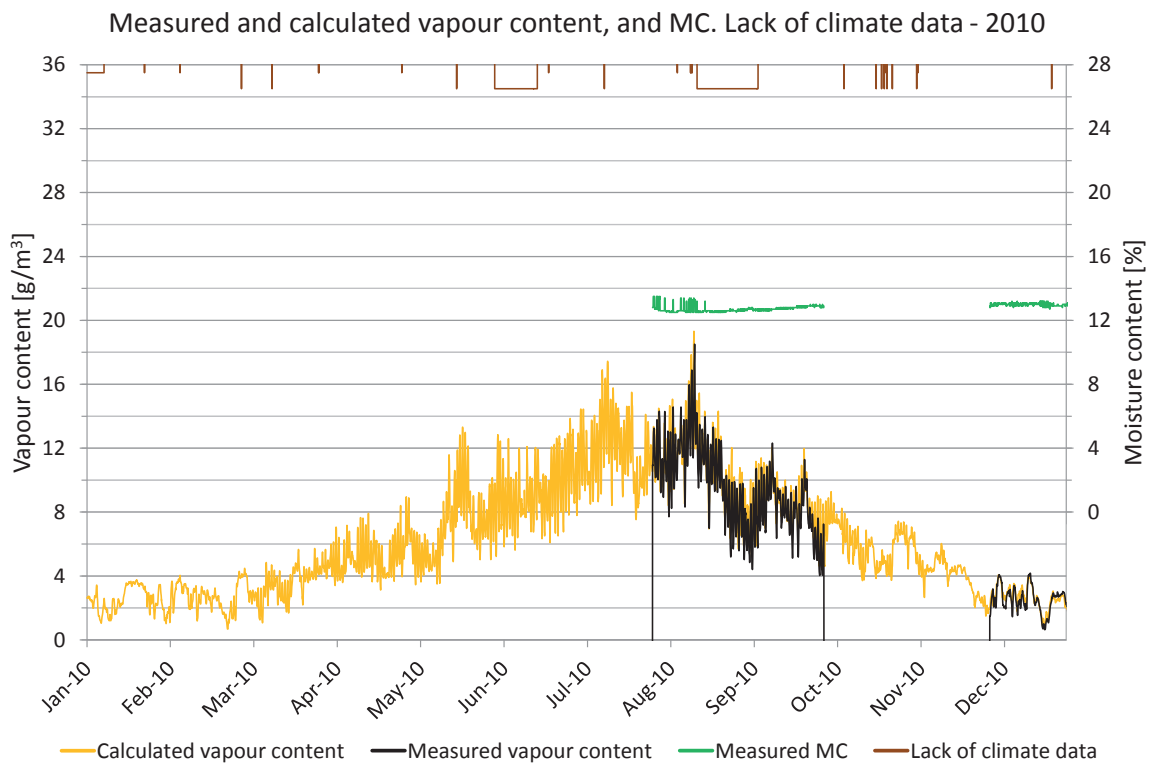


Figure 7.19.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

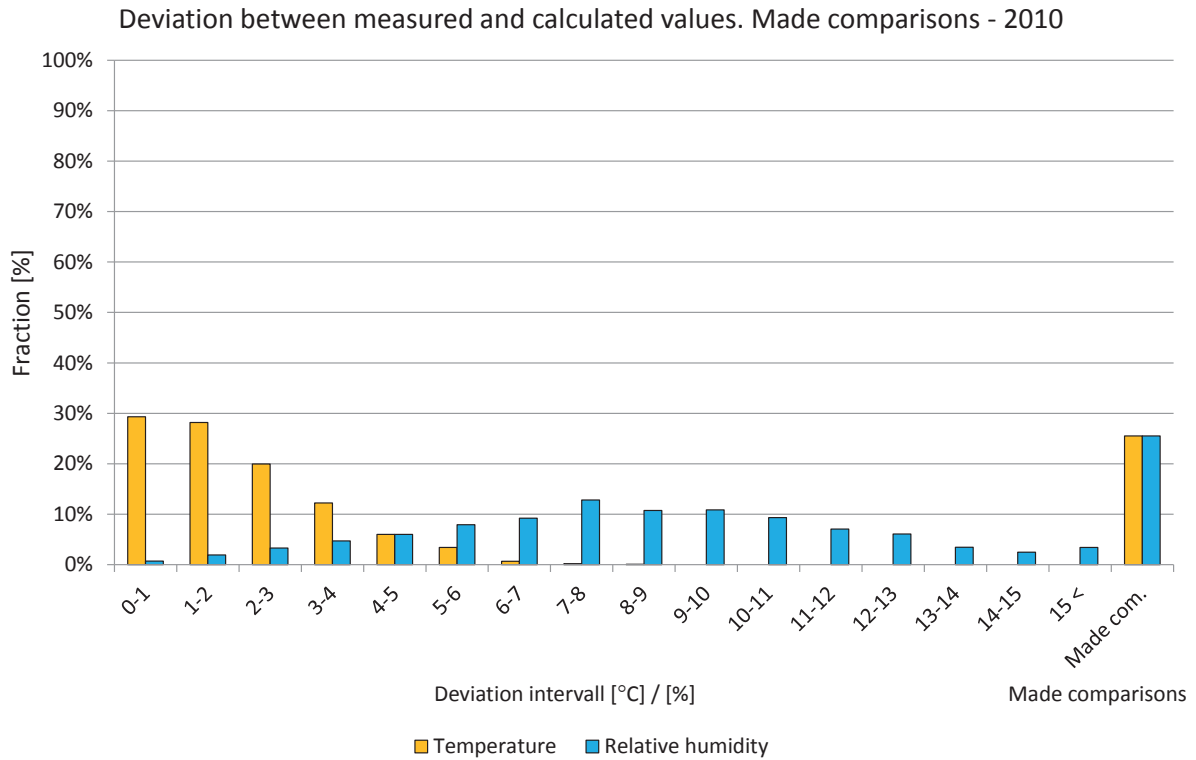


Figure 7.19.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

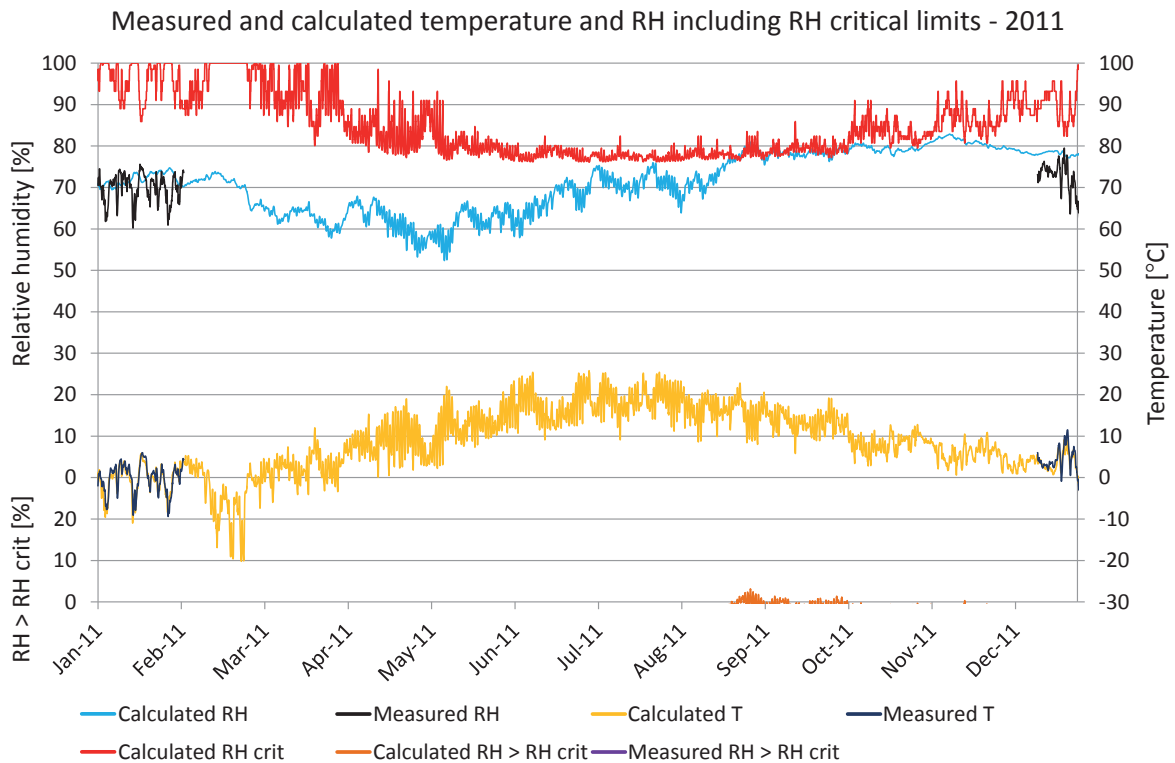


Figure 7.19.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

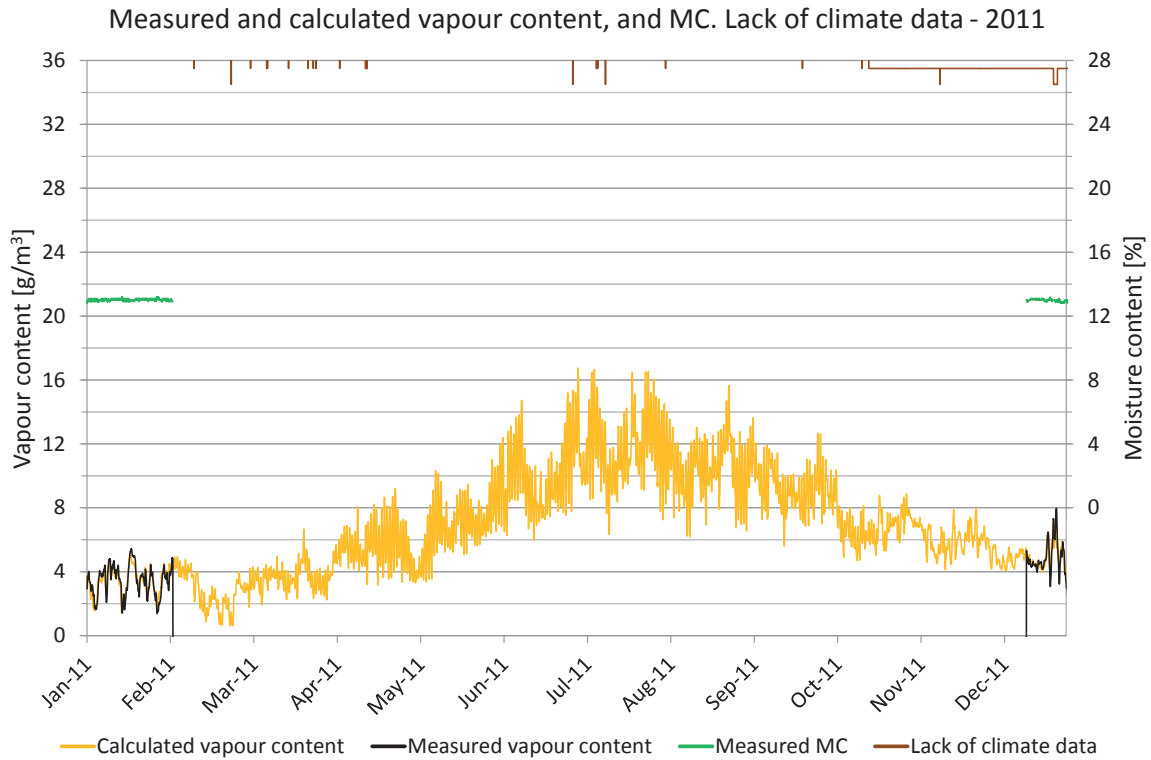


Figure 7.19.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

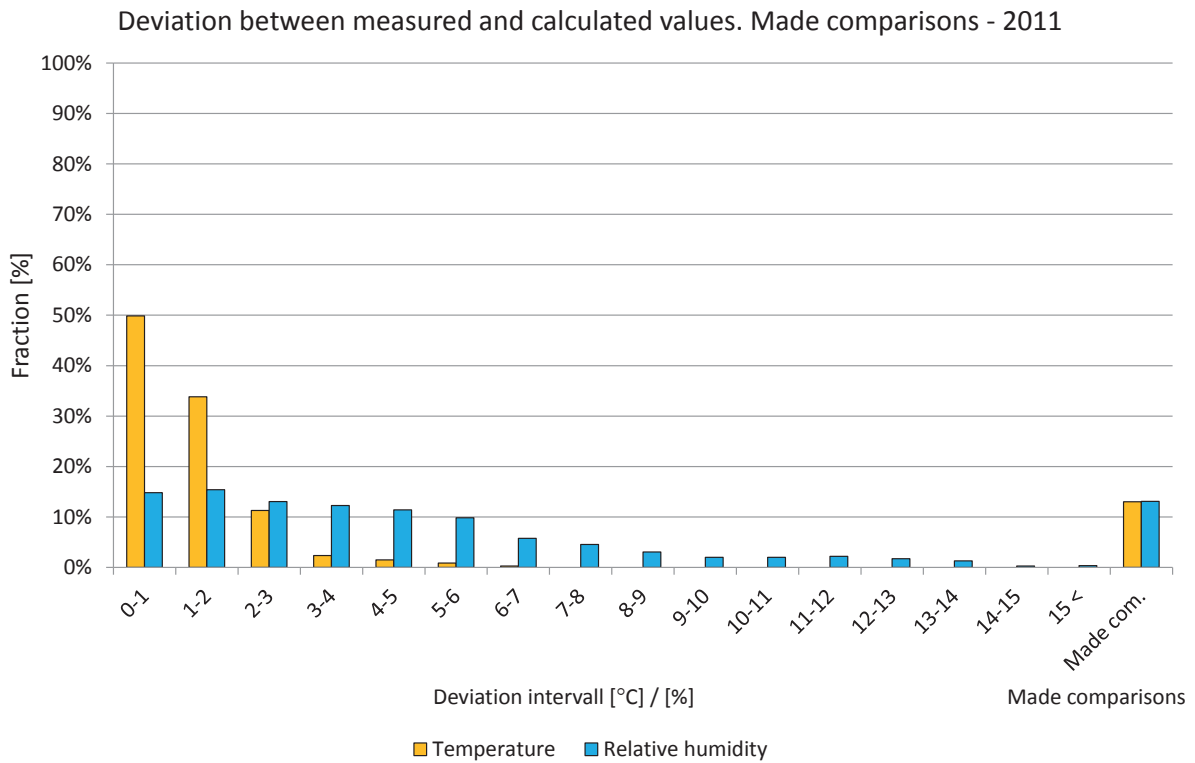


Figure 7.19.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7 Results

7.22 Position 22

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor. Unfortunately there was a complete lack of measured data during 2010 and 2011. This means that only calculated data are shown for 2010 and 2011 and no charts presenting deviation between measured and calculated values are presented.

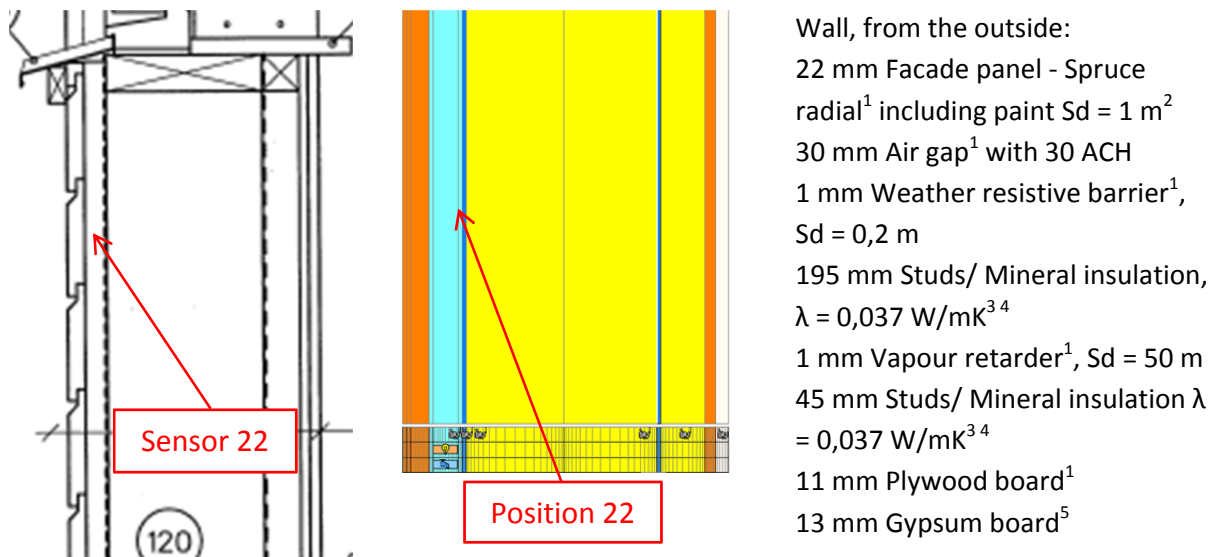


Figure 7.22.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.22.2. Location of the studied position. Photo: SP Trä Skellefteå.

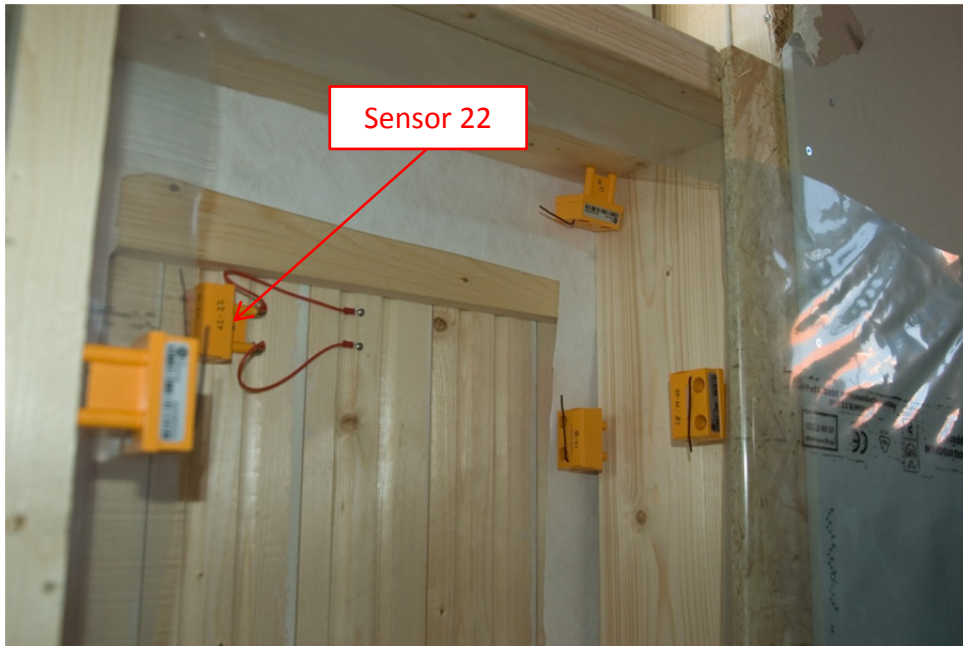


Figure 7.22.3. Location of the studied position. Photo: SP Trä Skellefteå.

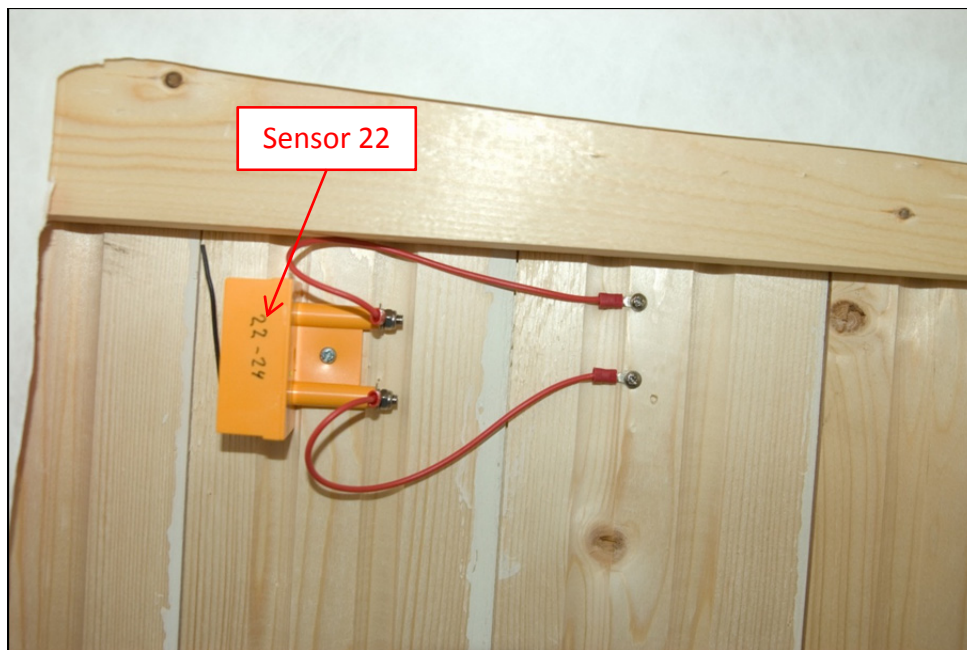


Figure 7.22.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

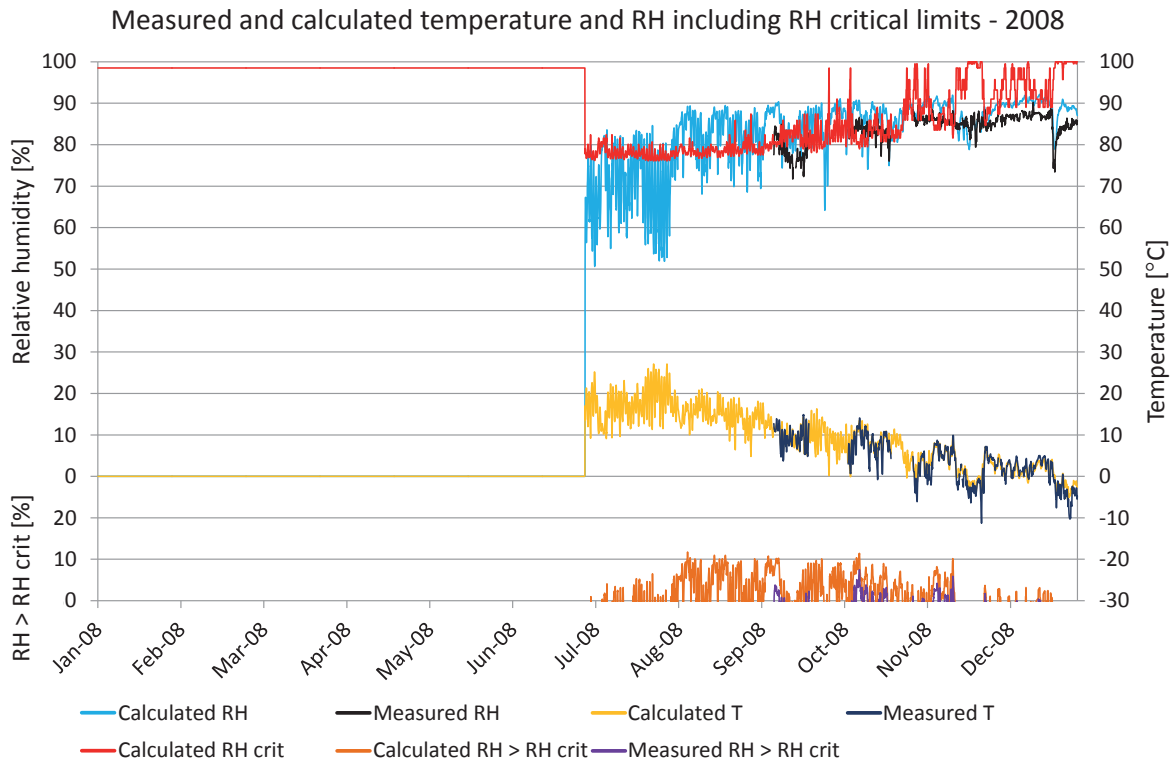


Figure 7.22.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

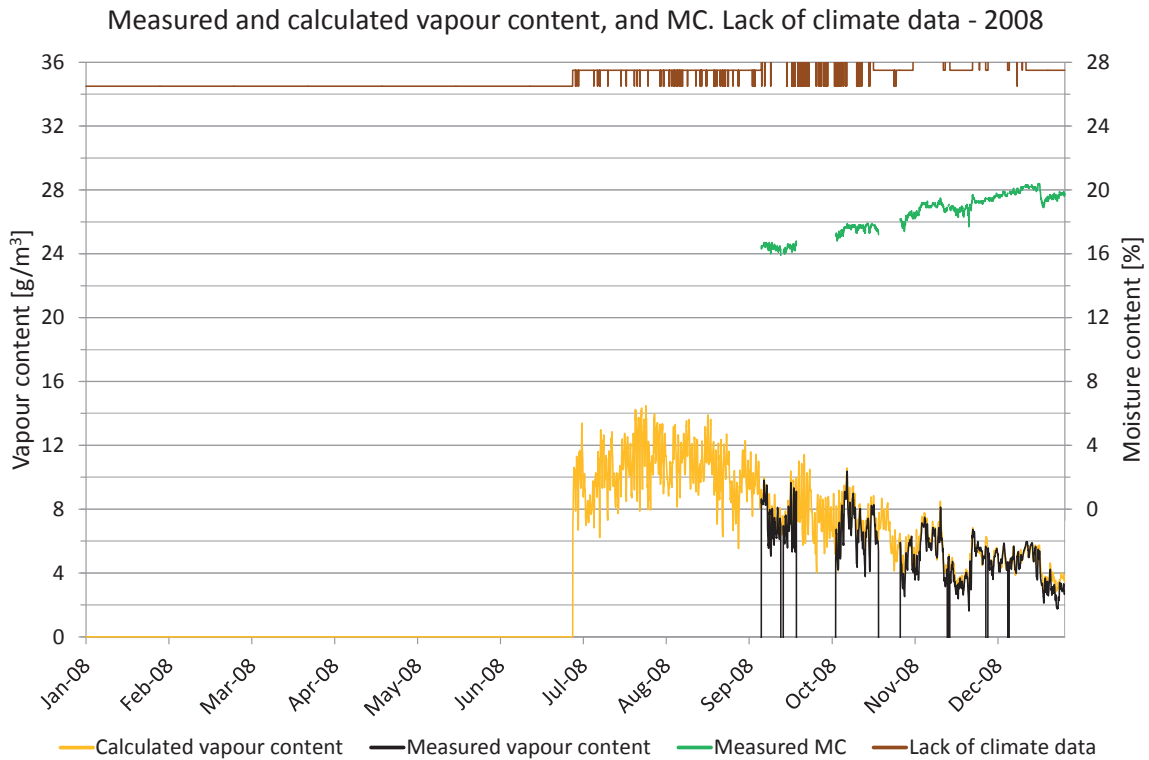


Figure 7.22.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

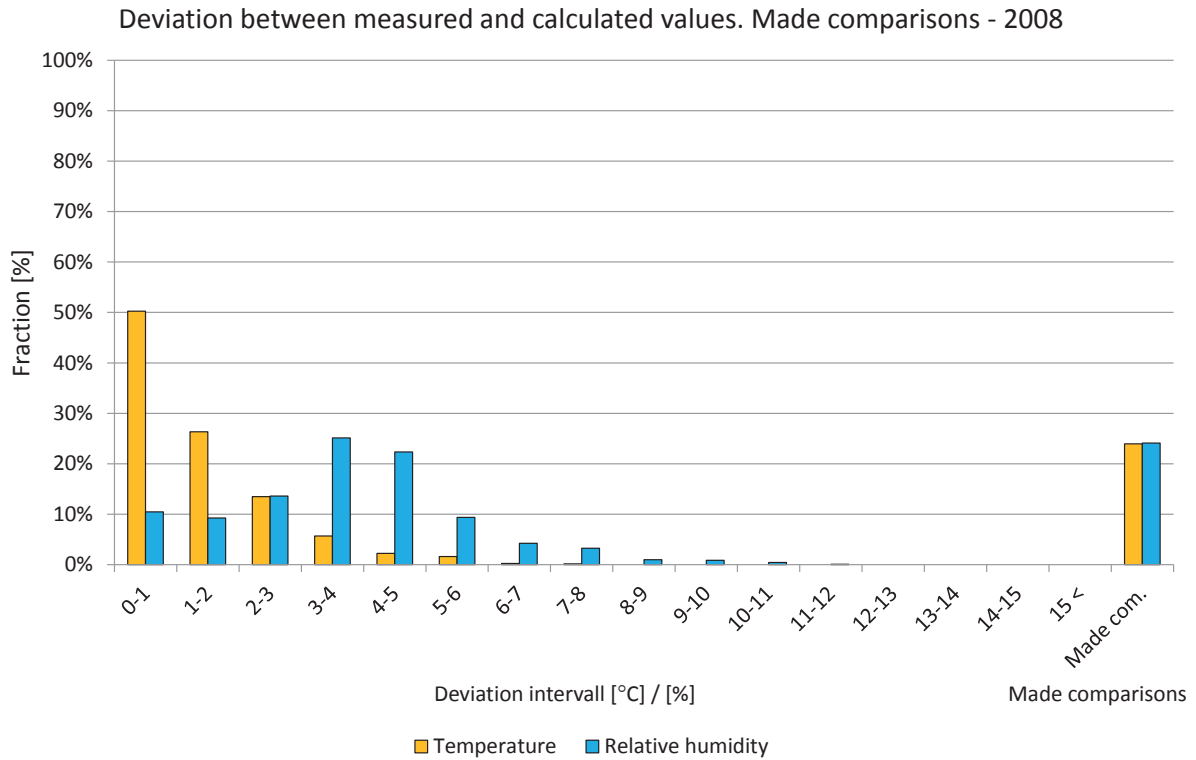


Figure 7.22.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

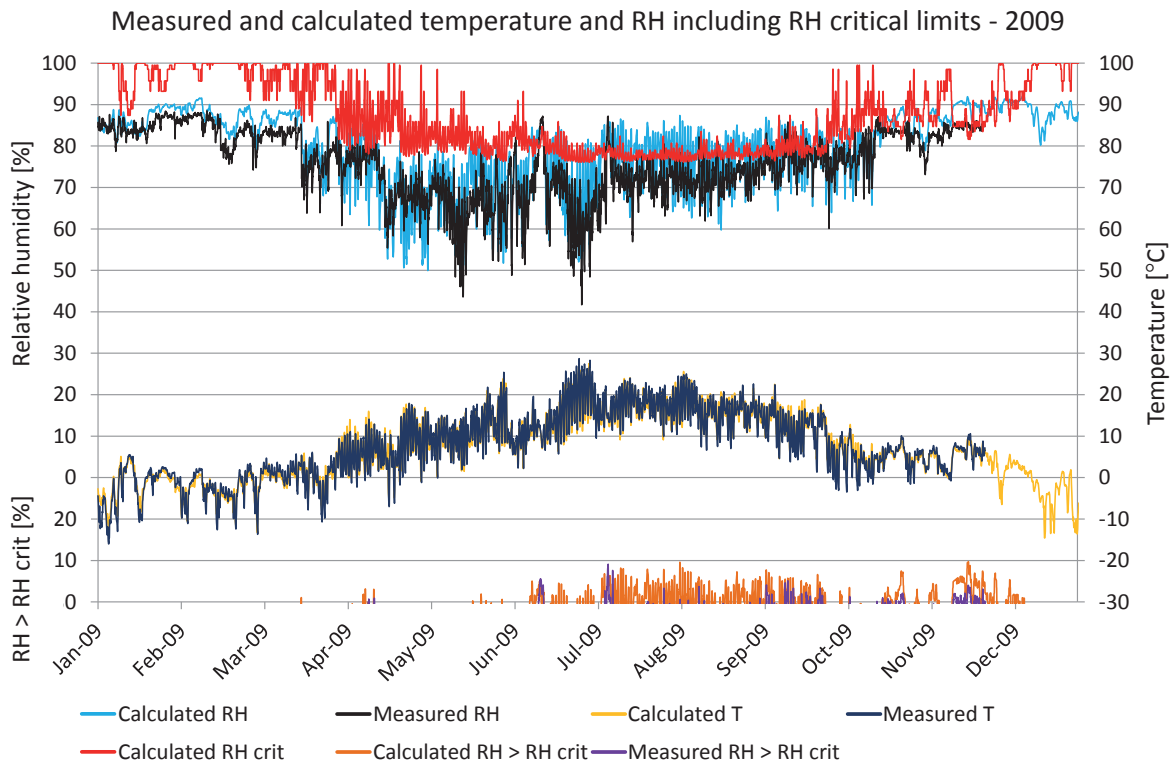


Figure 7.22.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

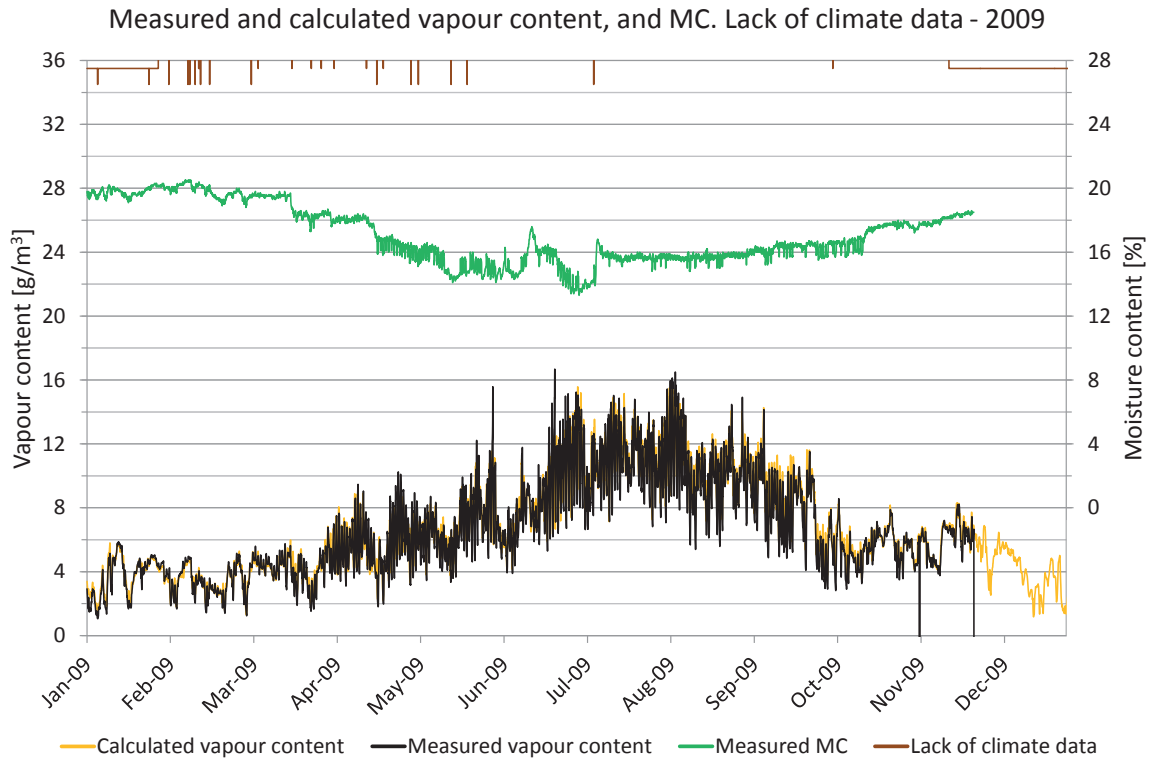


Figure 7.22.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

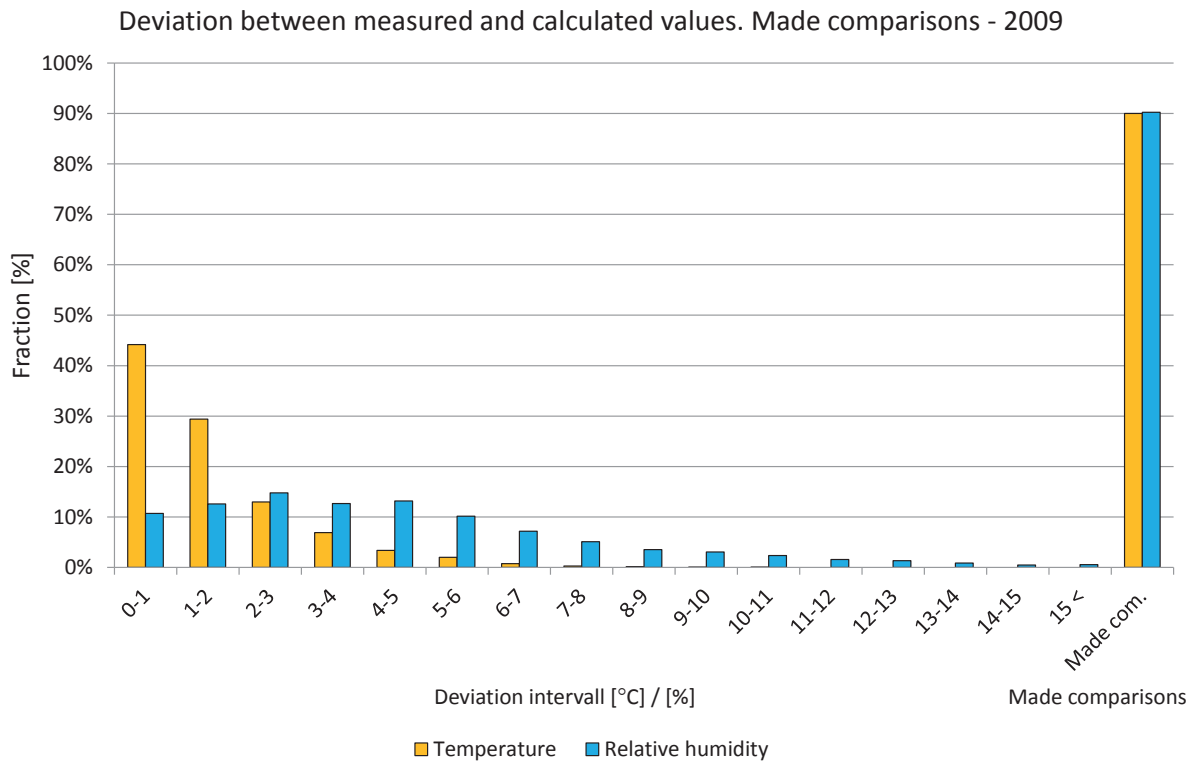


Figure 7.22.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

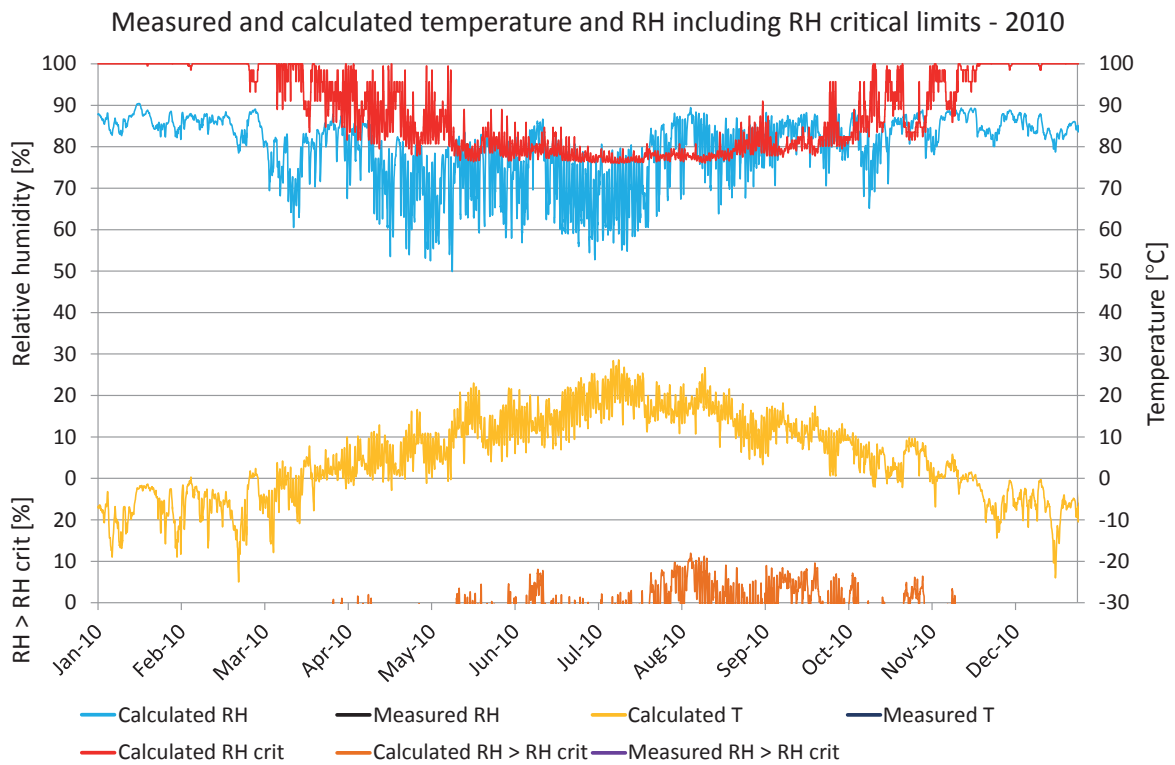


Figure 7.22.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

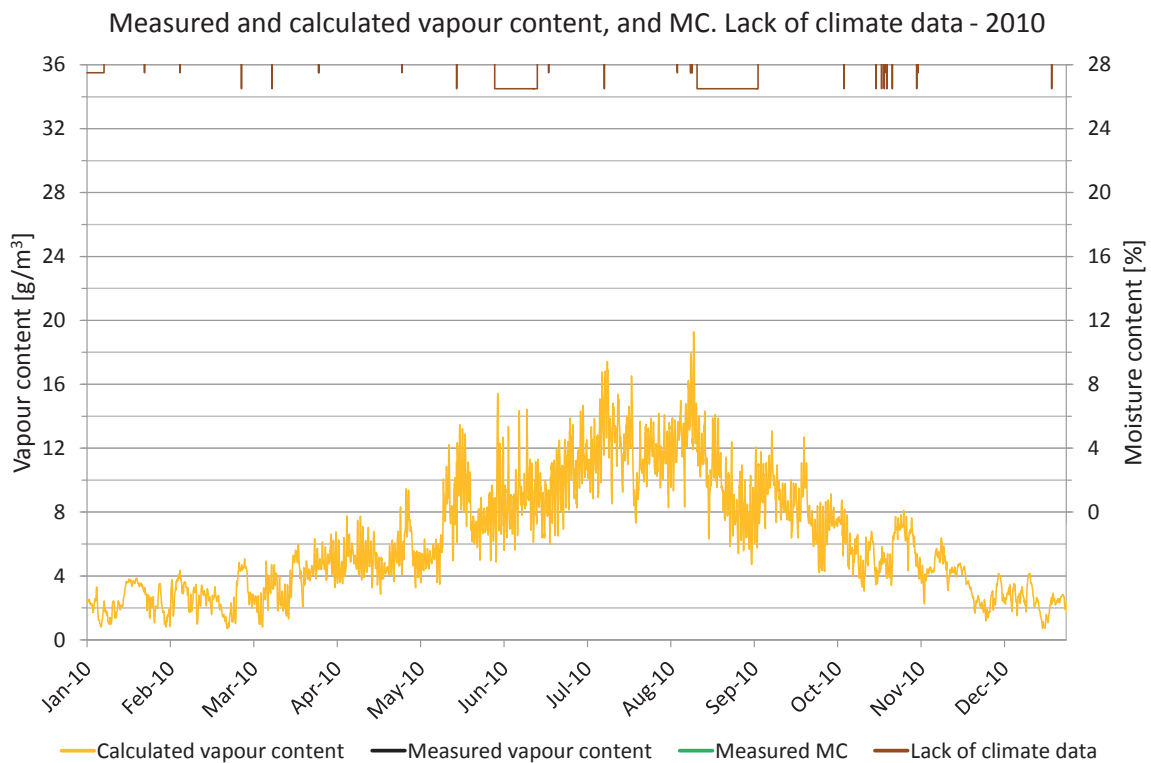


Figure 7.22.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

Year 2011

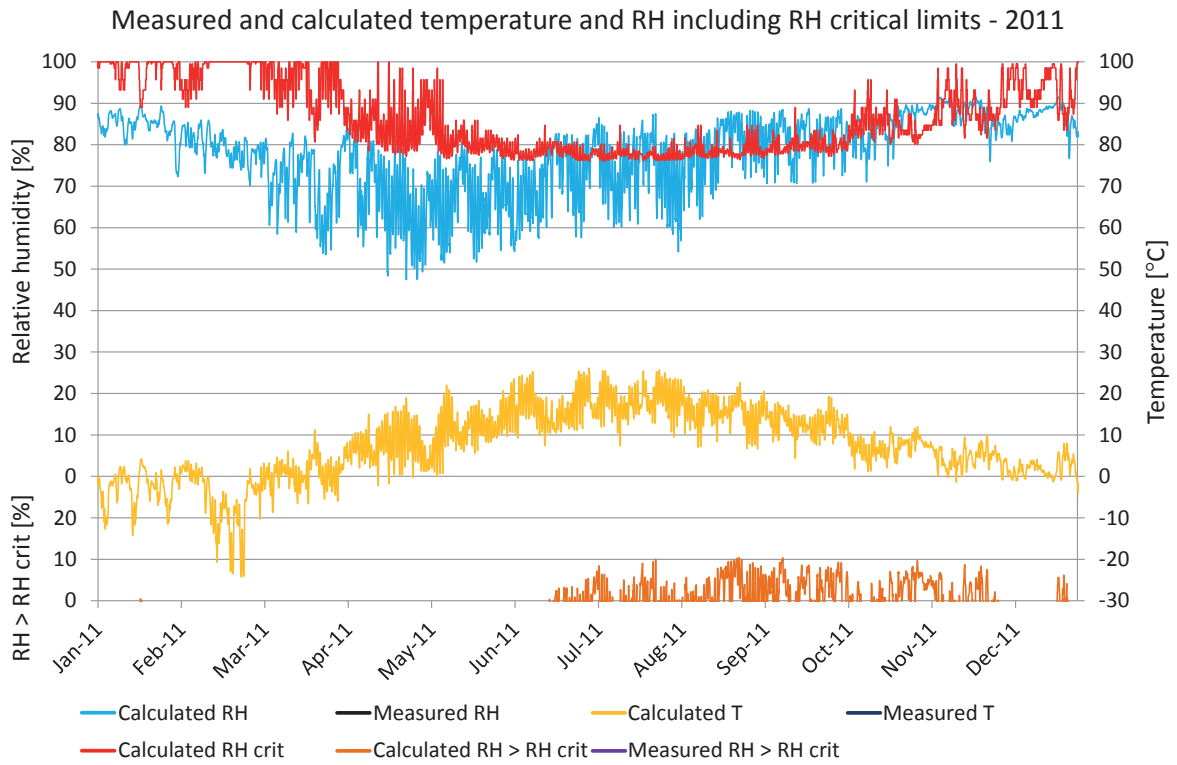


Figure 7.22.13. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

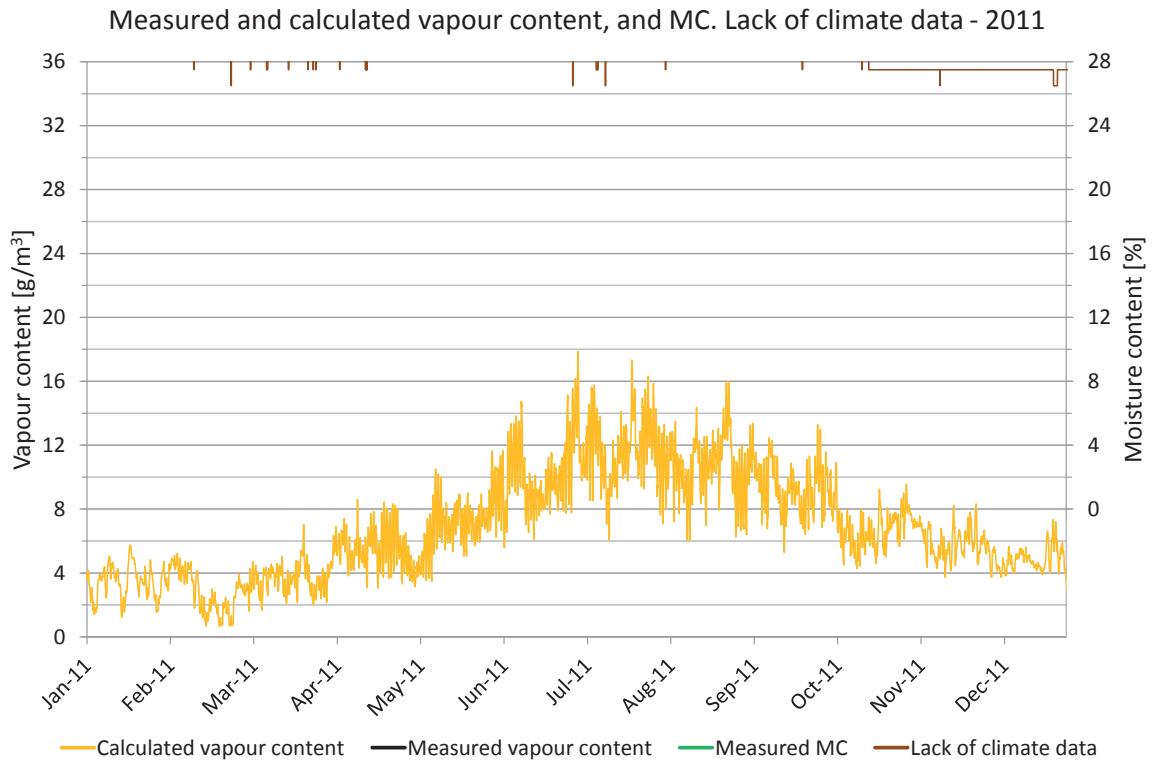


Figure 7.22.14. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

7.25 Position 25

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

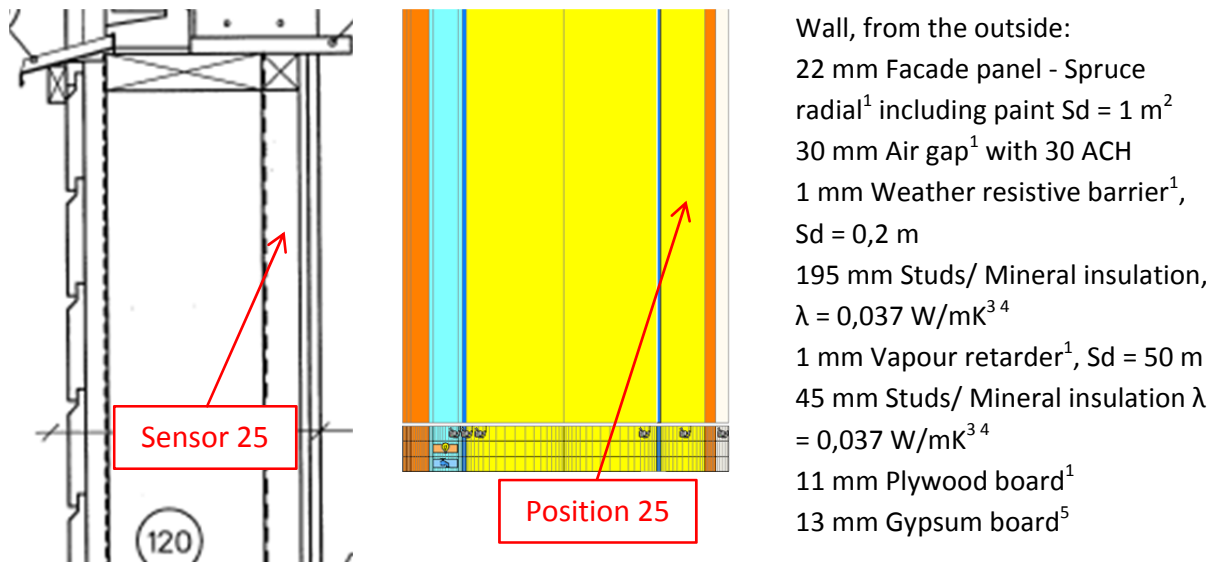


Figure 7.25.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.25.2. Location of the studied position. Photo: SP Trä Skellefteå.

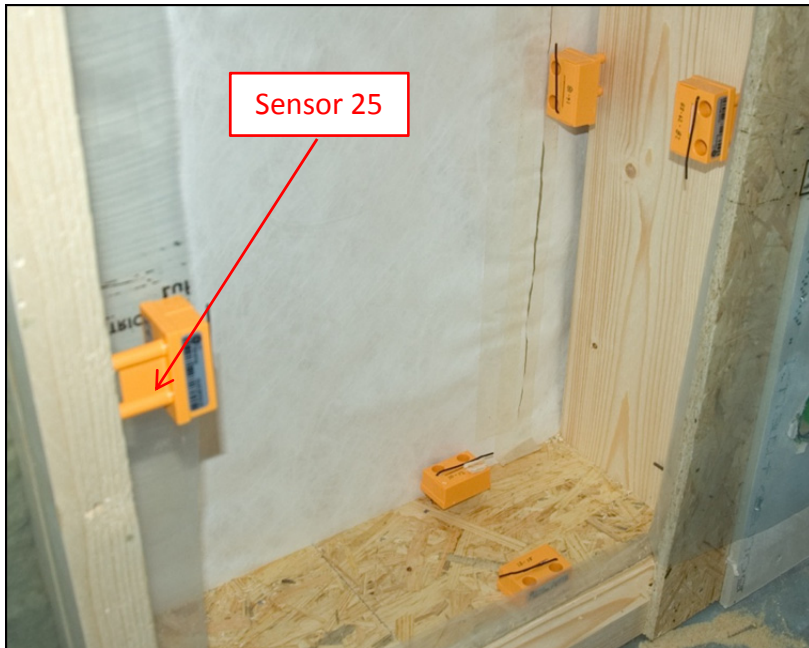


Figure 7.25.3. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.25.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

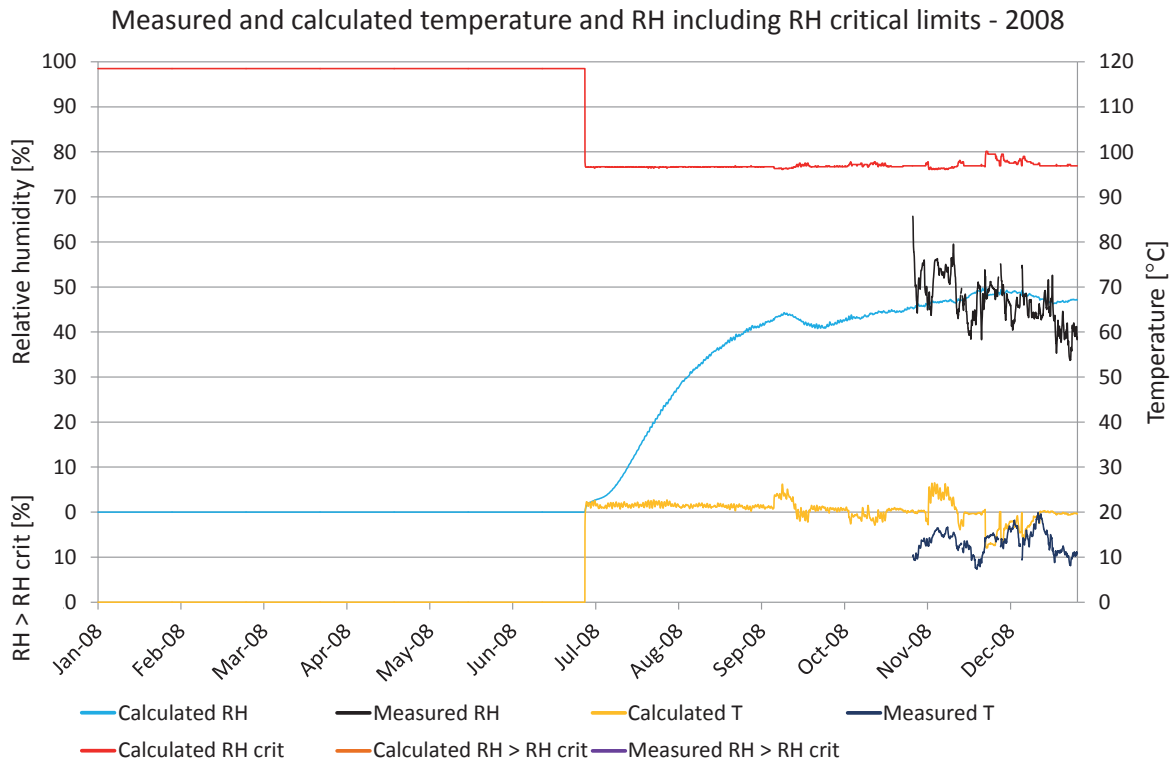


Figure 7.25.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

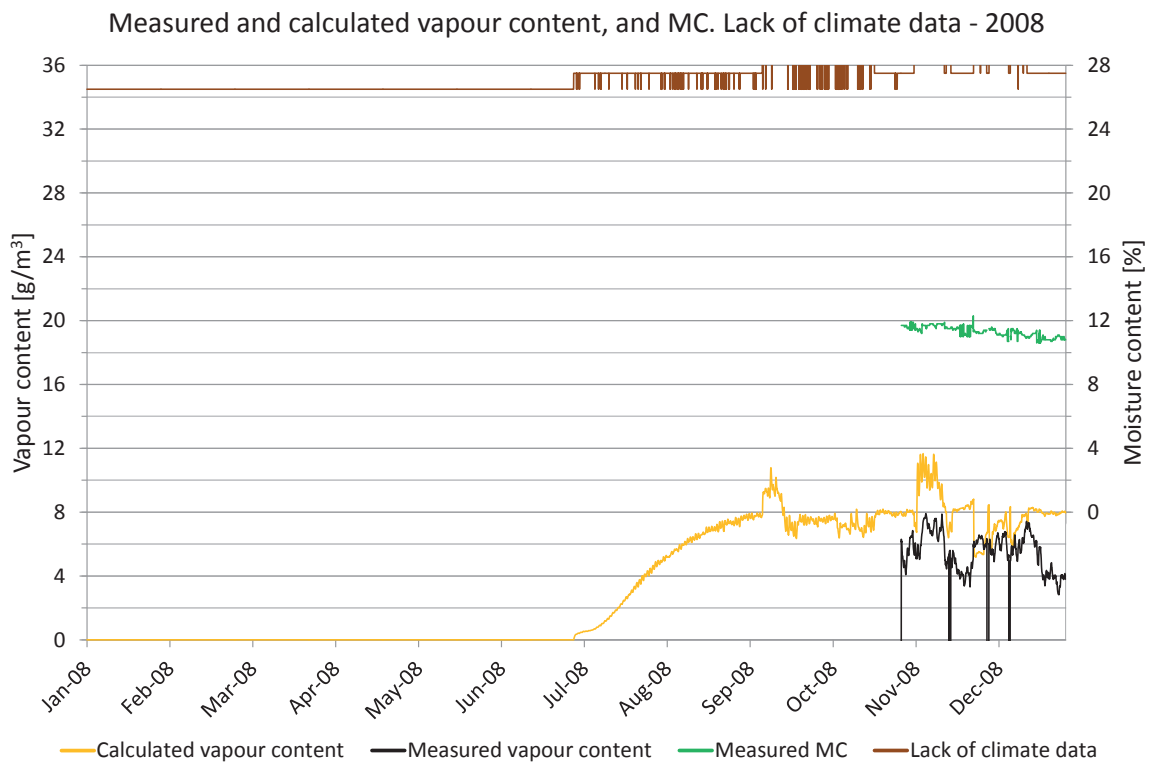


Figure 7.25.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

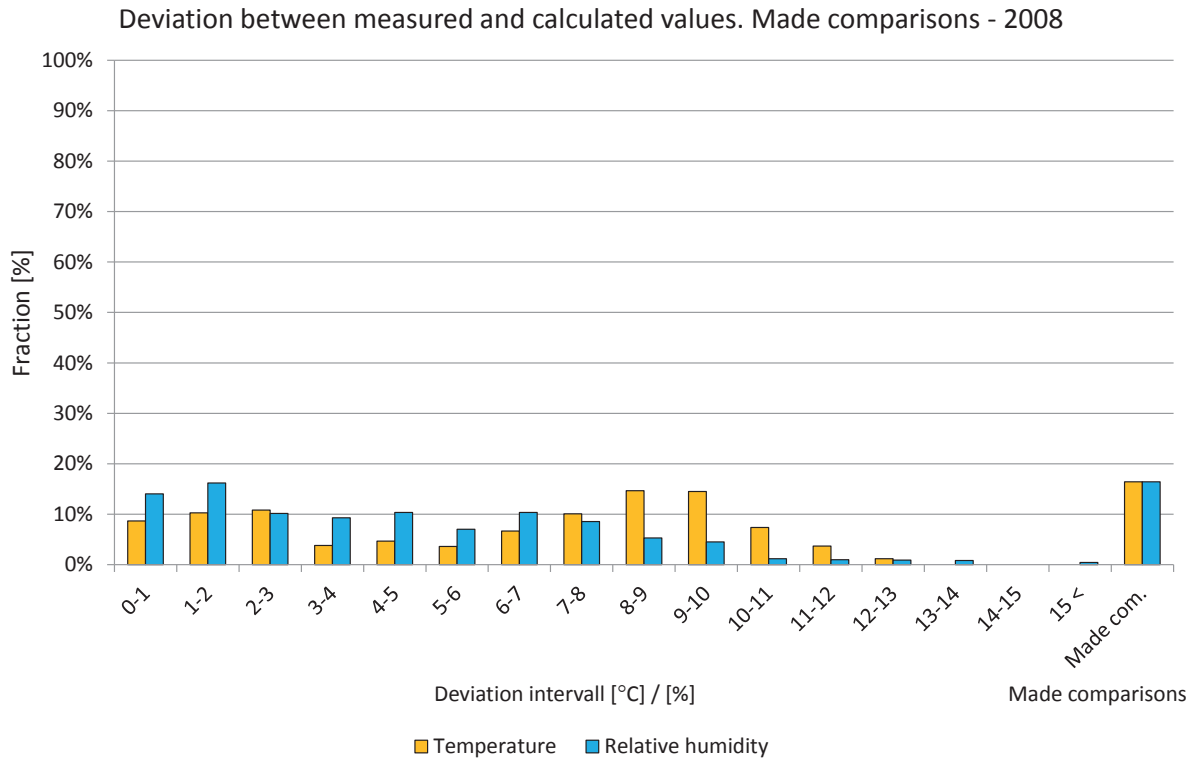


Figure 7.25.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

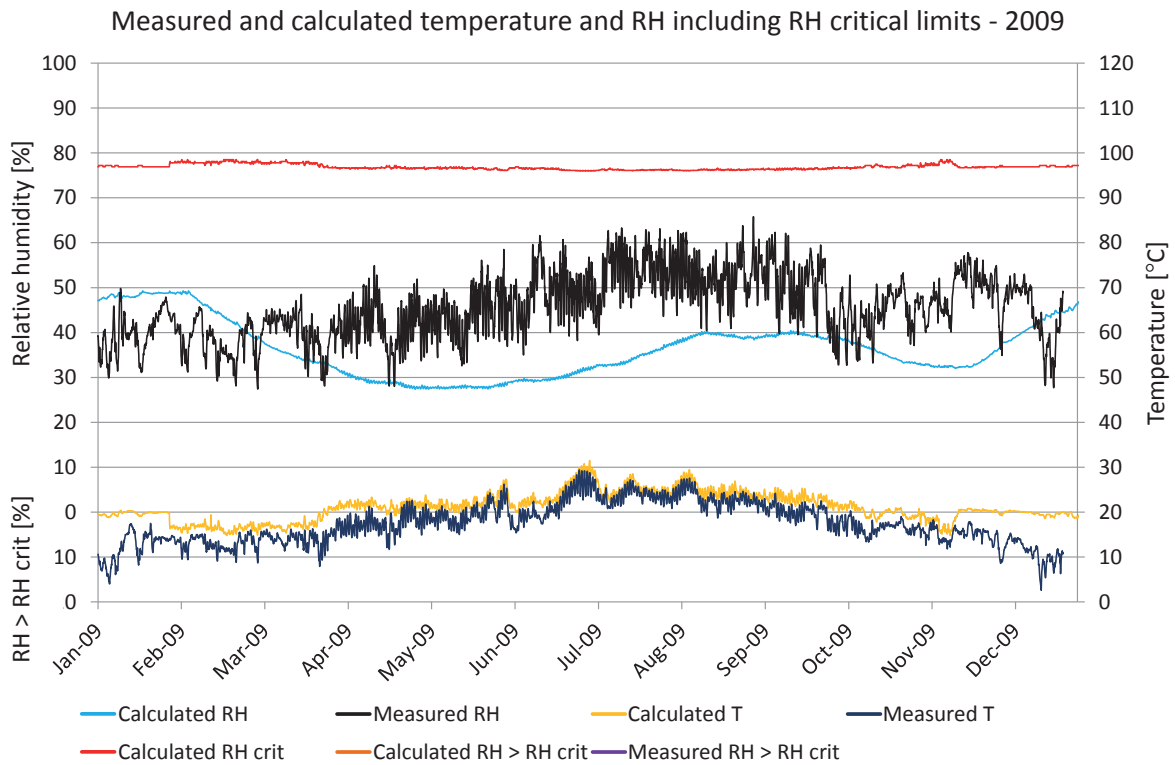


Figure 7.25.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

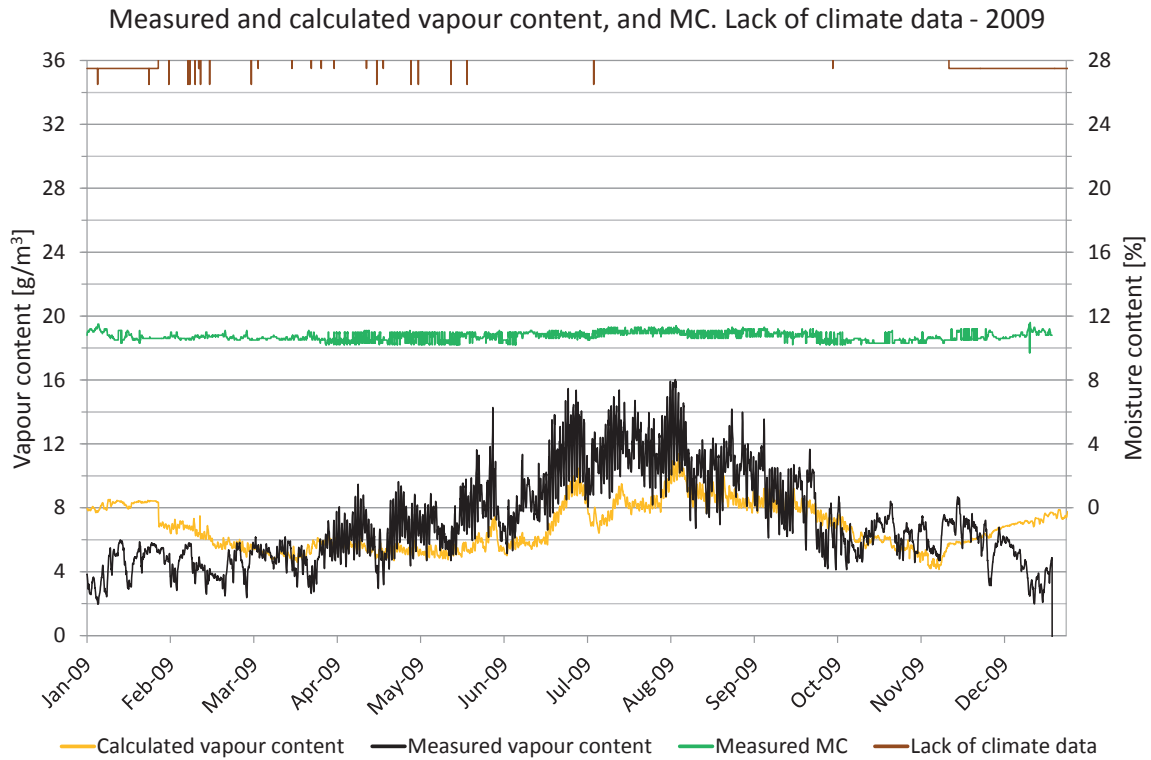


Figure 7.25.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

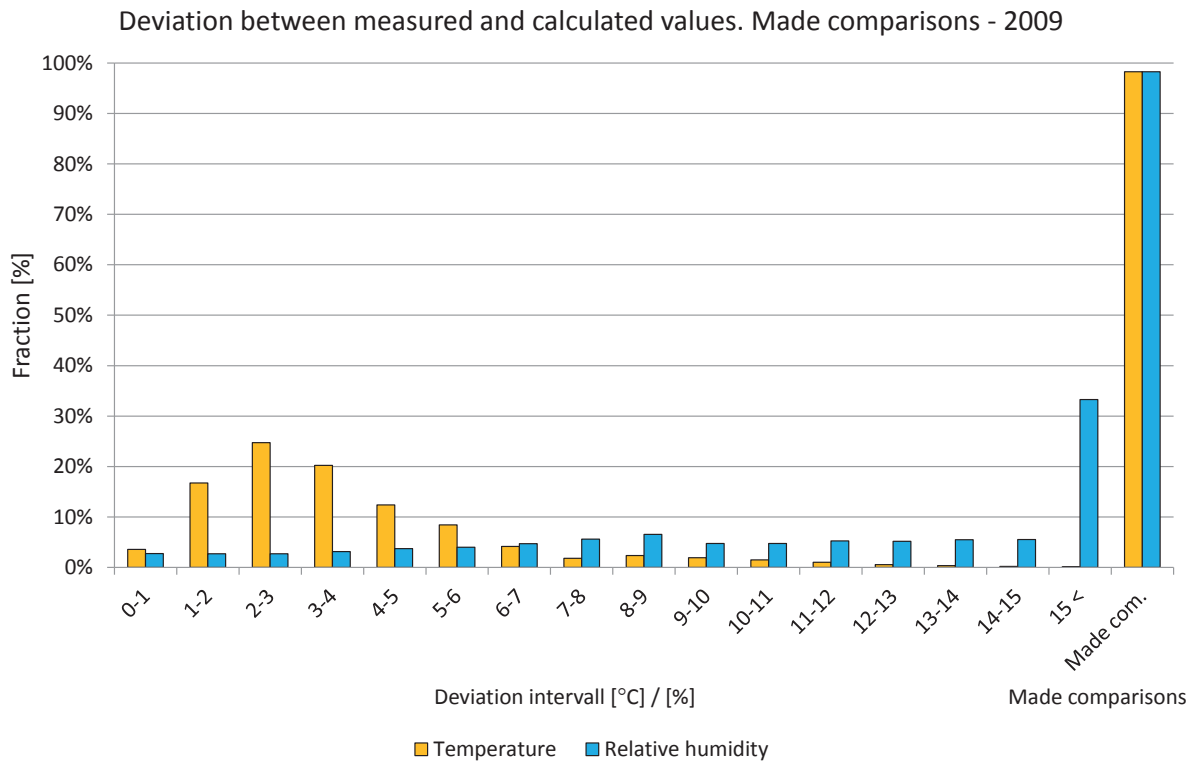


Figure 7.25.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

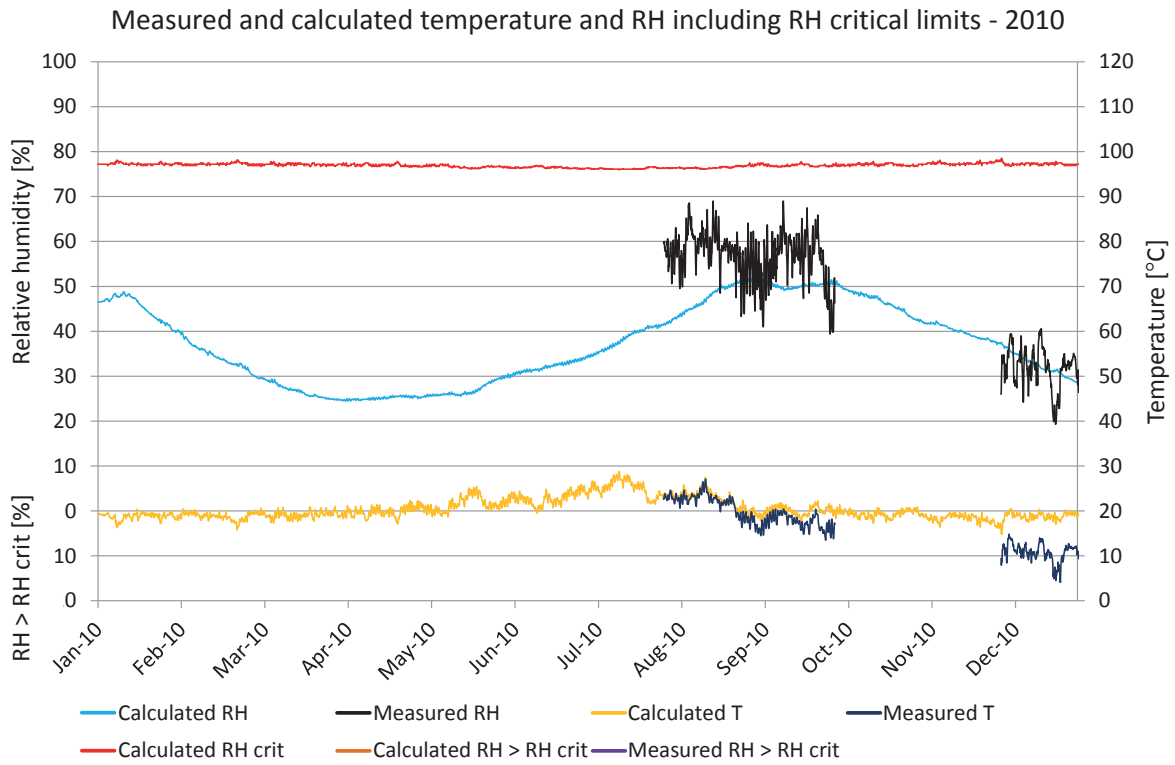


Figure 7.25.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

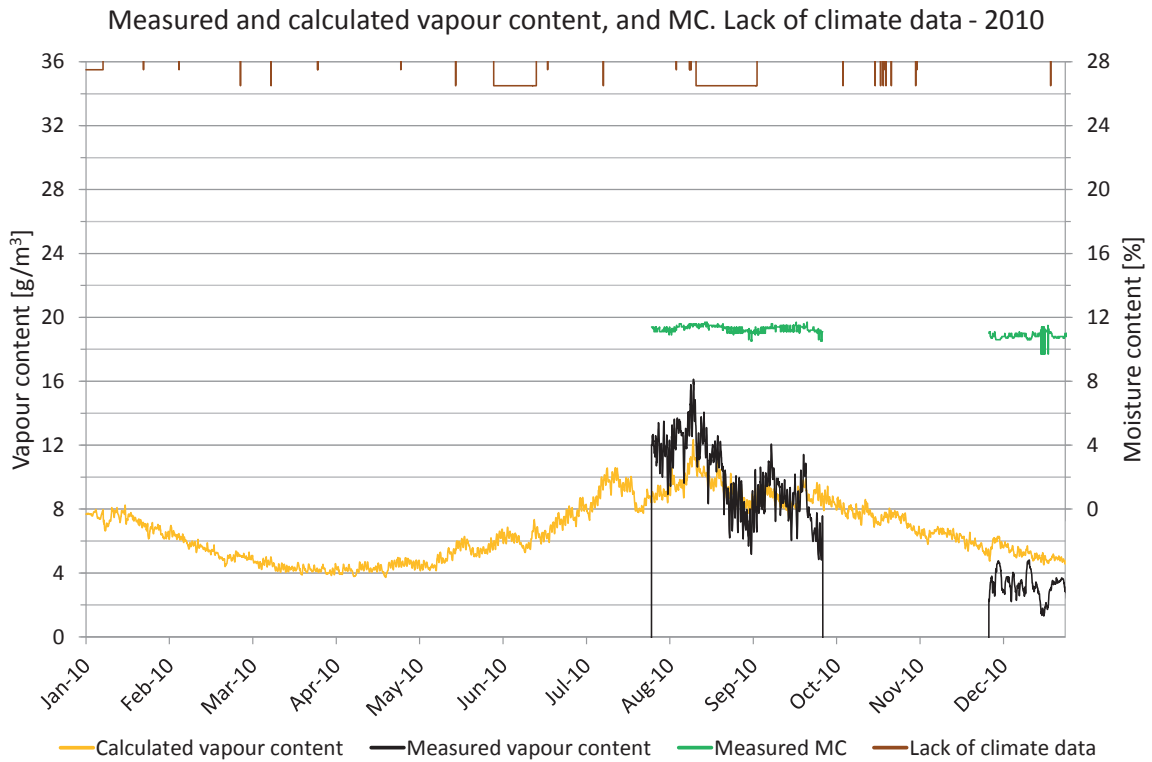


Figure 7.25.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

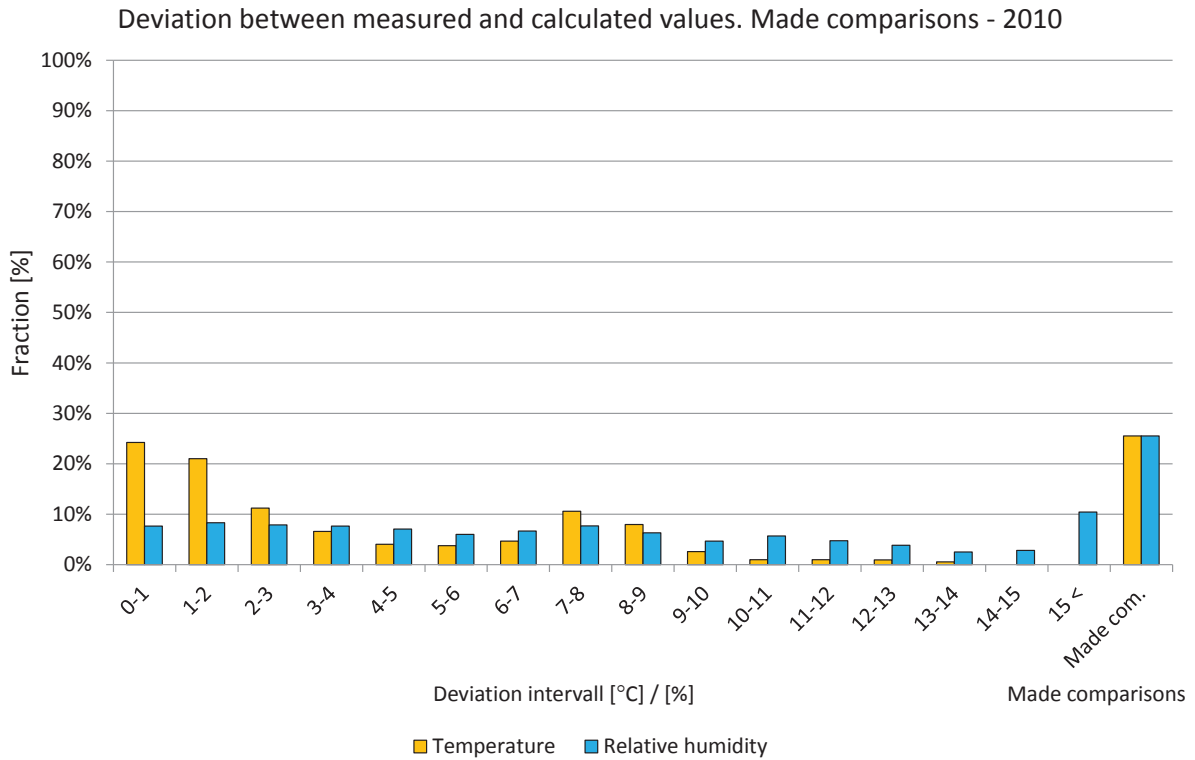


Figure 7.25.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

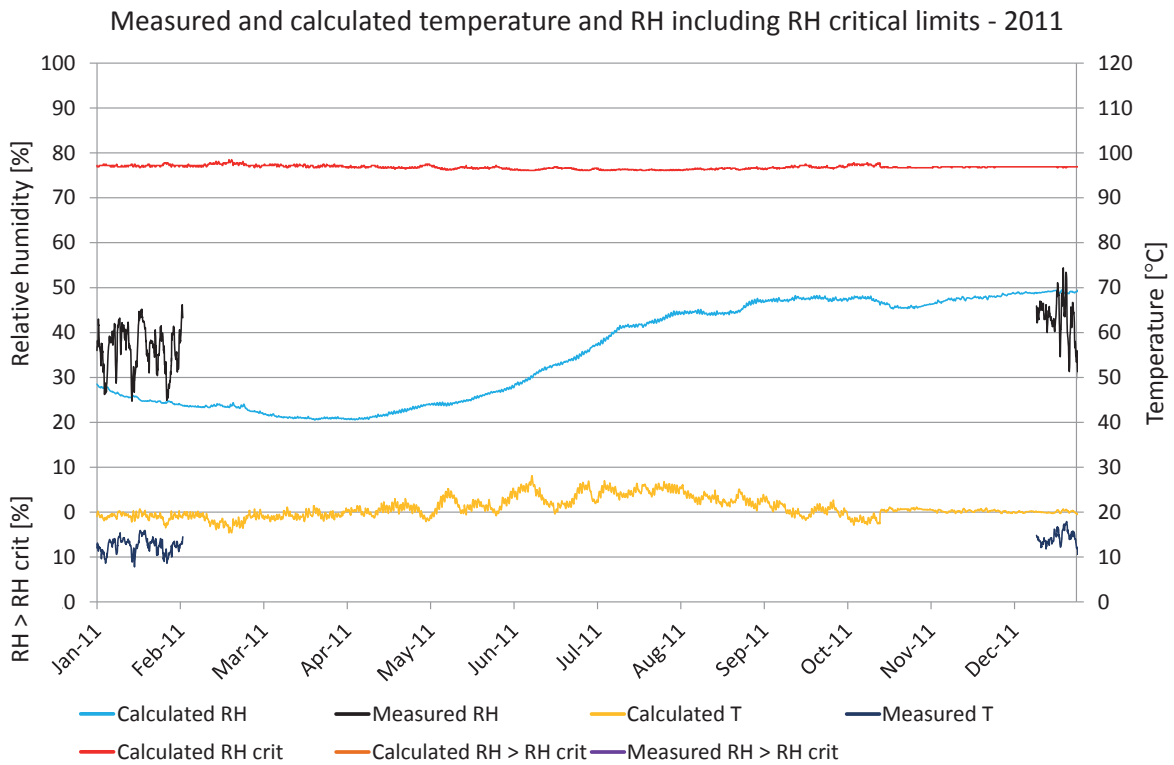


Figure 7.25.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

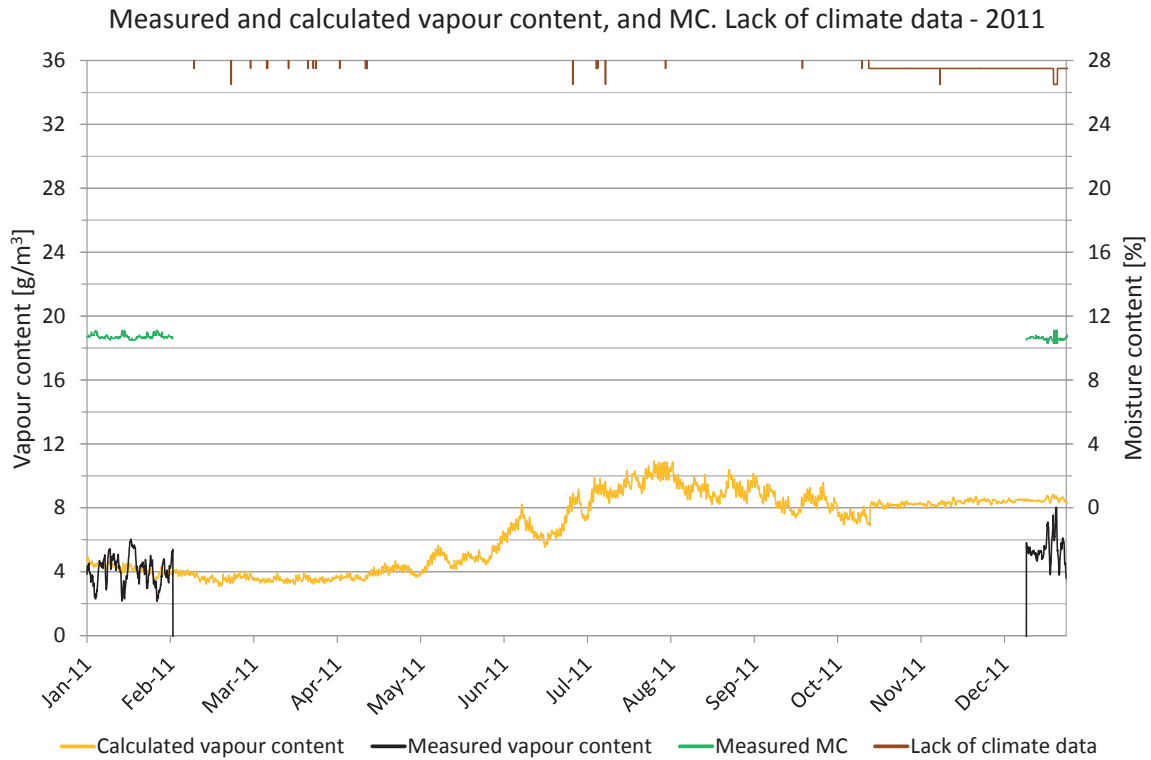


Figure 7.25.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

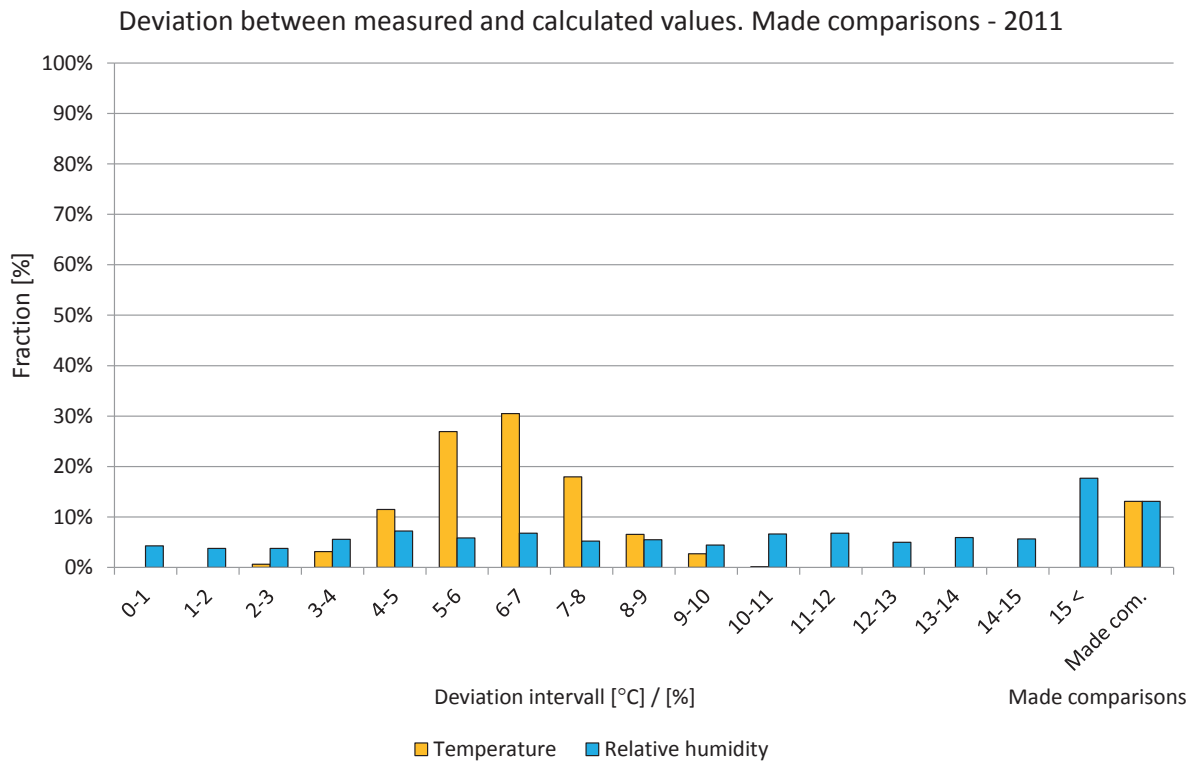


Figure 7.25.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.28 Position 28

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located below a window in a wall that is facing north on the first floor.

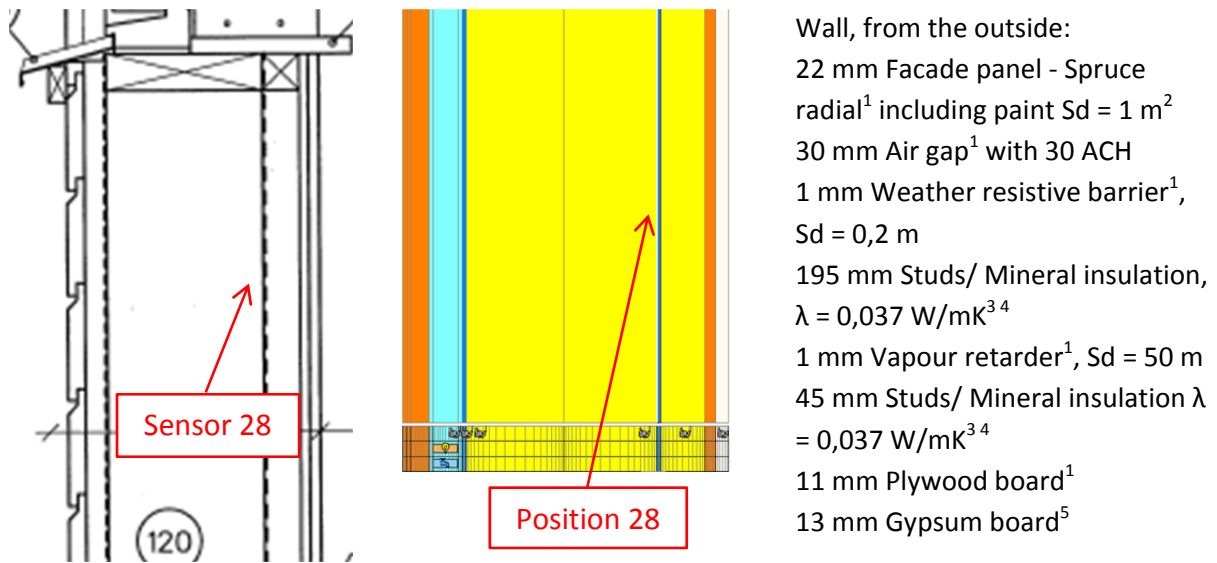


Figure 7.28.1. Vertical cross sectional drawing and WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Nevander, L-E., 1994, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.



Figure 7.28.2. Location of the studied position. Photo: SP Trä Skellefteå.

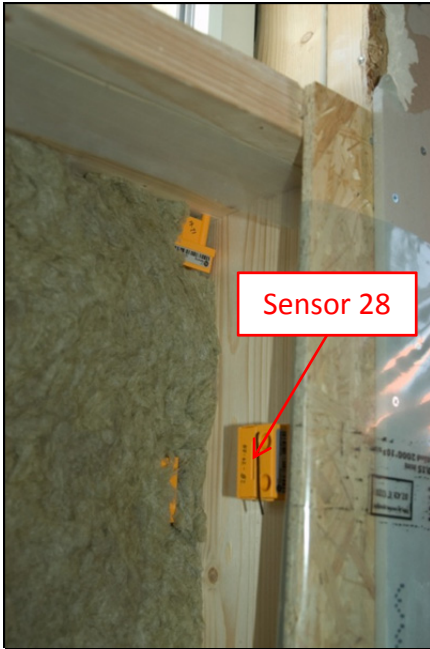


Figure 7.28.3. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.28.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

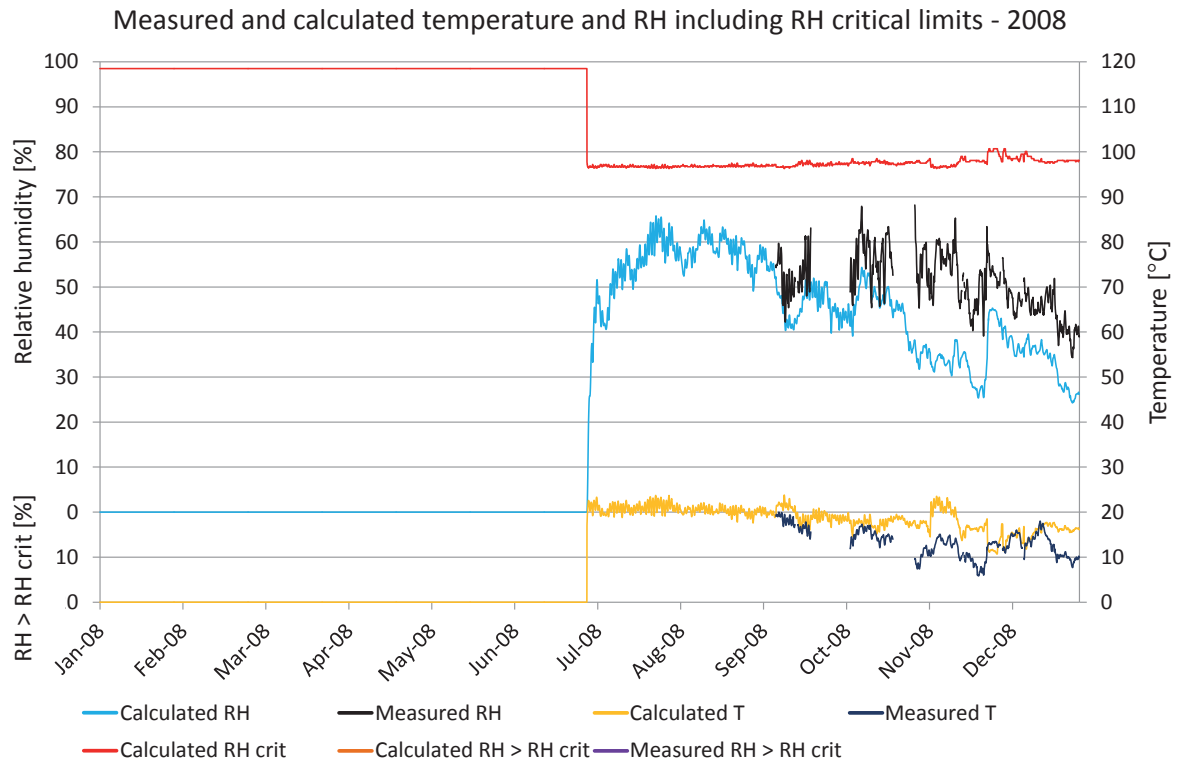


Figure 7.28.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

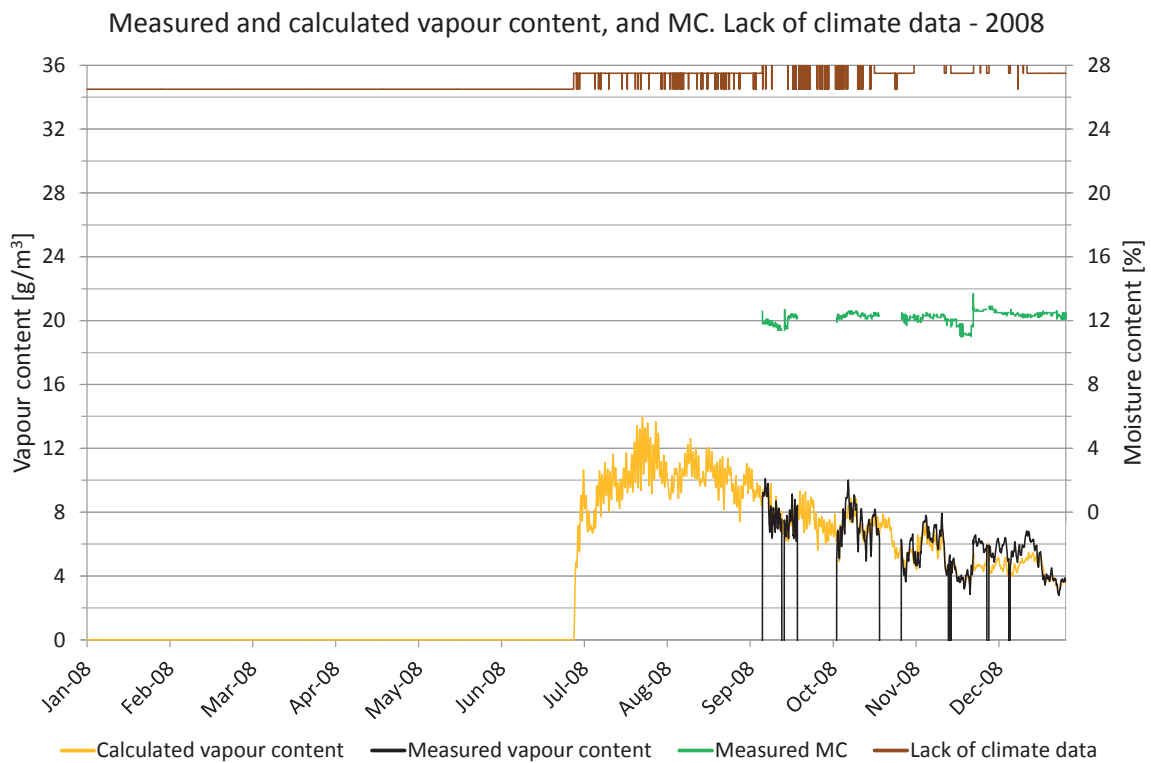


Figure 7.28.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

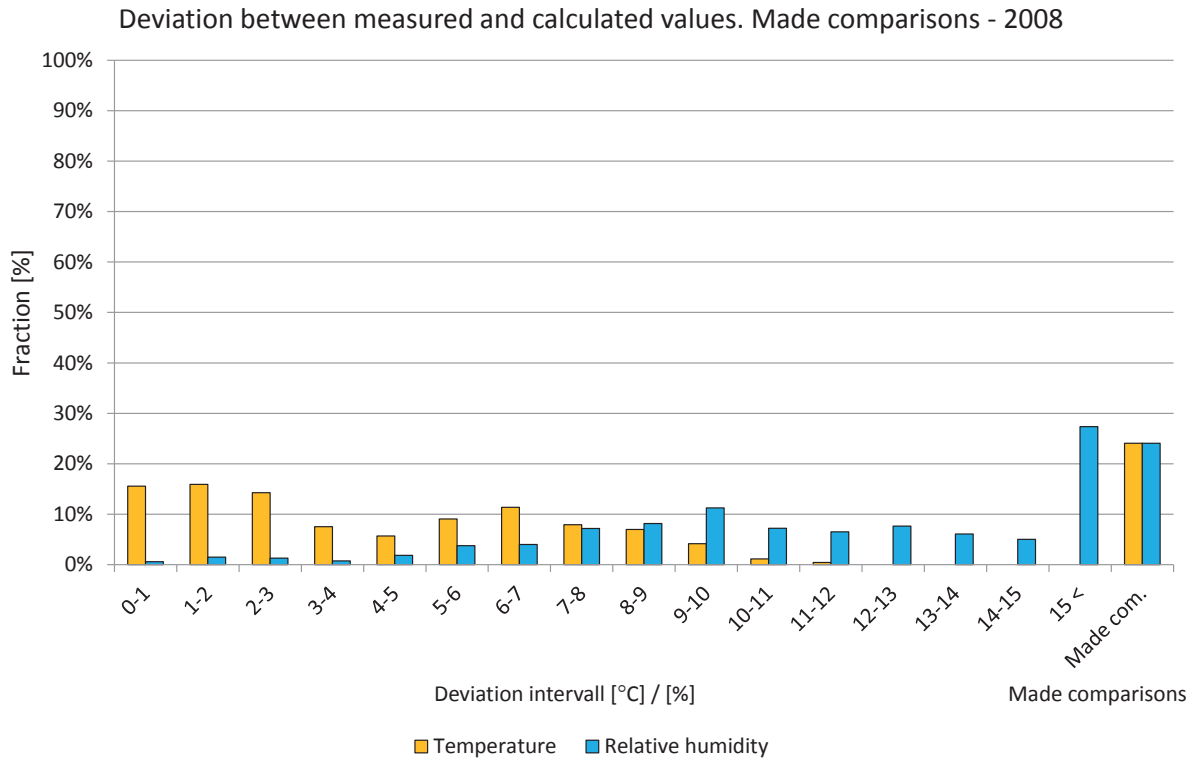


Figure 7.28.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

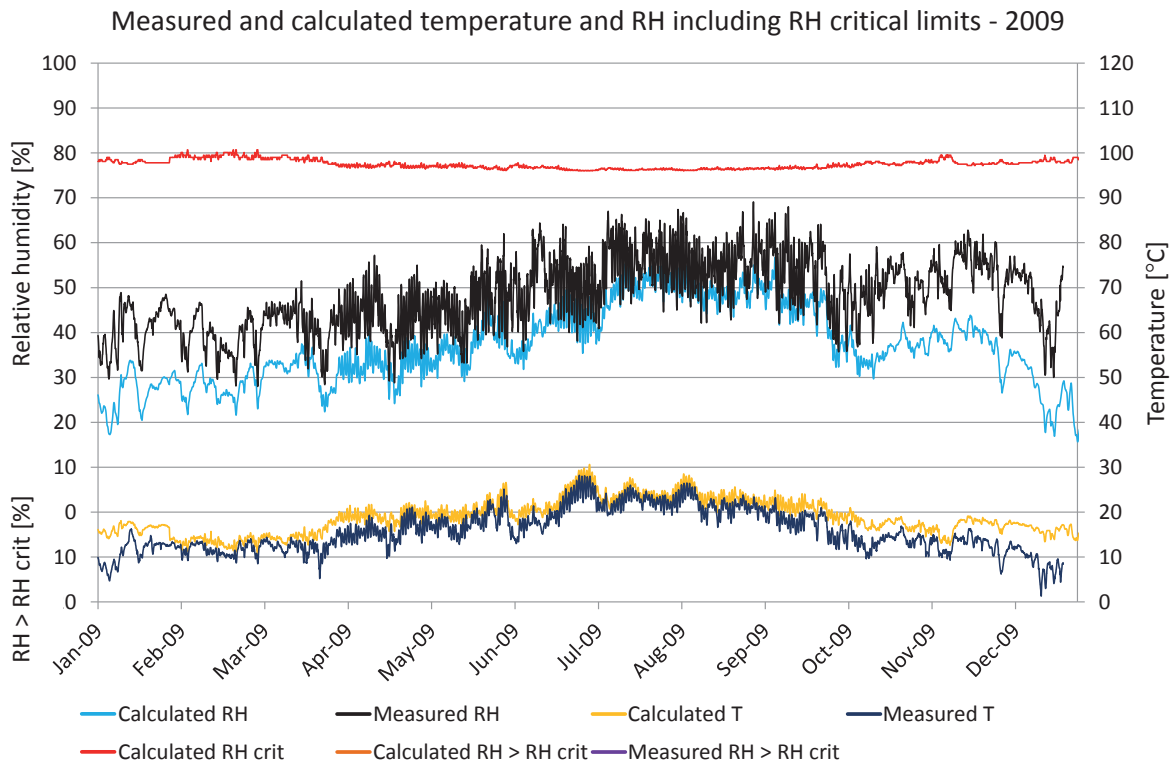


Figure 7.28.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

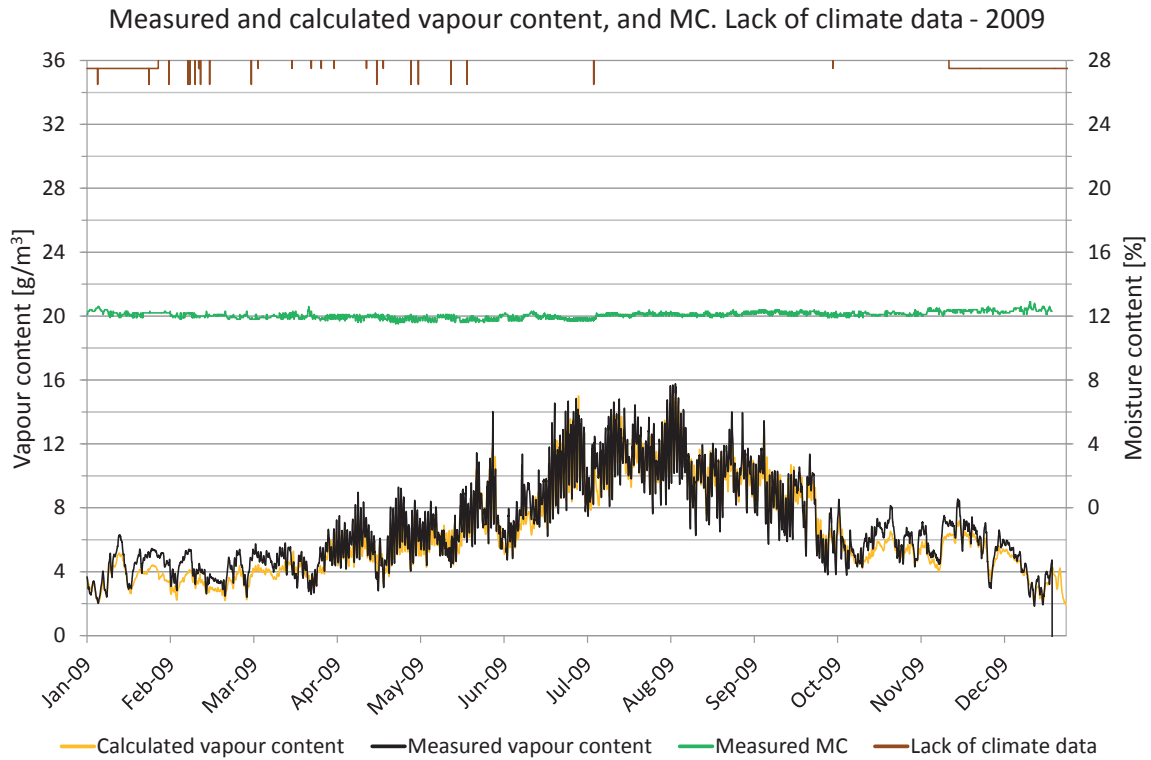


Figure 7.28.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

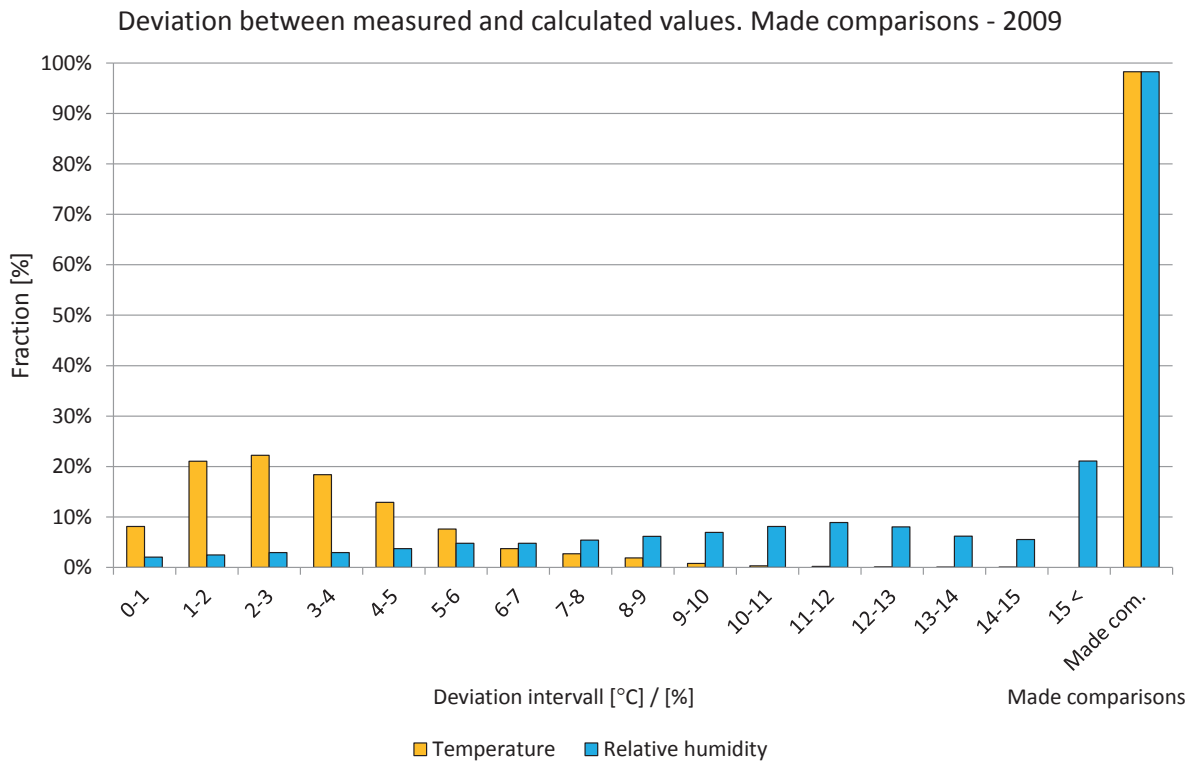


Figure 7.28.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

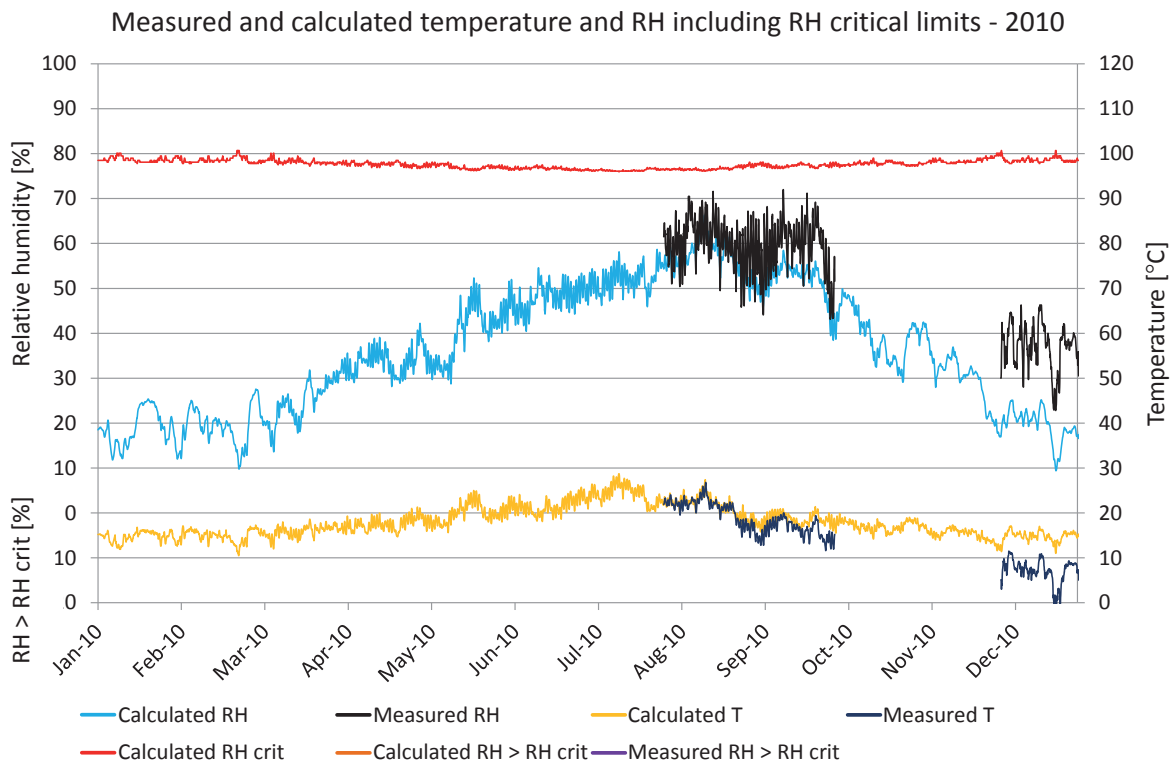


Figure 7.28.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

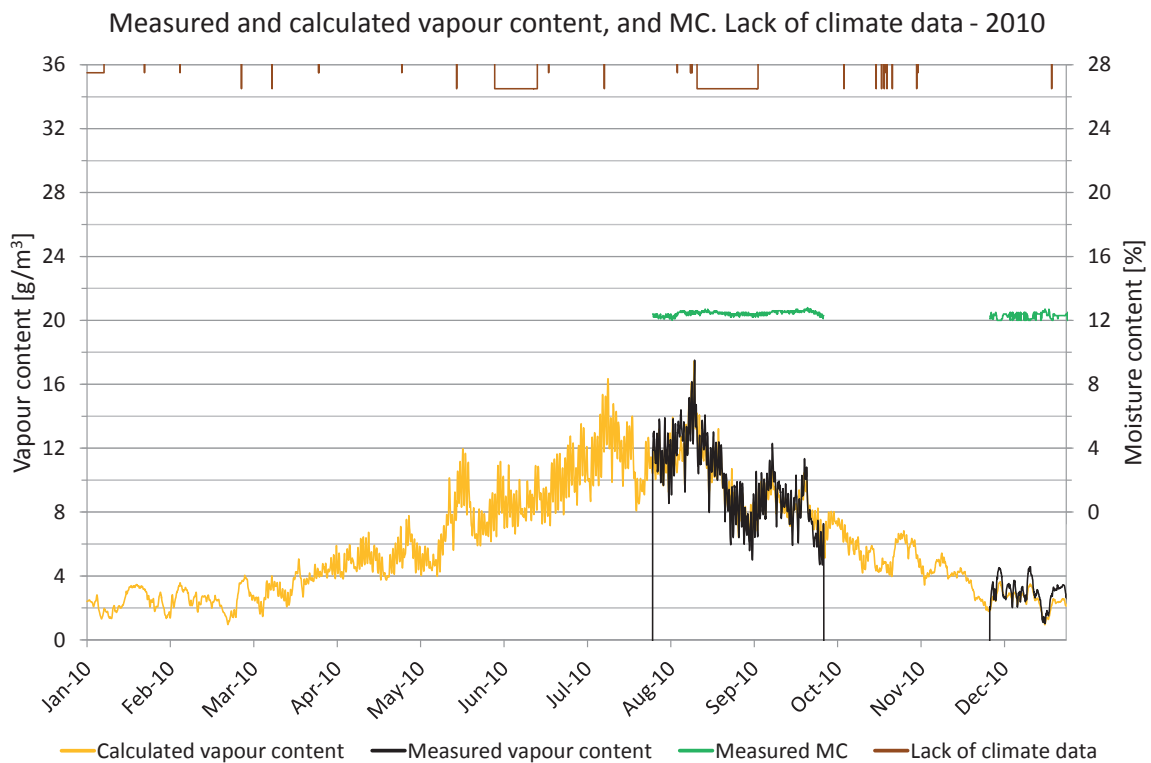


Figure 7.28.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

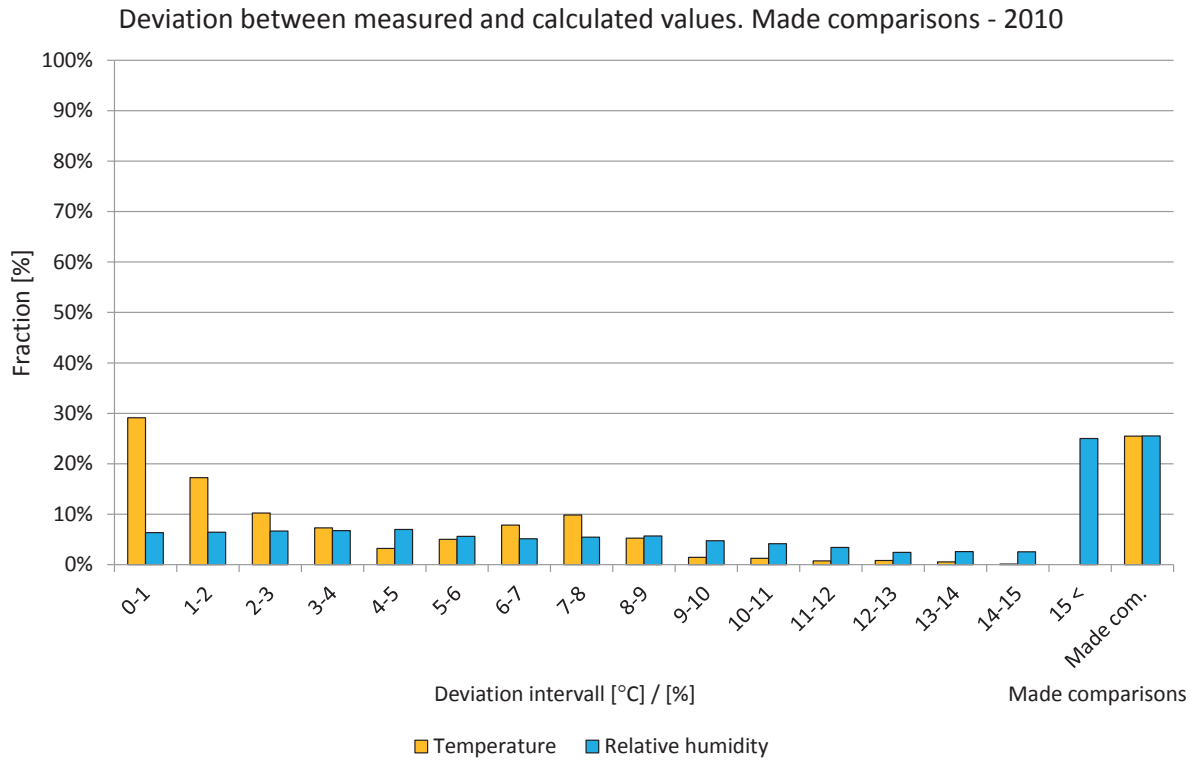


Figure 7.28.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

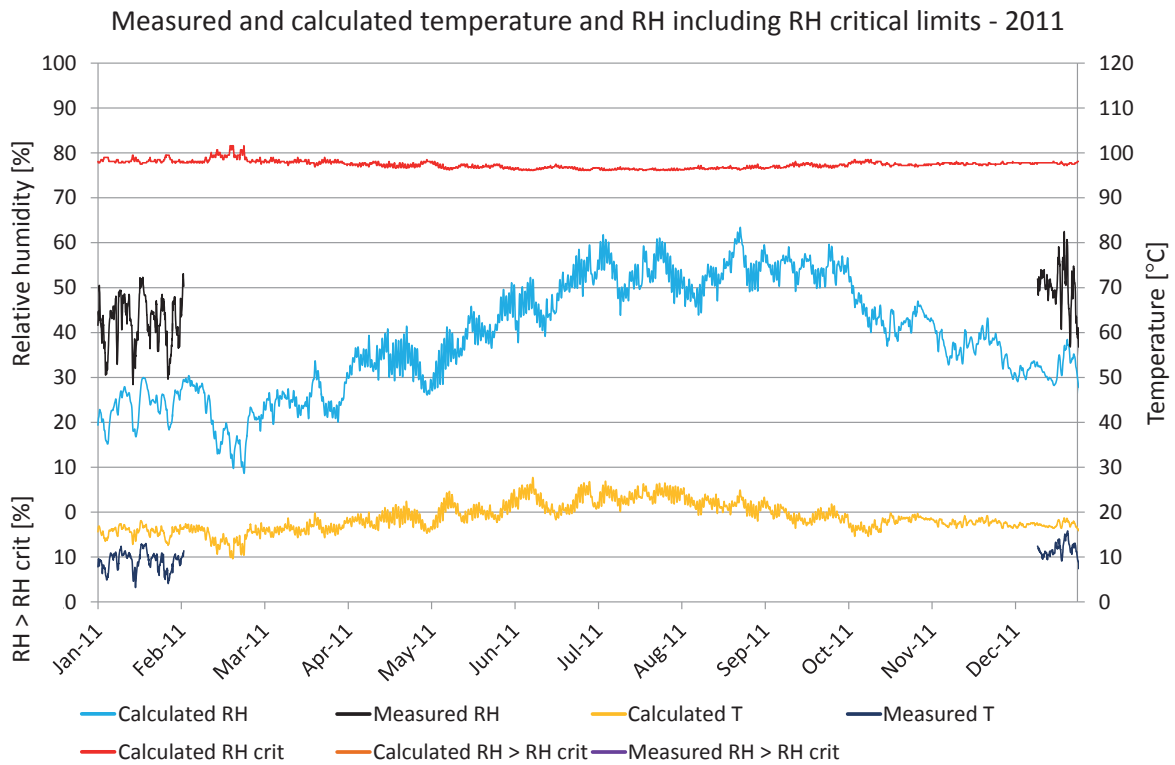


Figure 7.28.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

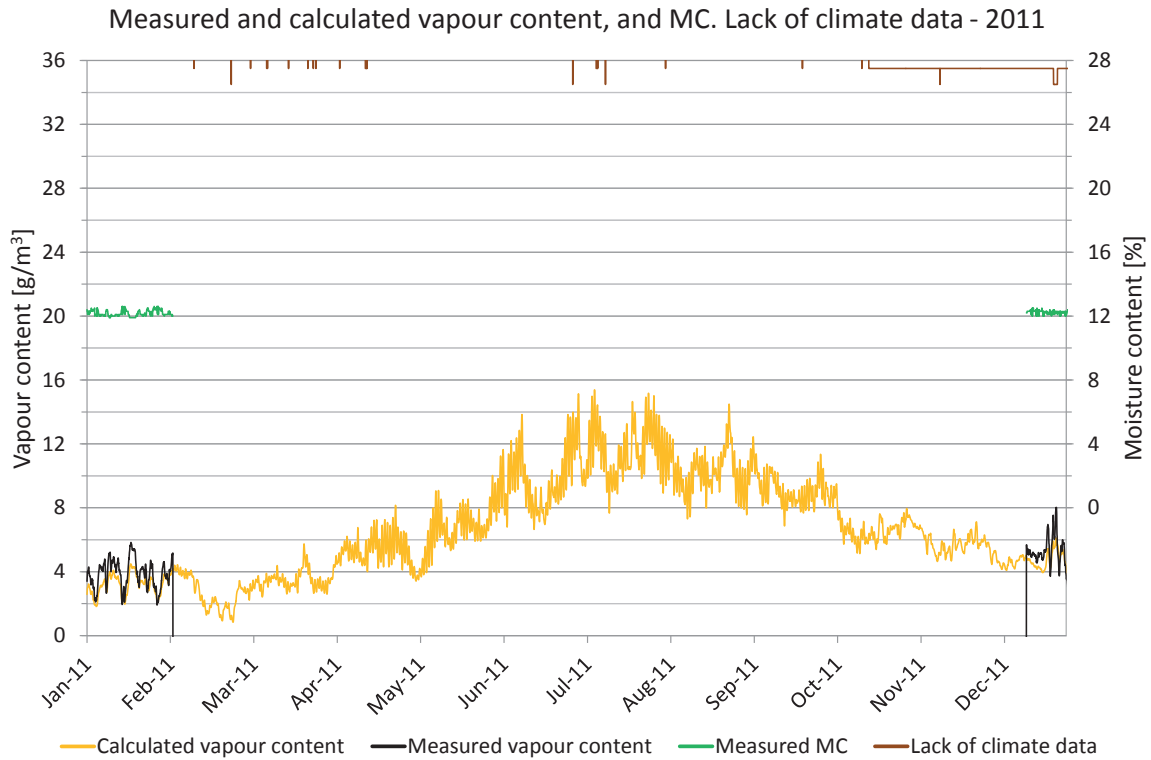


Figure 7.28.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

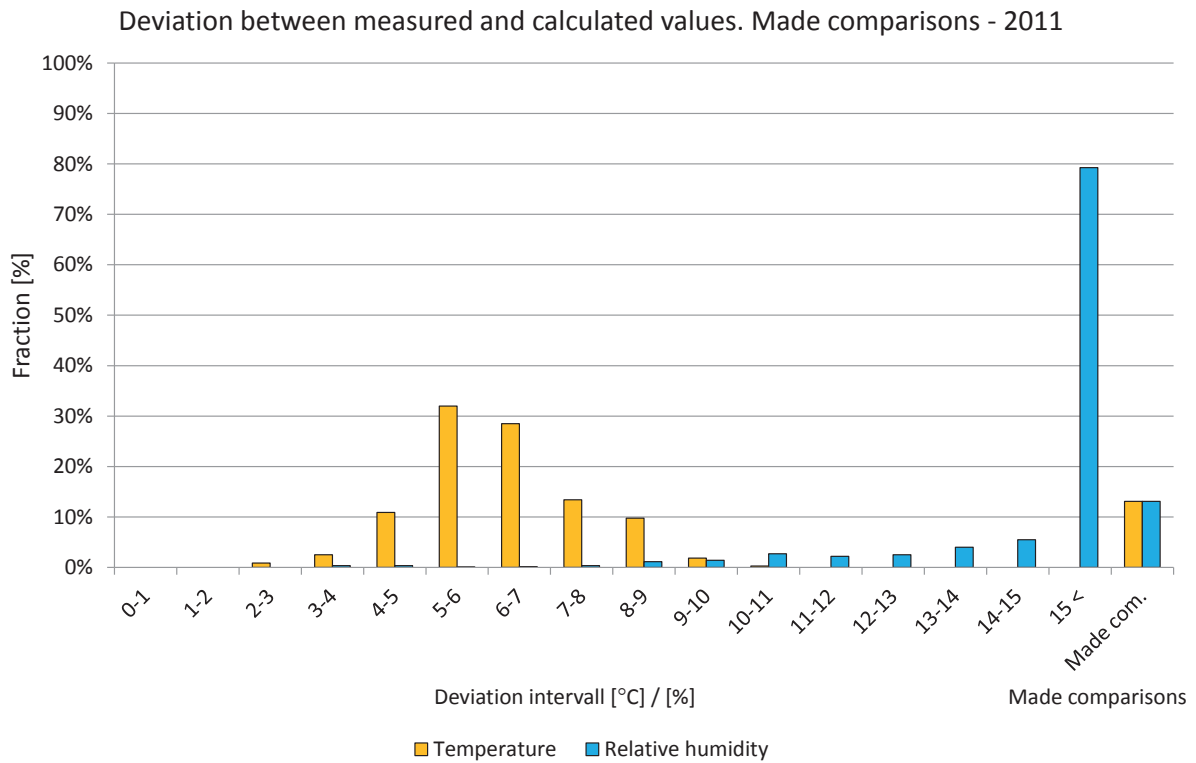


Figure 7.28.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.36 Position 36

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof. Unfortunately there was a complete lack of measured data during 2011. This means that only calculated data are shown for 2011 and no charts presenting deviation between measured and calculated values are presented.

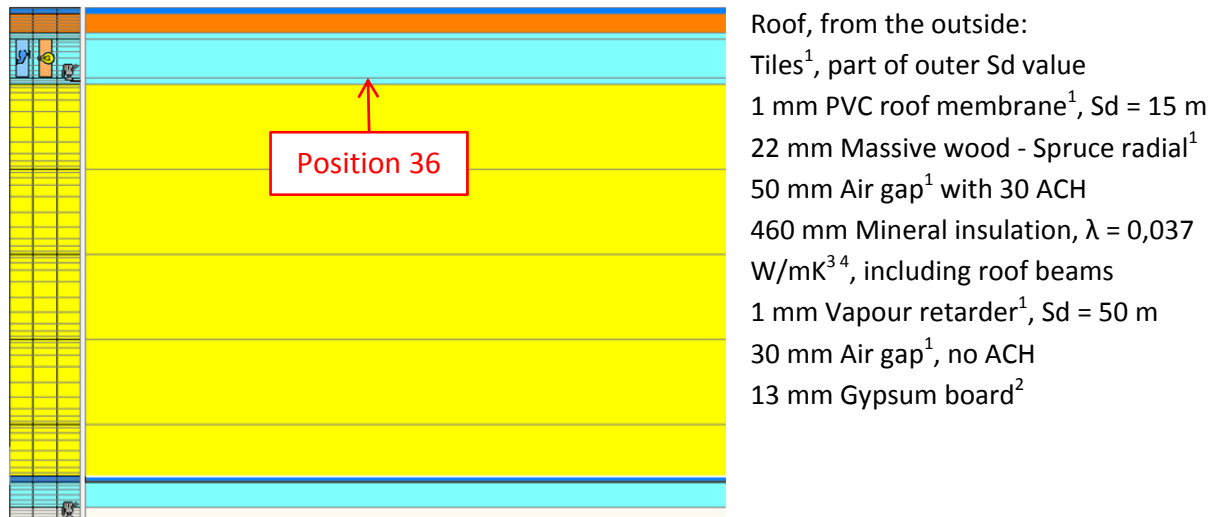


Figure 7.36.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

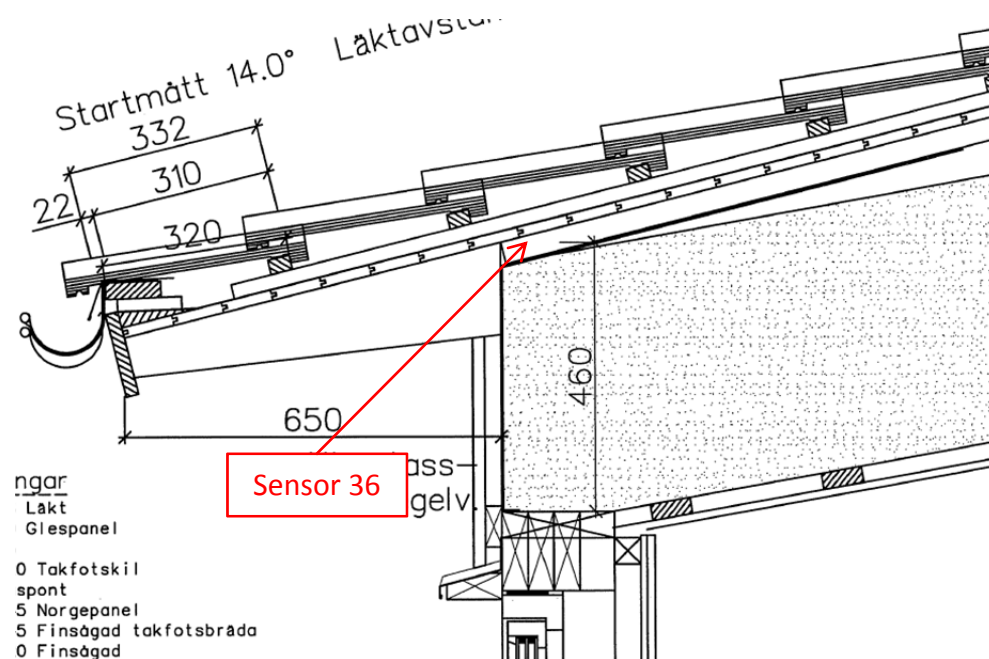


Figure 7.36.2. Location of the studied position.



Figure 7.36.3. Location of the studied position. Photo: SP Trä Skellefteå.

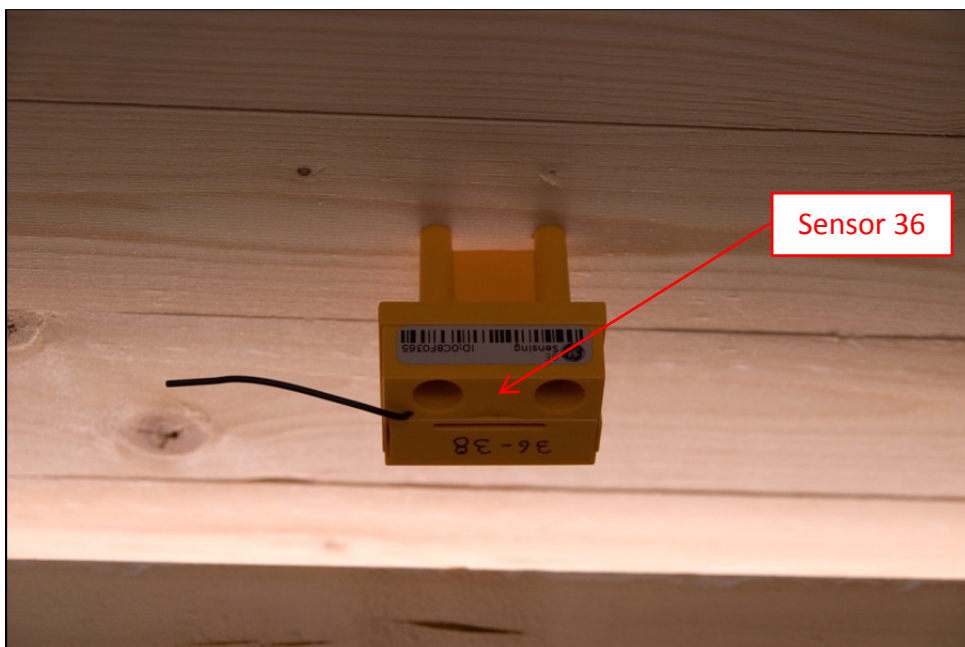


Figure 7.36.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

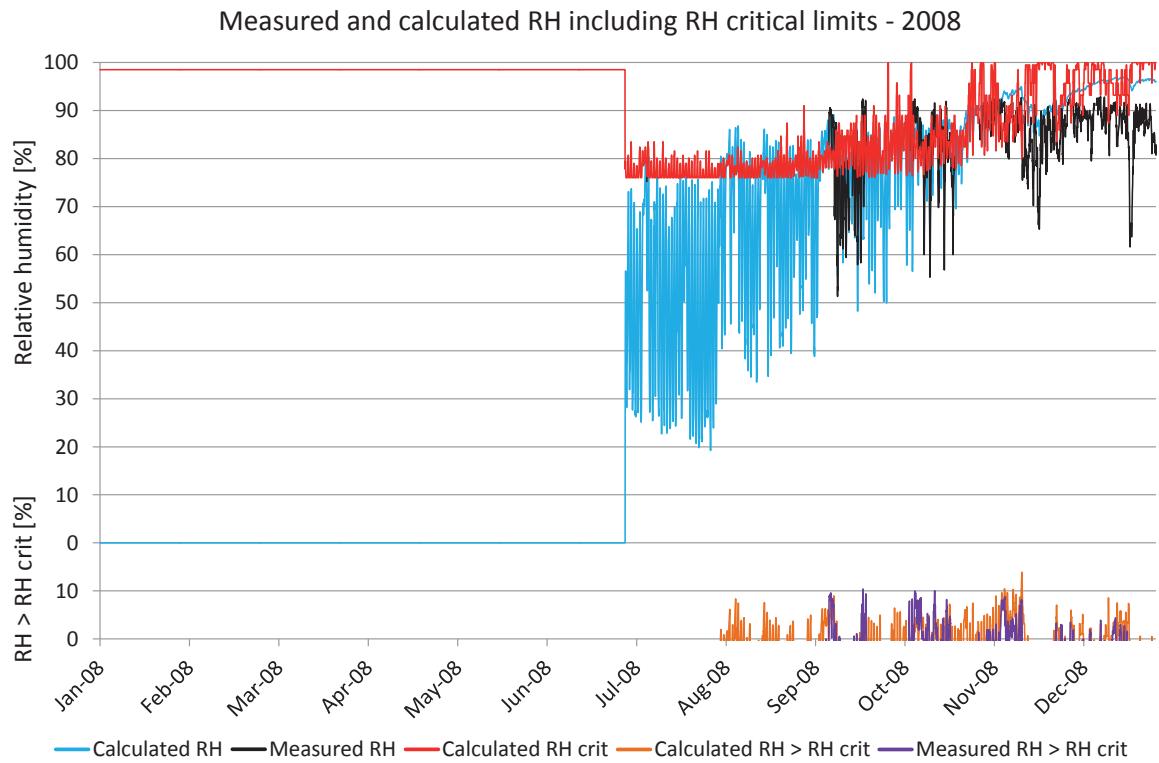


Figure 7.36.5. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

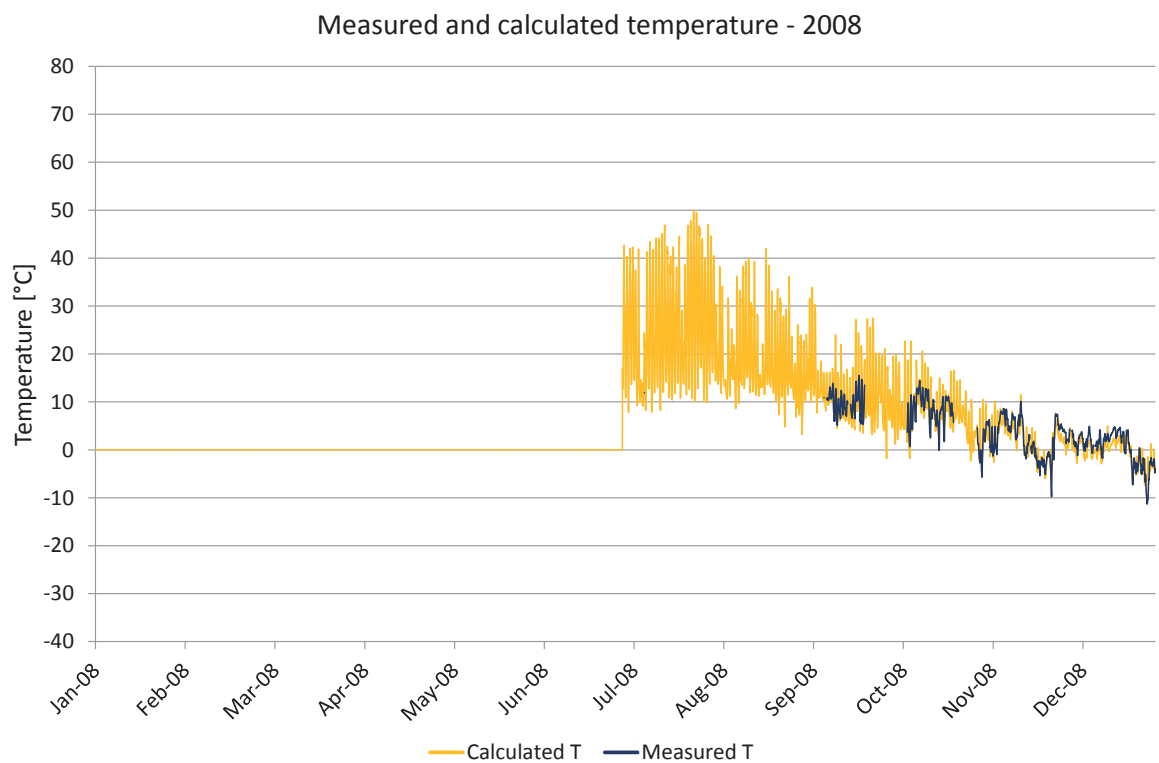


Figure 7.36.6. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

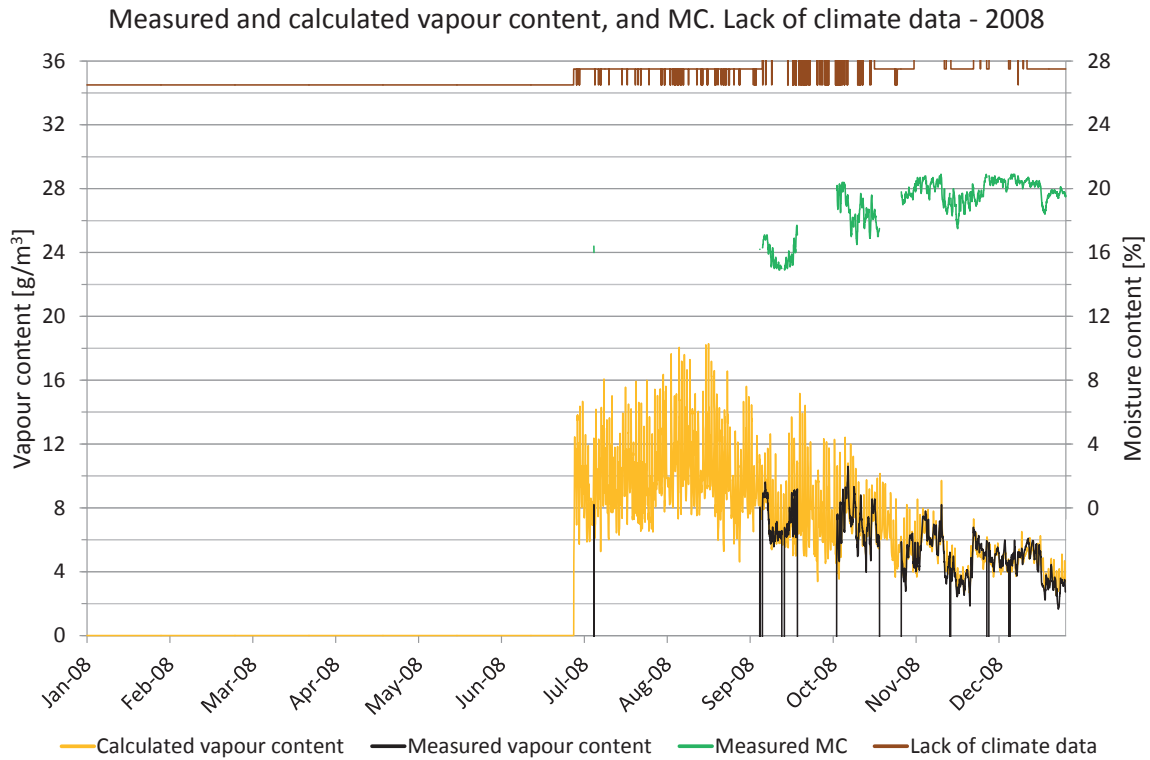


Figure 7.36.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

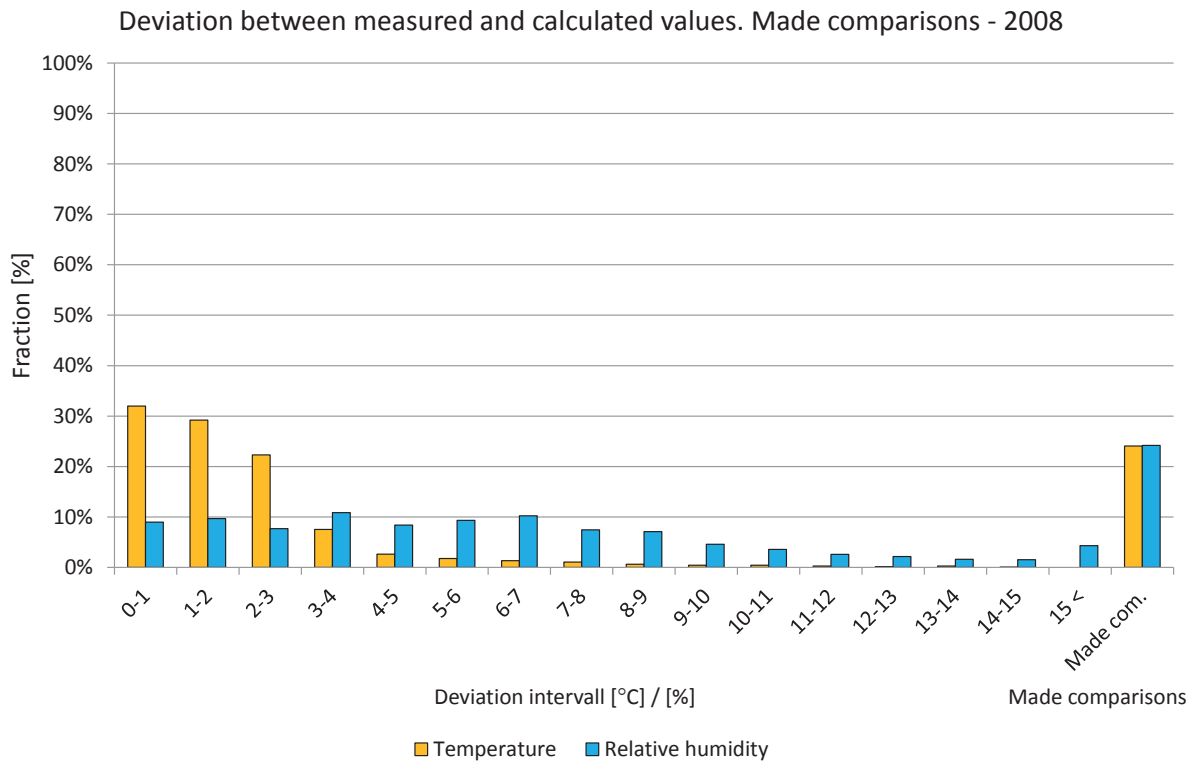


Figure 7.36.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

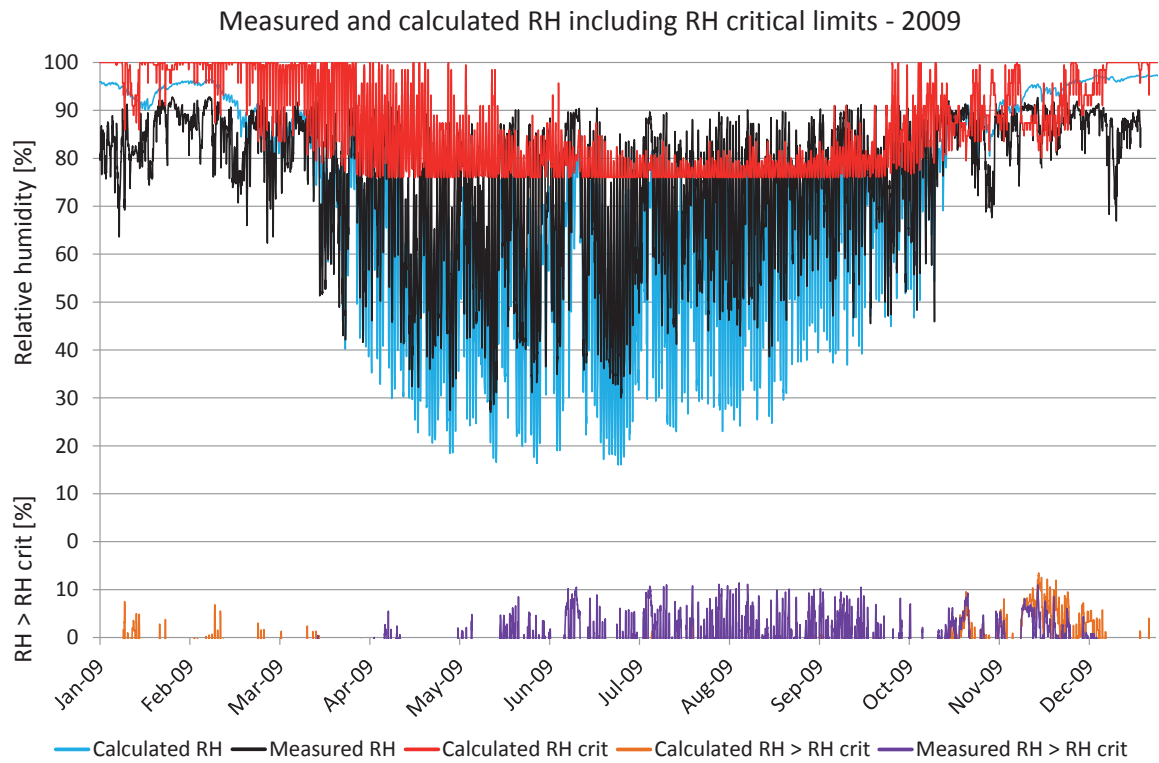


Figure 7.36.9. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

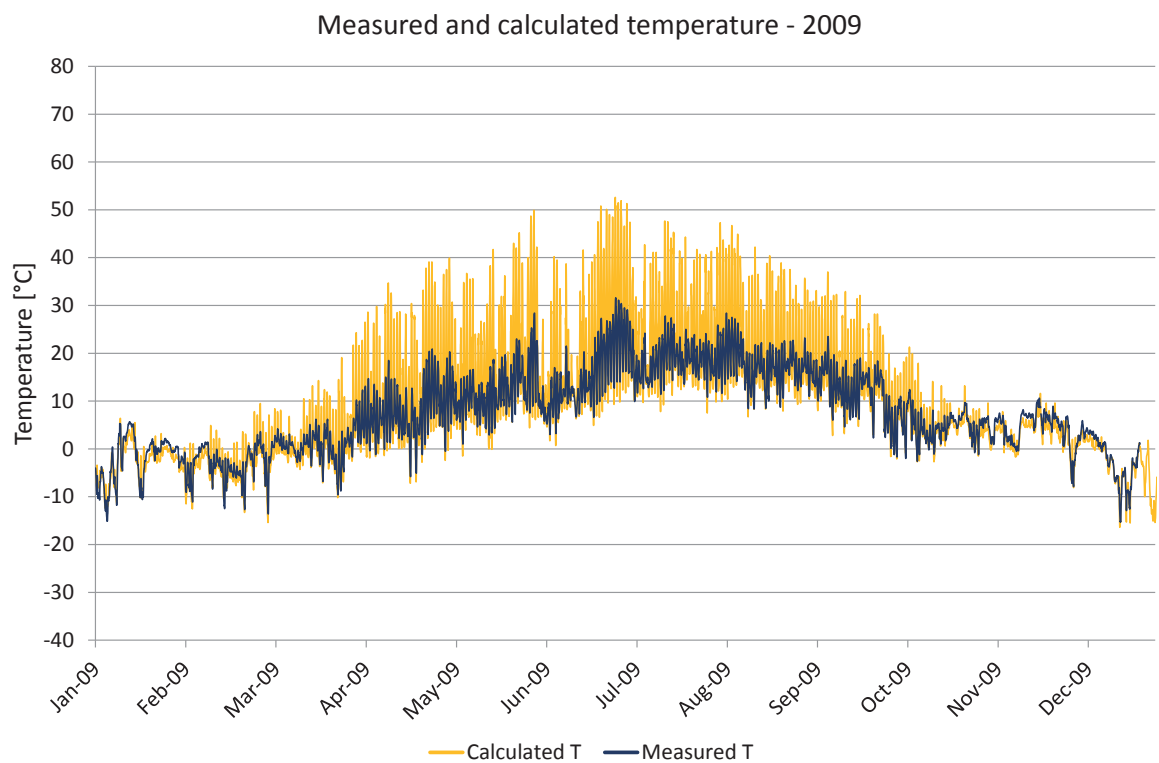


Figure 7.36.10. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

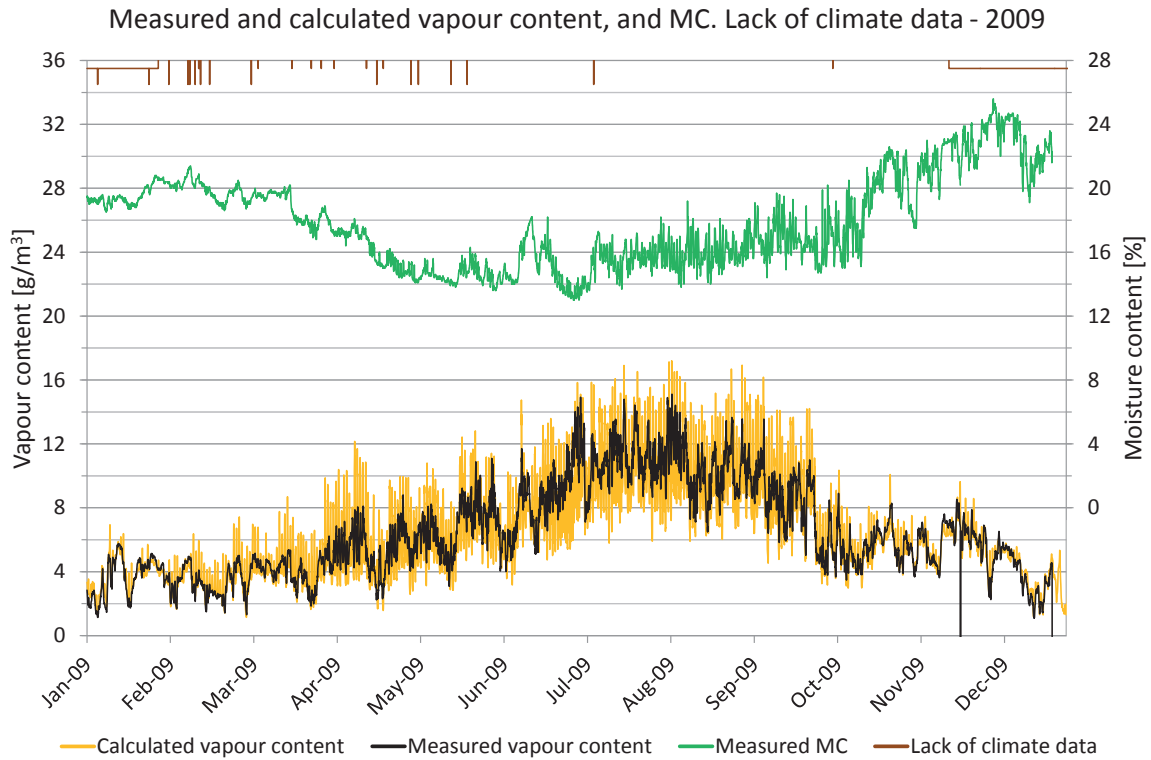


Figure 7.36.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

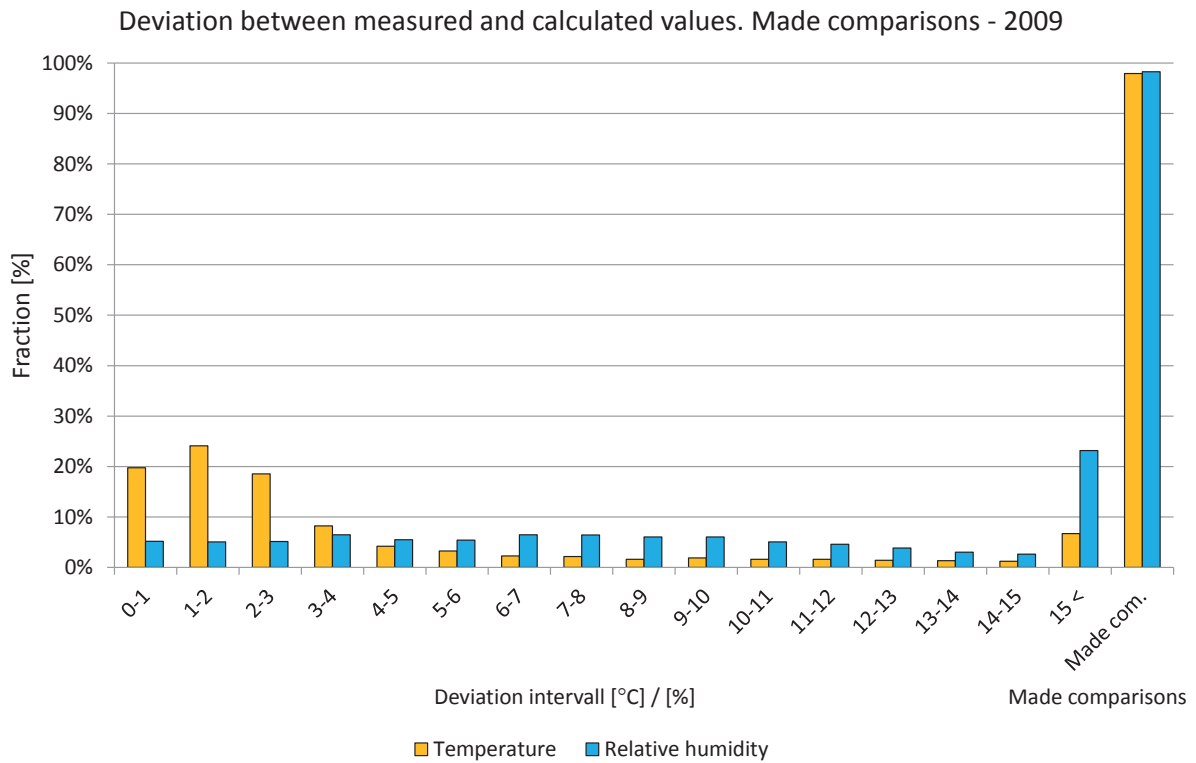


Figure 7.36.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

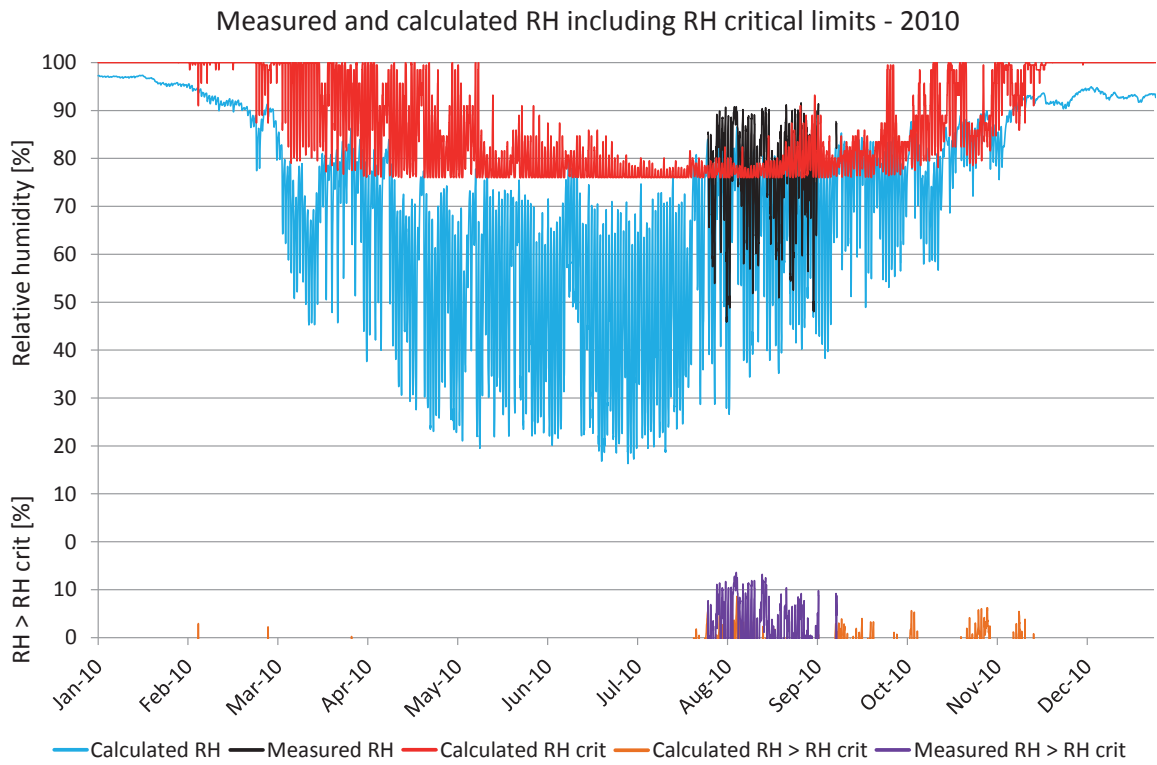


Figure 7.36.13. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

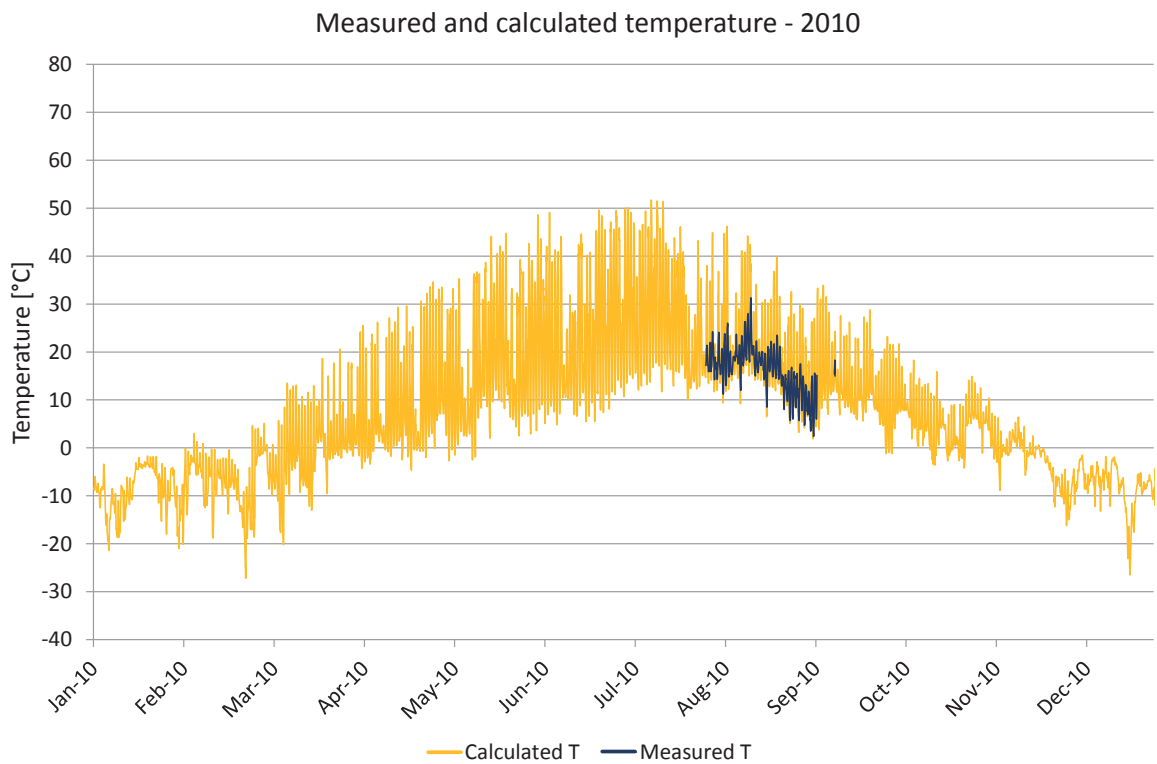


Figure 7.36.14. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

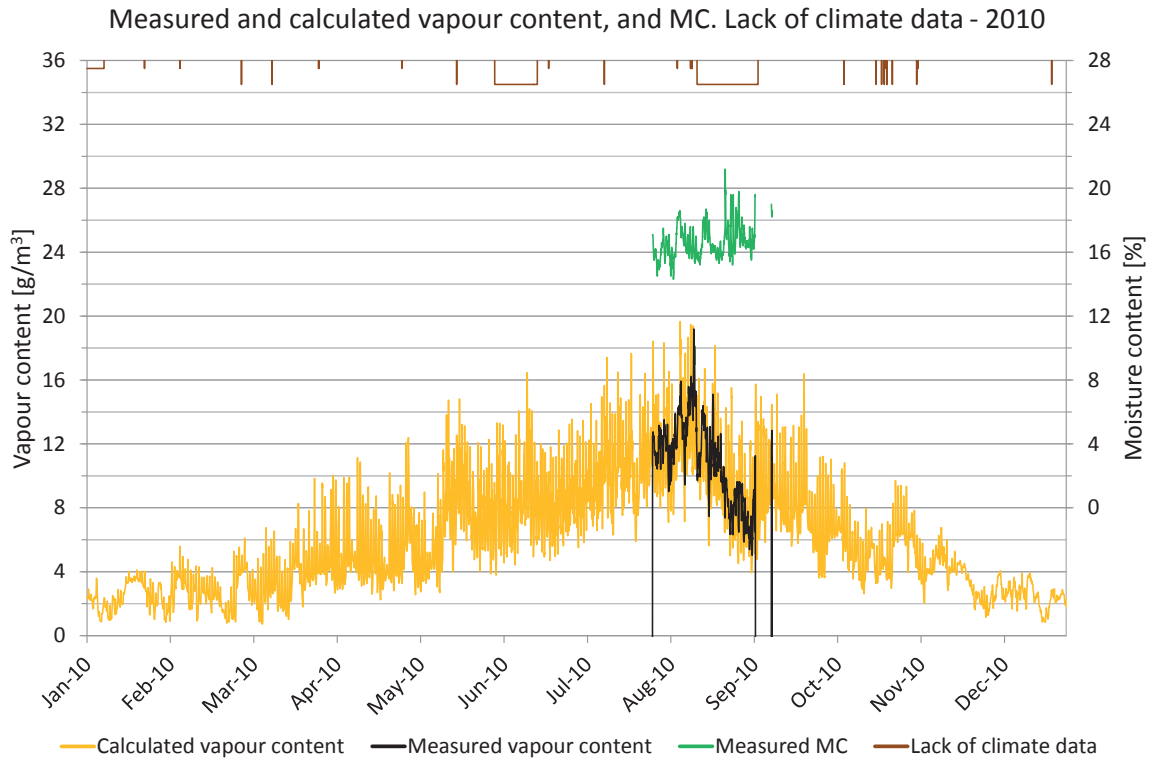


Figure 7.36.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

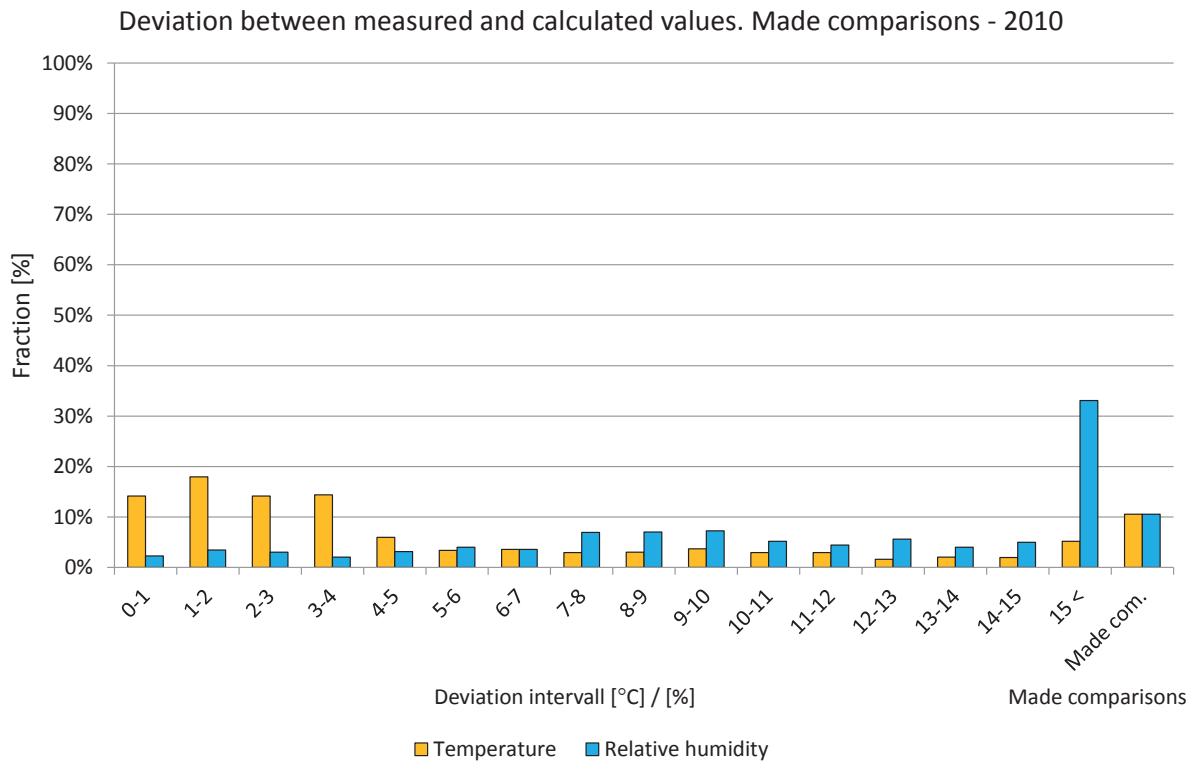


Figure 7.36.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

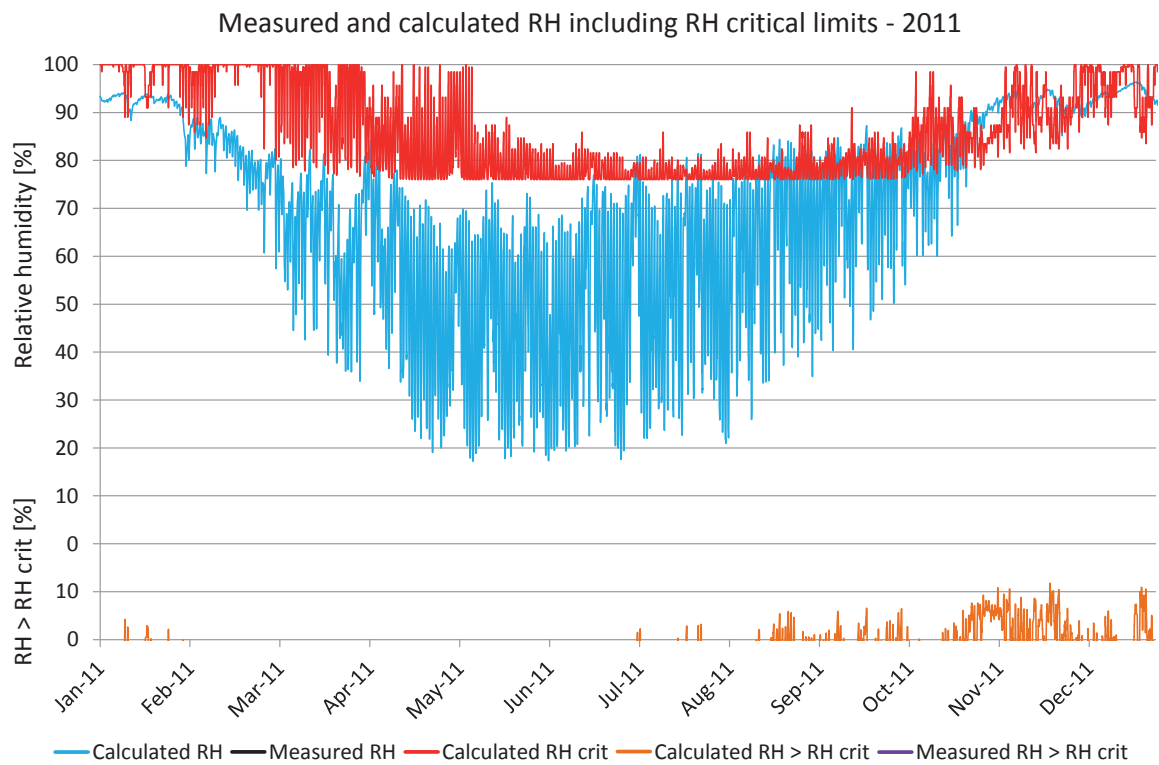


Figure 7.36.17. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

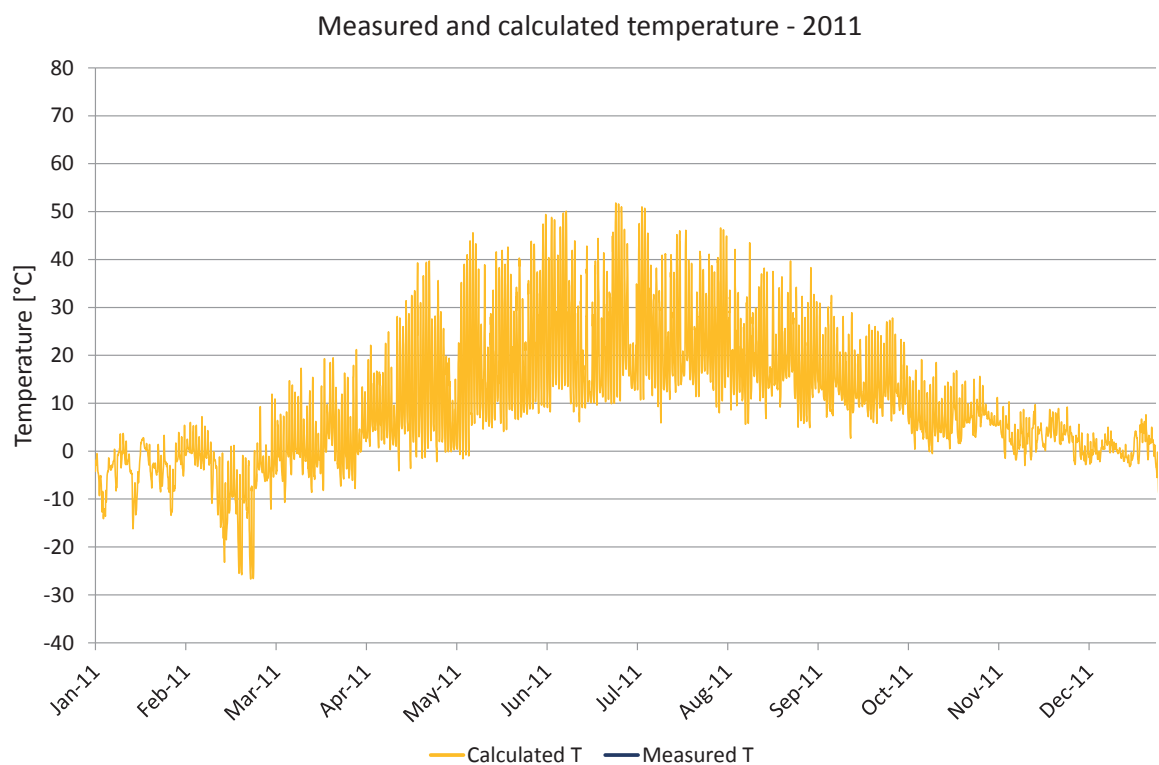


Figure 7.36.18. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

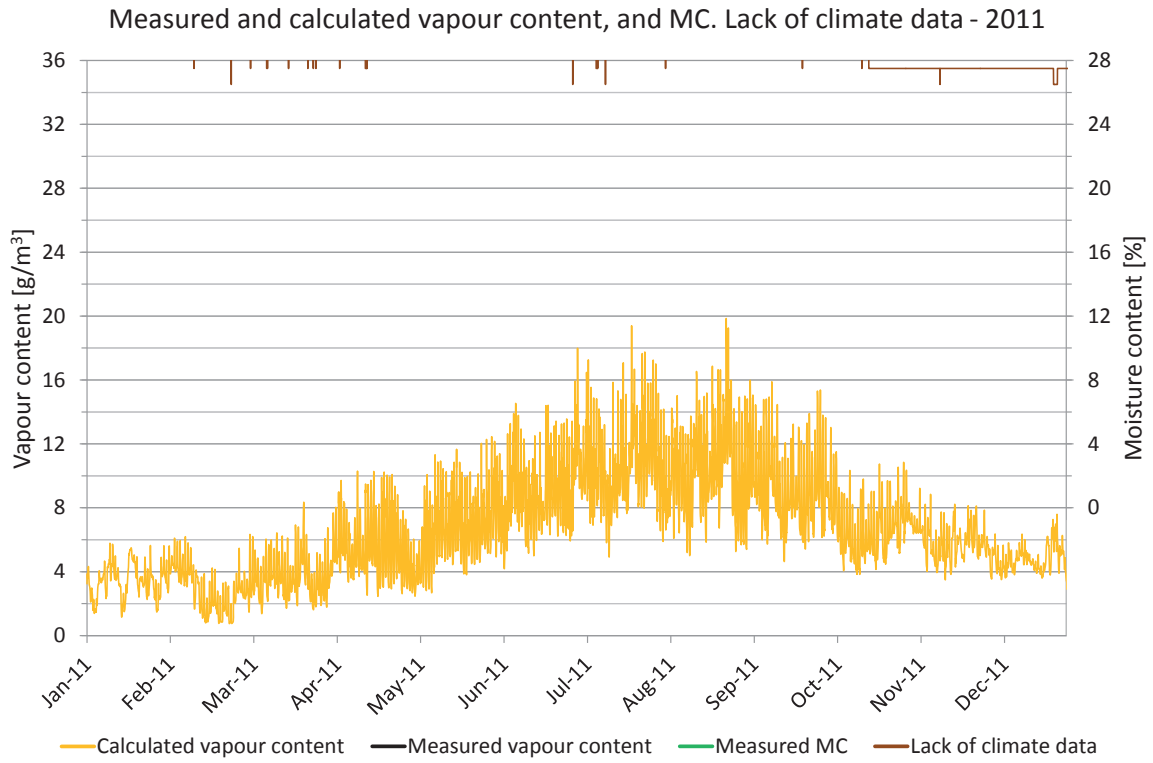


Figure 7.36.19. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

7.39 Position 39

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

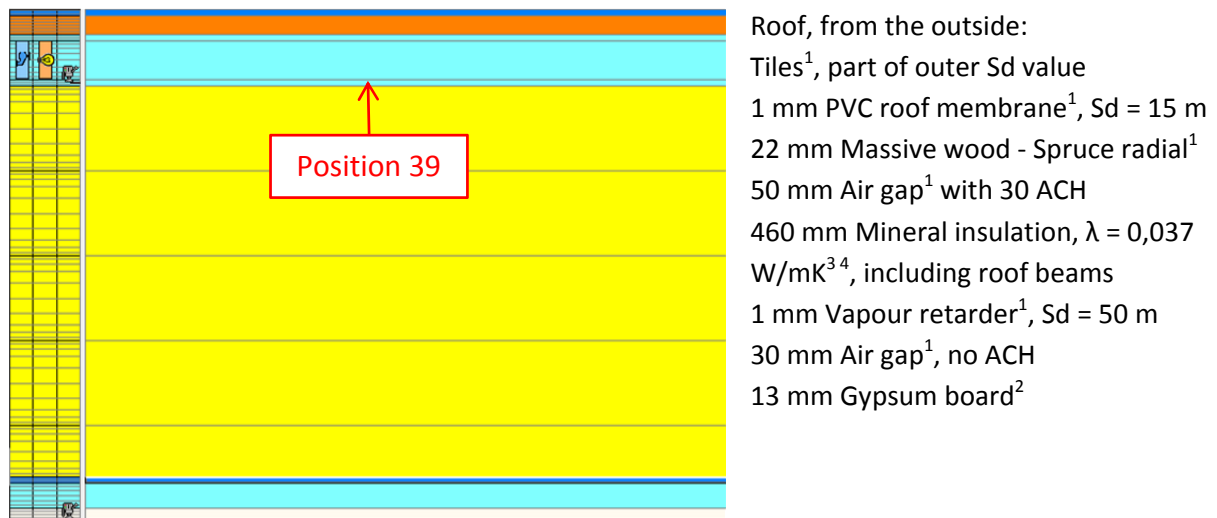


Figure 7.39.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

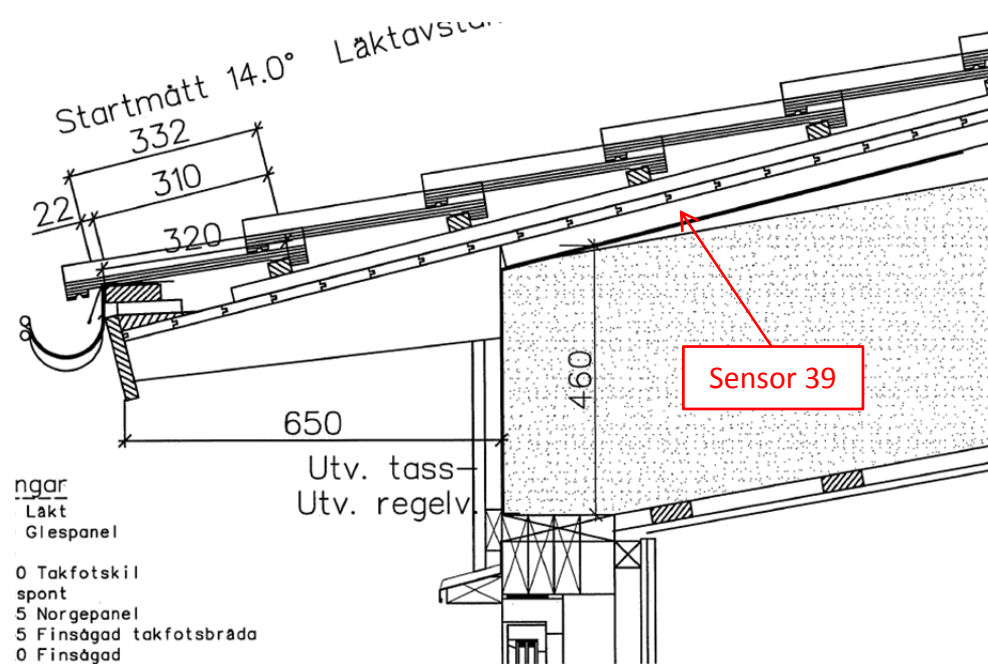


Figure 7.39.2. Location of the studied position.



Figure 7.39.3. Location of the studied position. Photo: SP Trä Skellefteå.

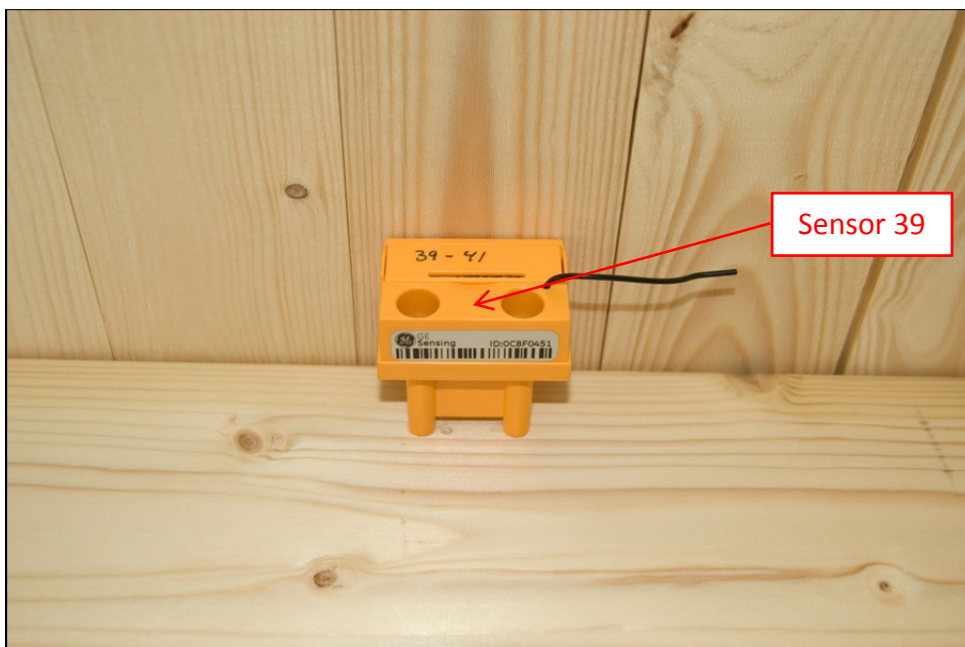


Figure 7.39.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

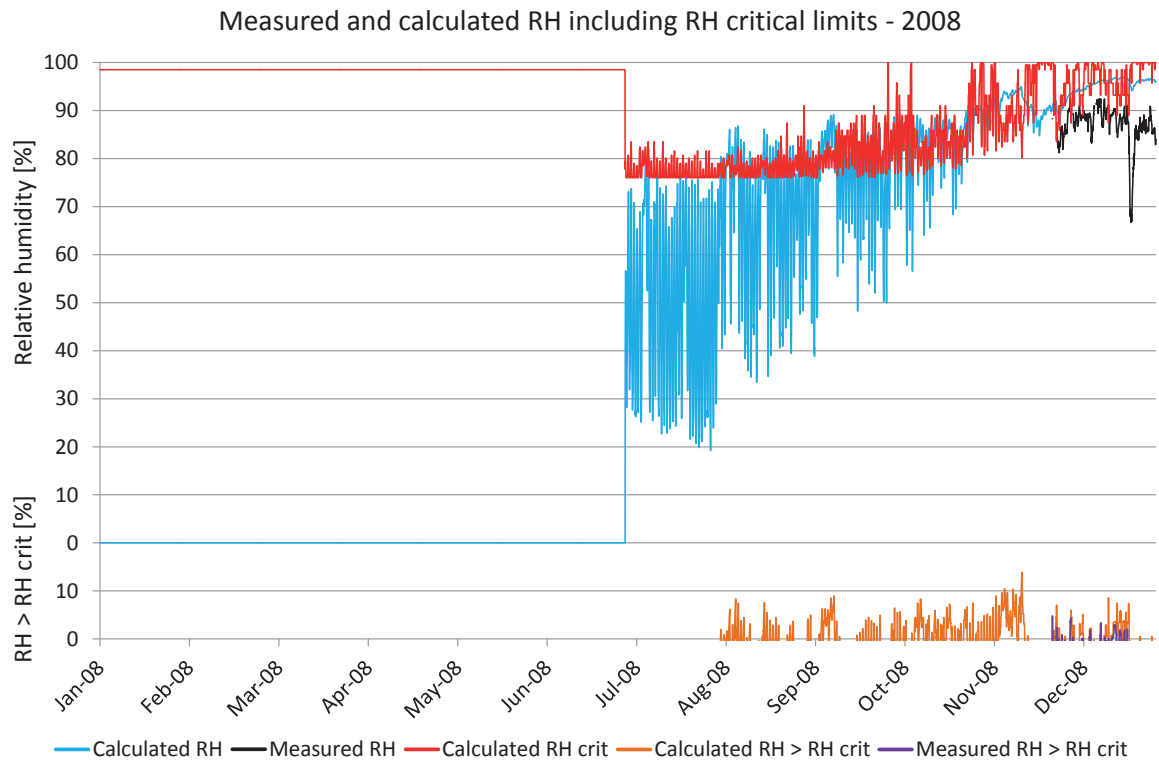


Figure 7.39.5. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

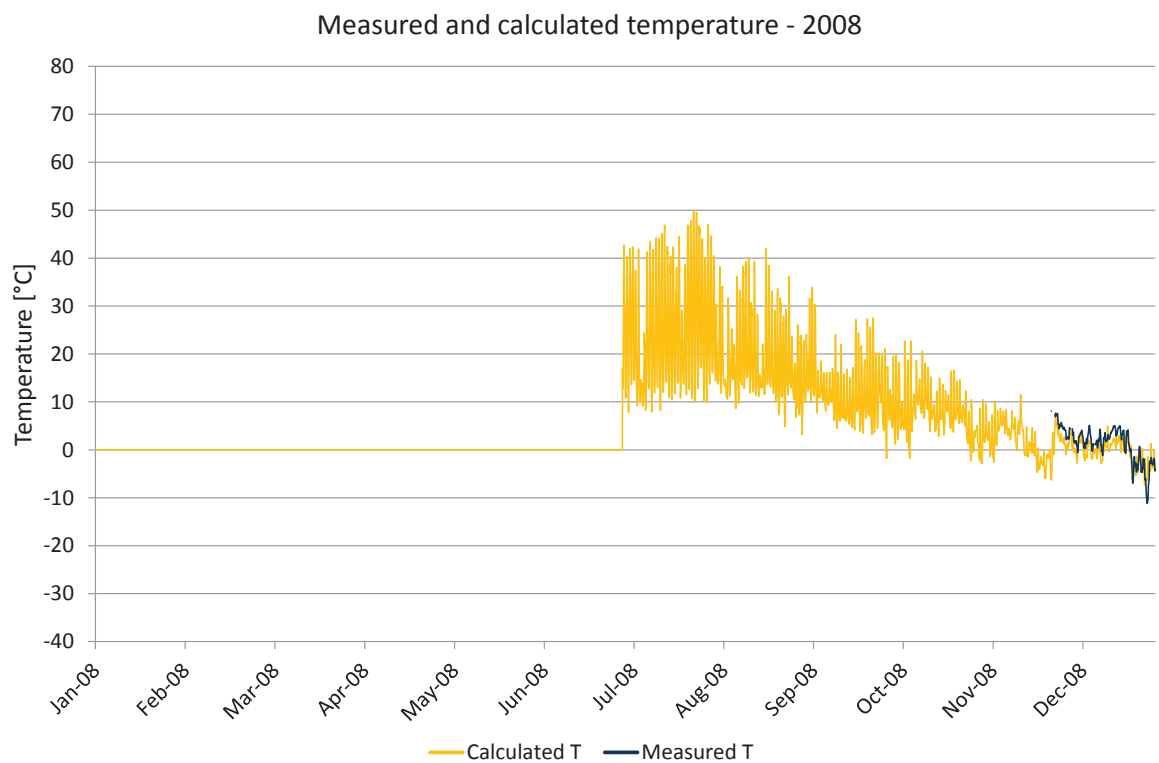


Figure 7.39.6. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

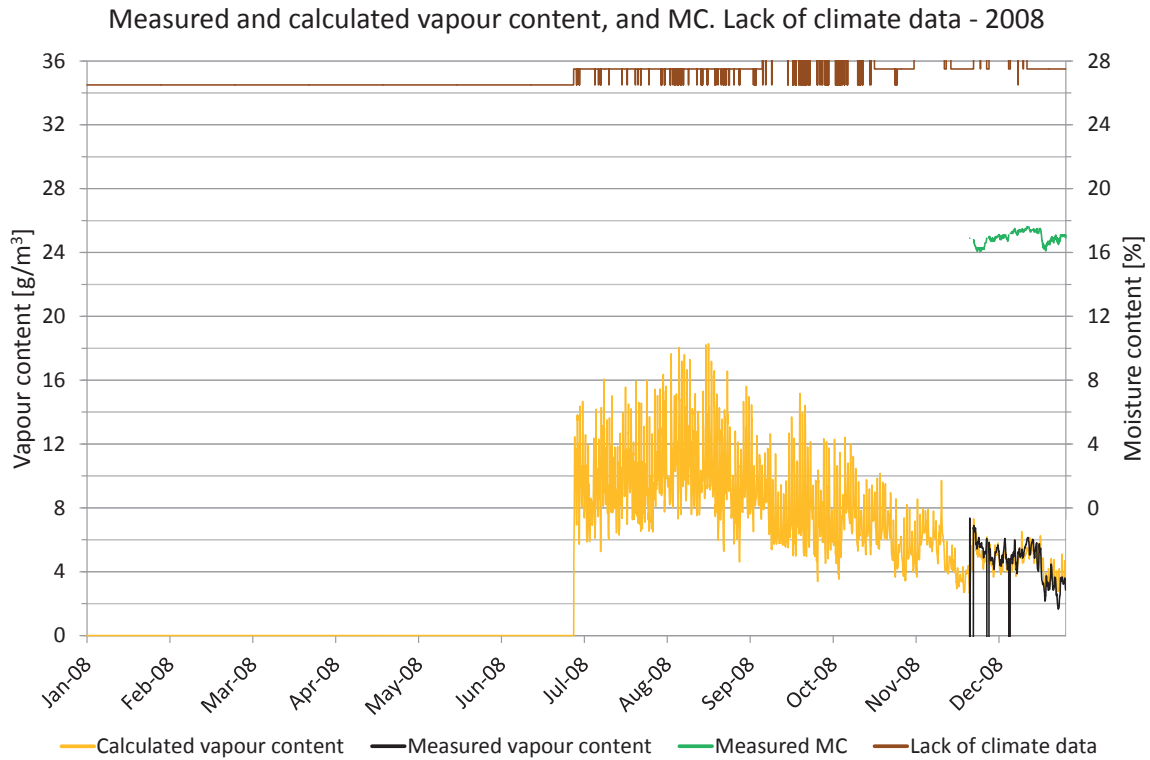


Figure 7.39.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

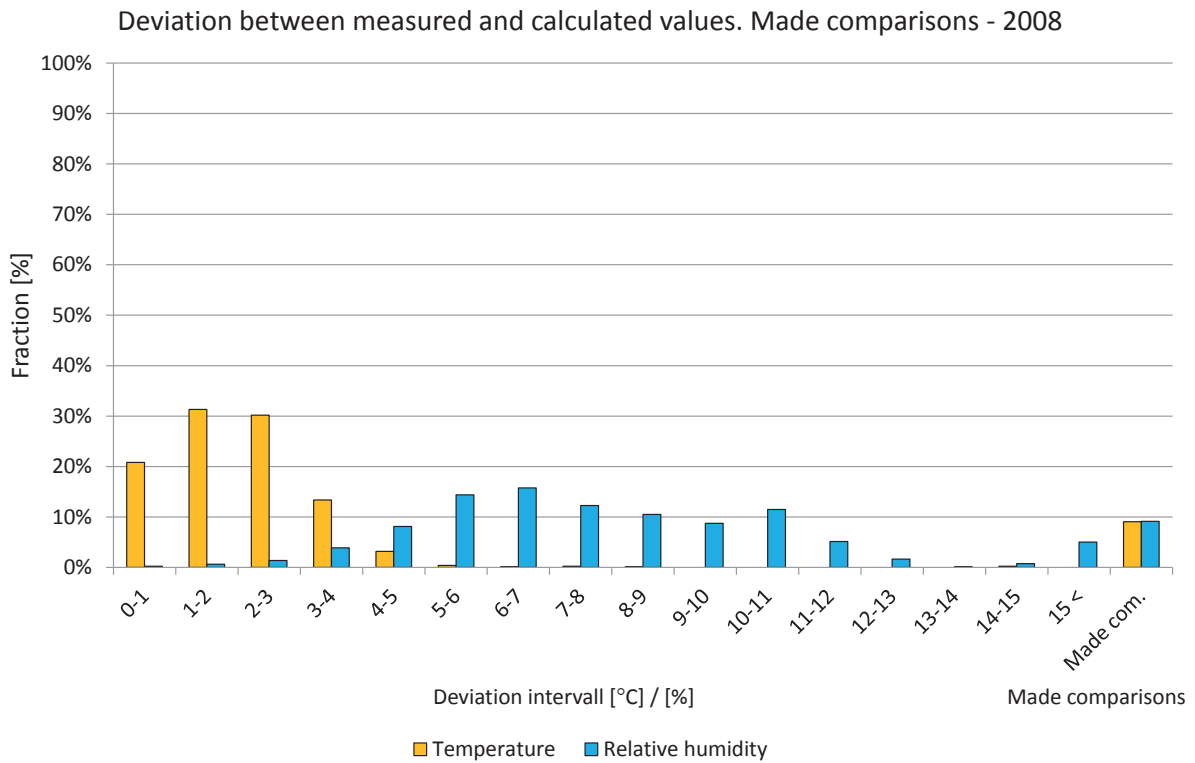


Figure 7.39.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

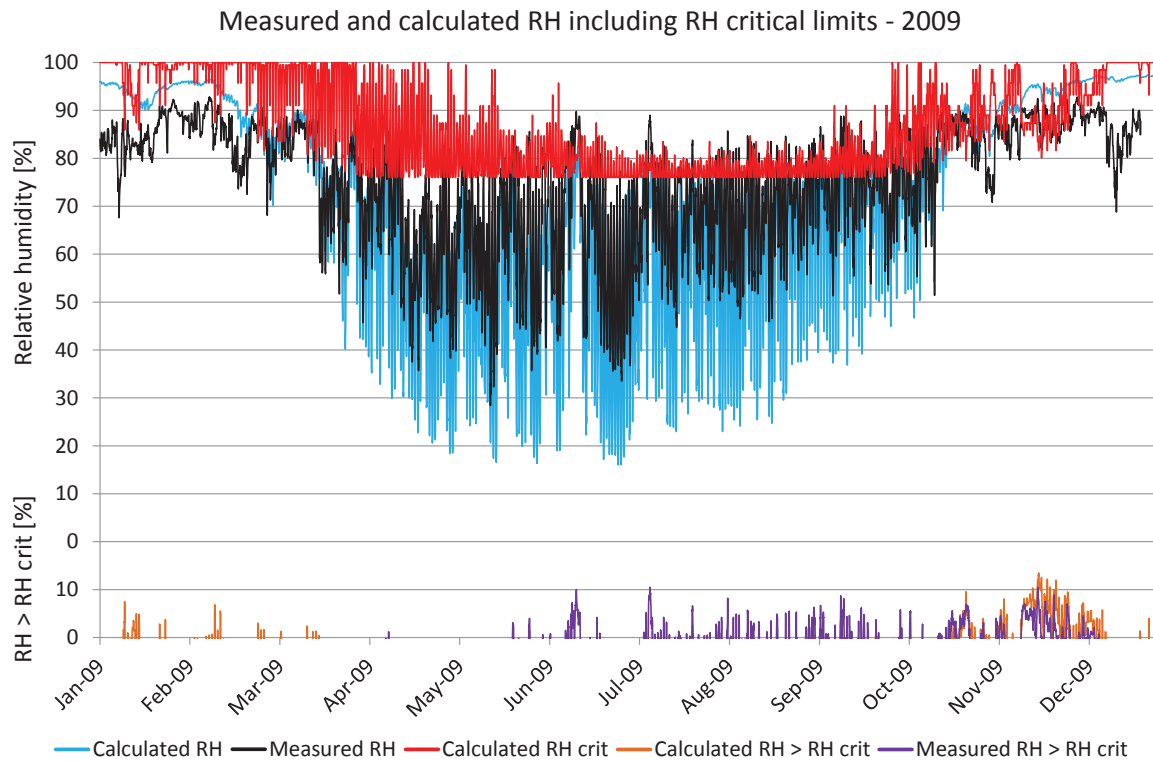


Figure 7.39.9. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

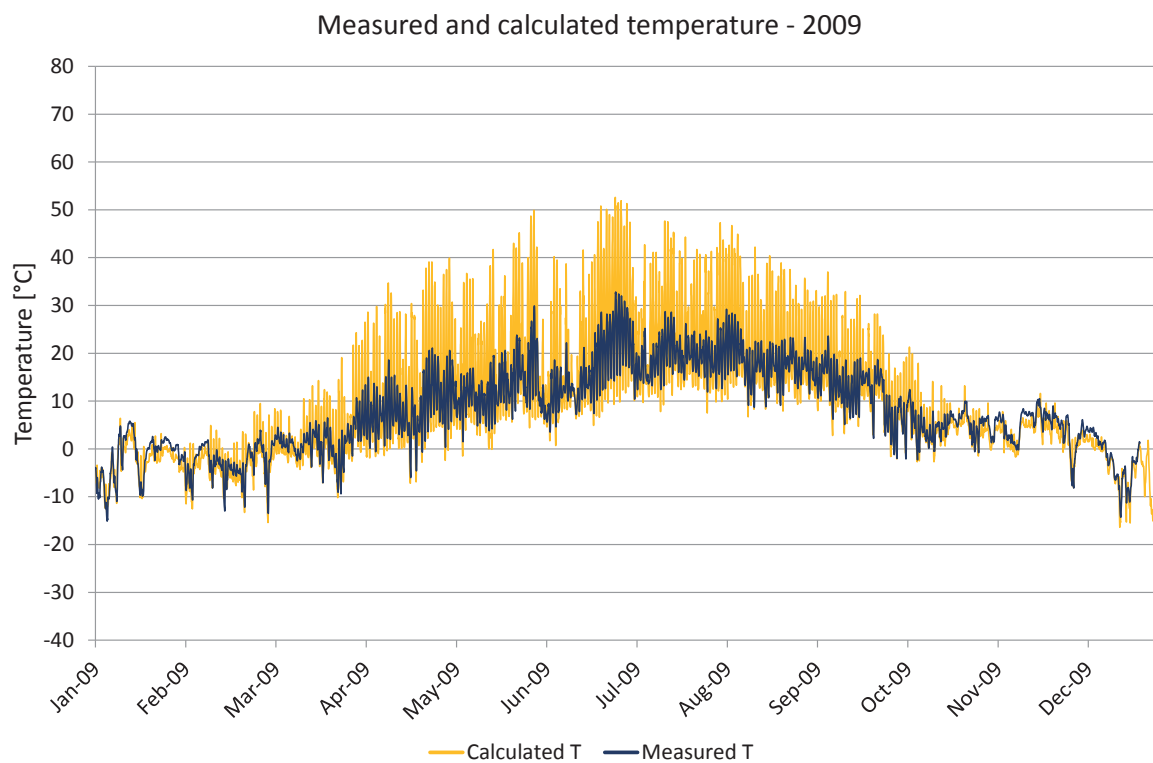


Figure 7.39.10. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

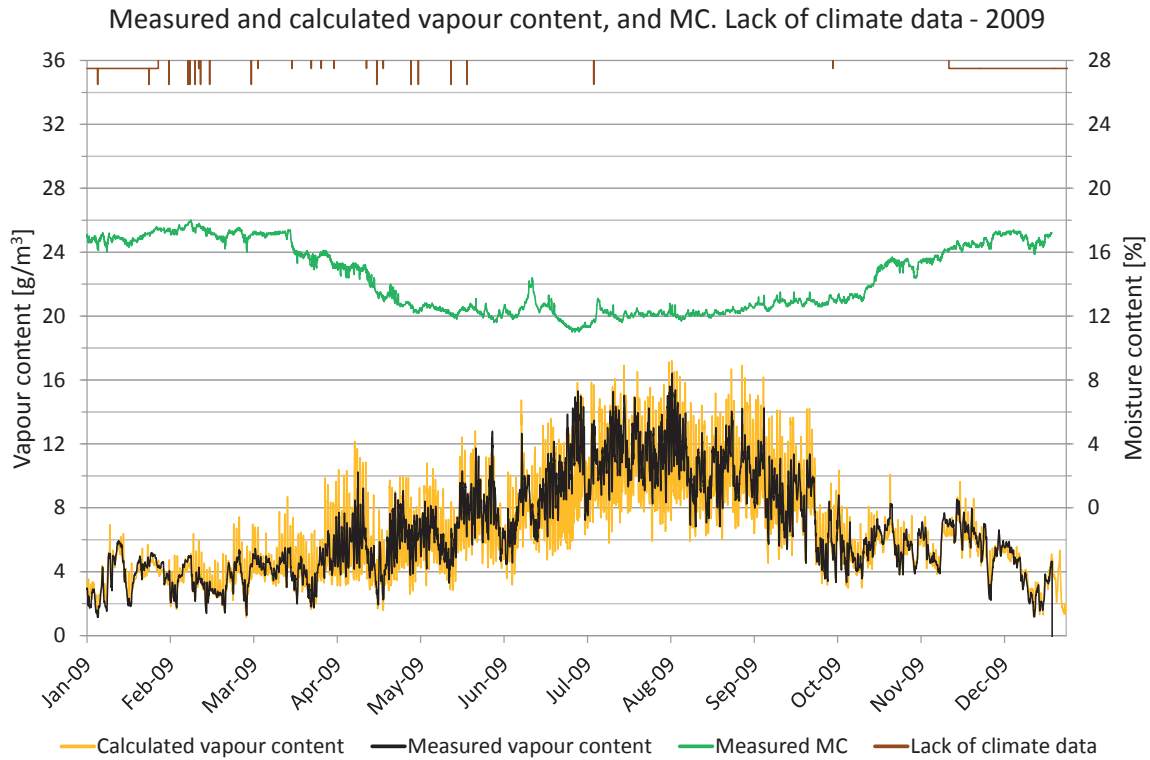


Figure 7.39.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

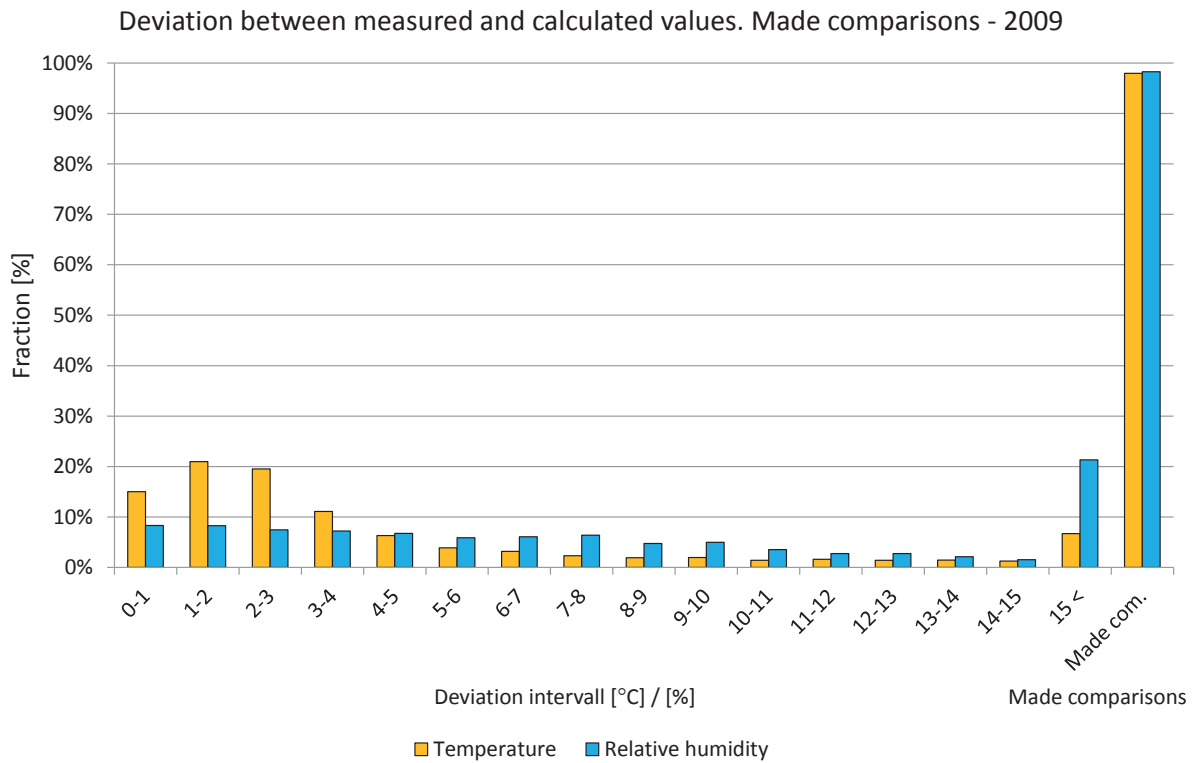


Figure 7.39.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

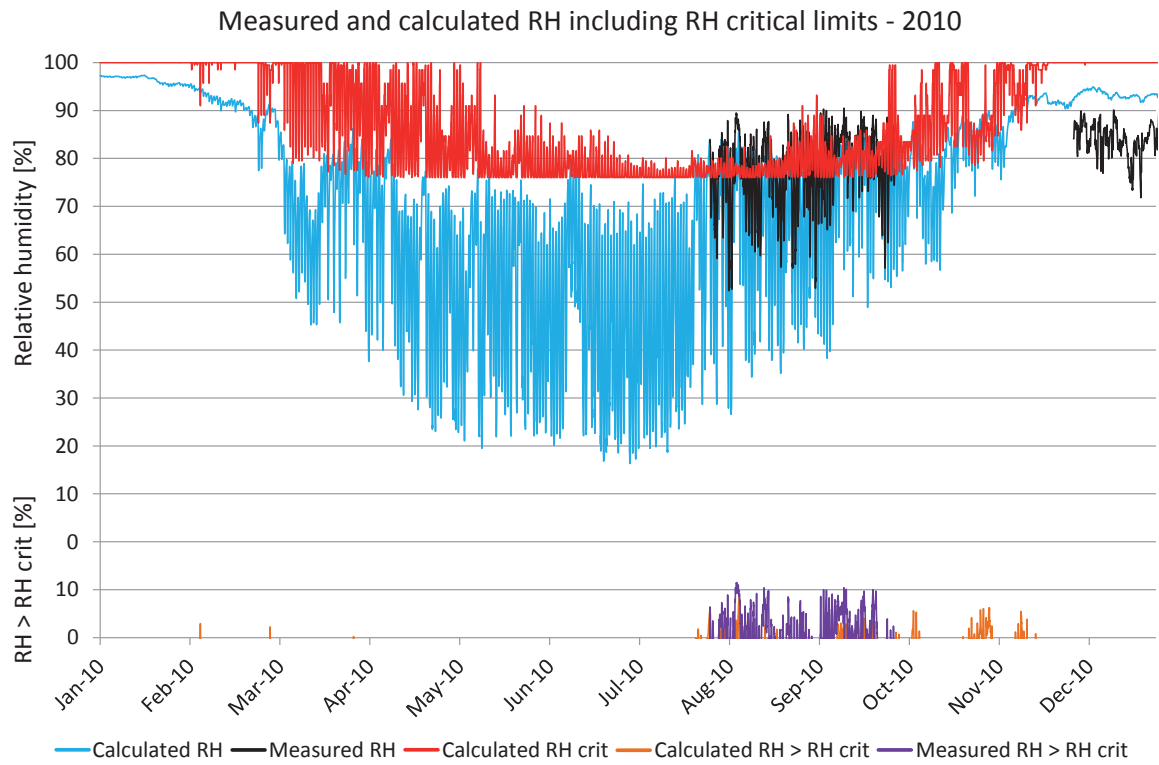


Figure 7.39.13. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

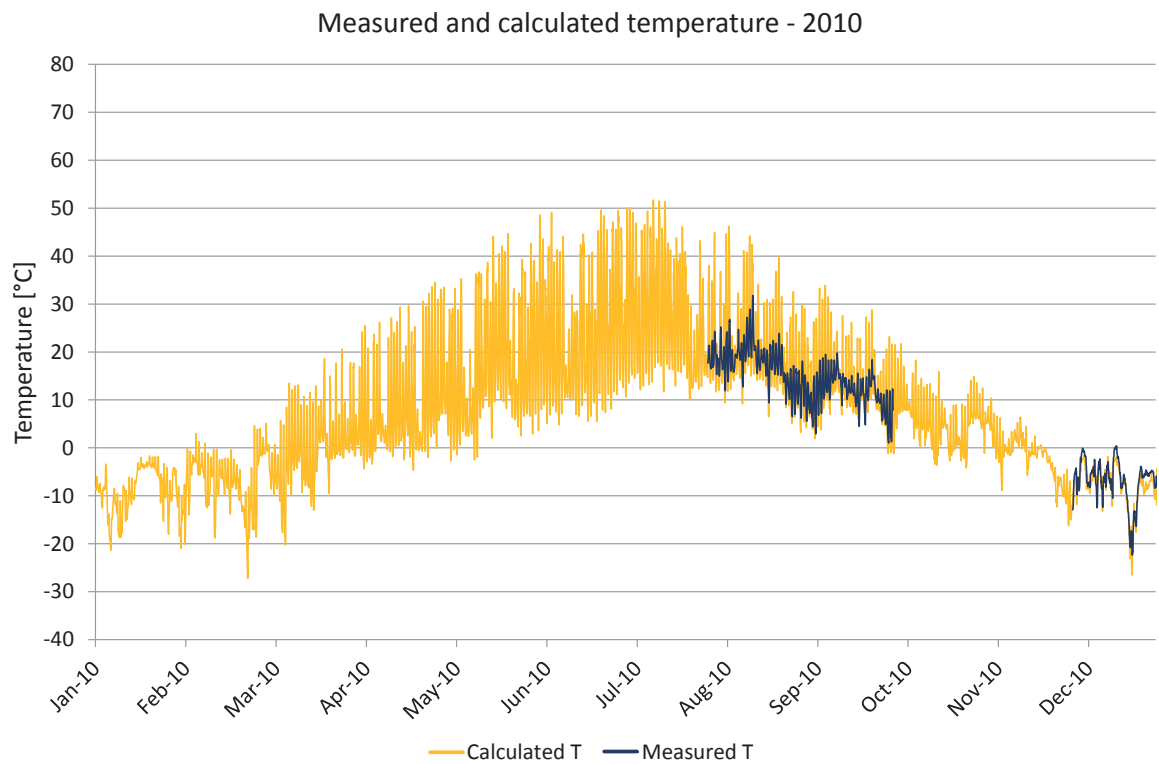


Figure 7.39.14. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

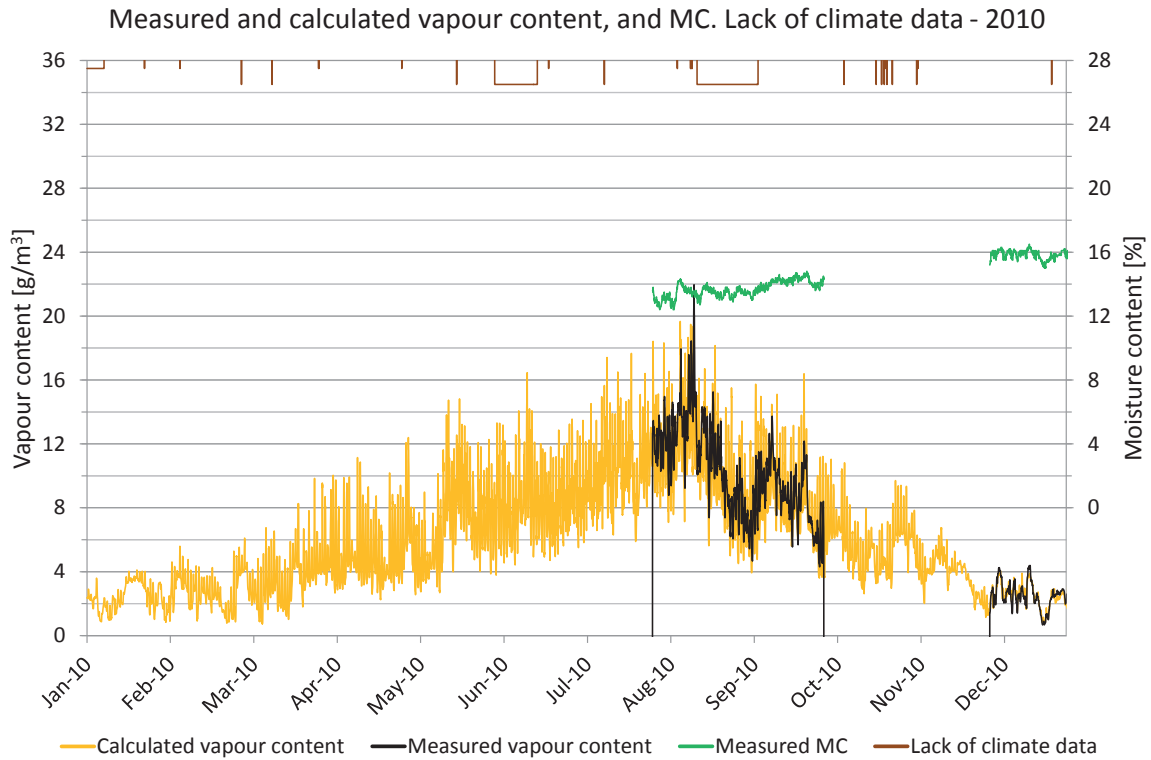


Figure 7.39.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

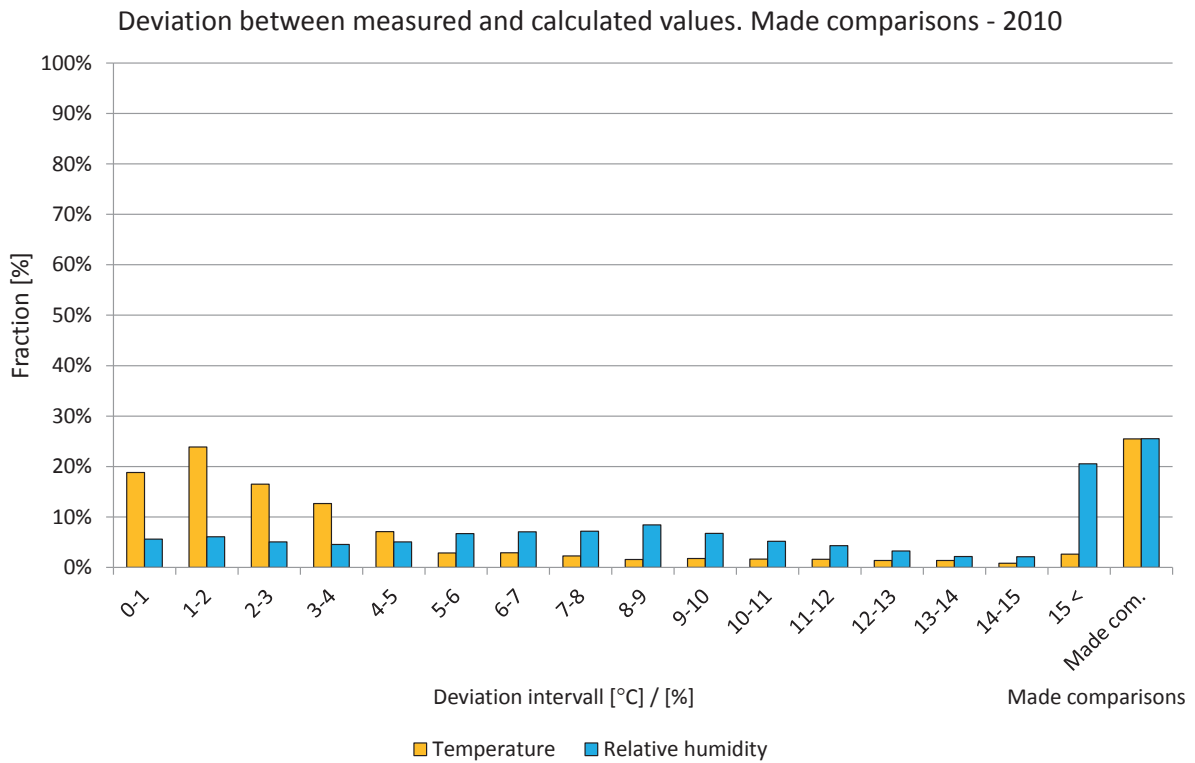


Figure 7.39.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

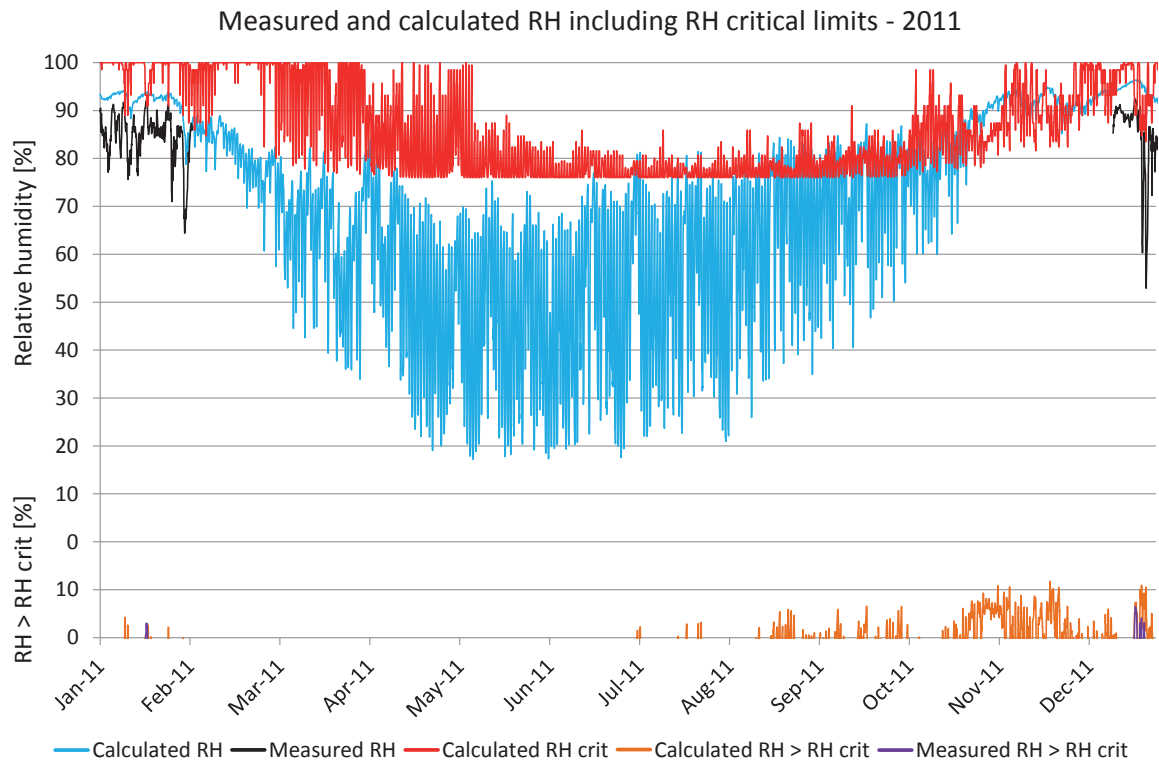


Figure 7.39.17. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

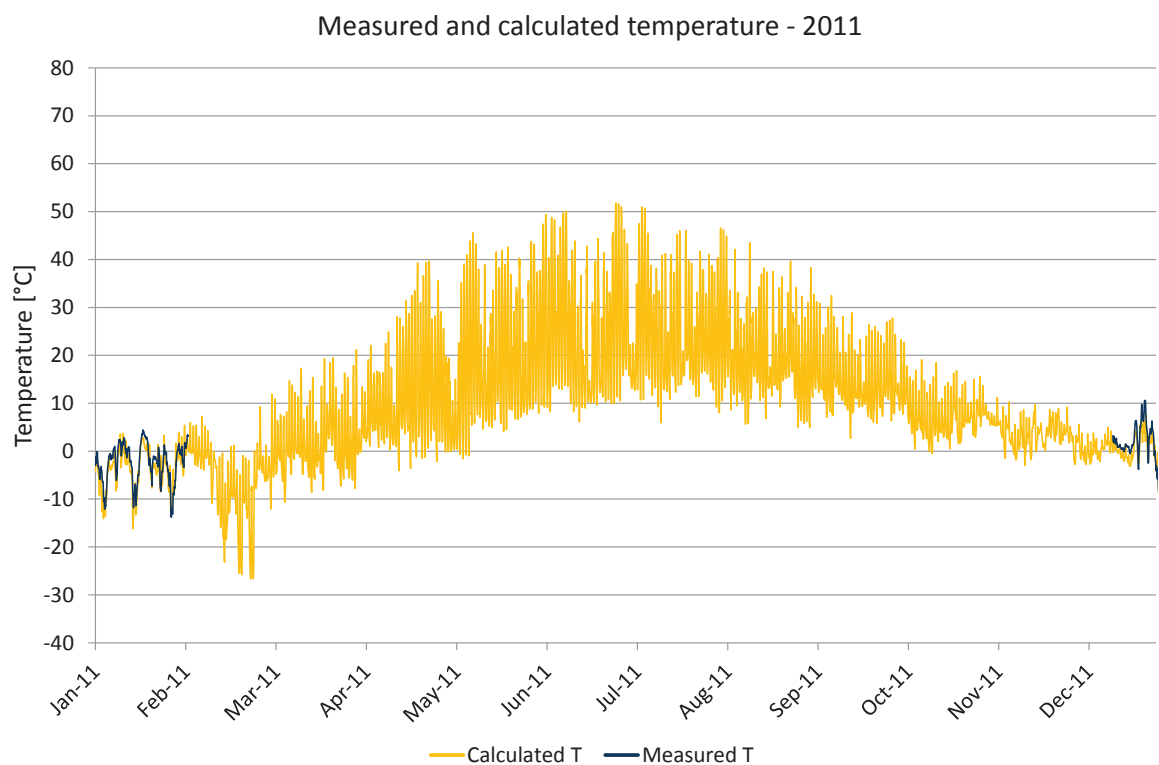


Figure 7.39.18. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

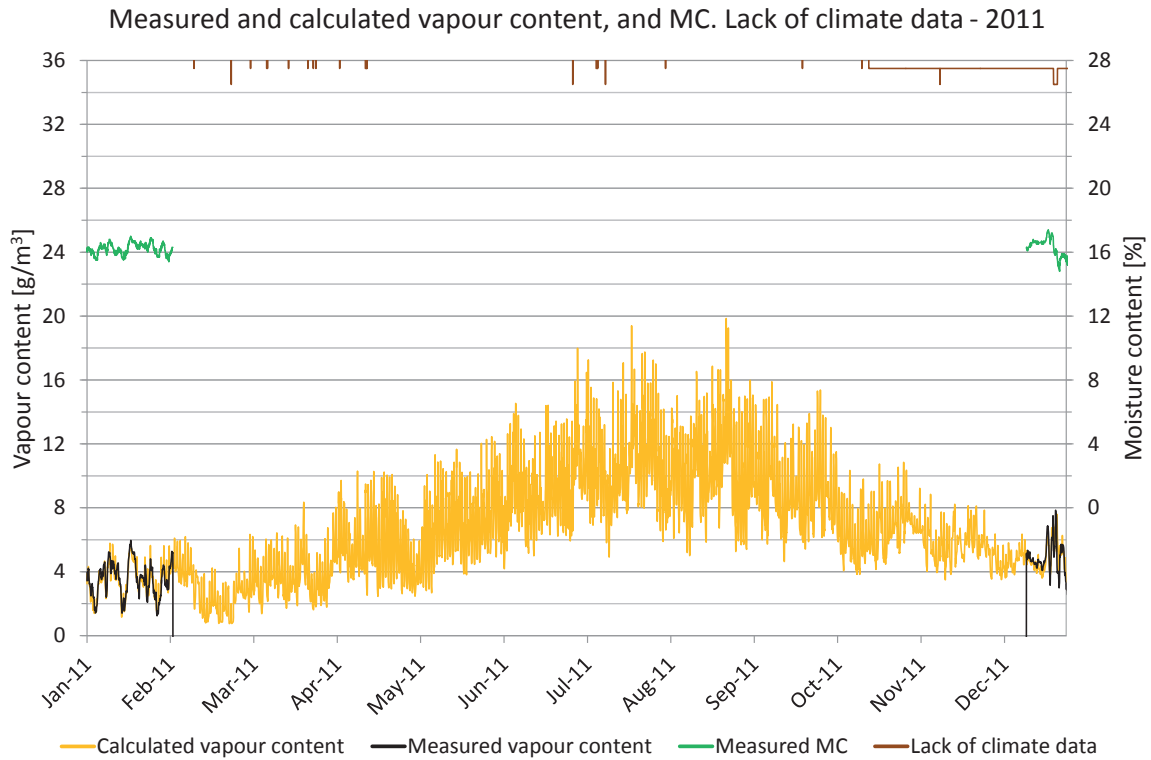


Figure 7.39.19. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

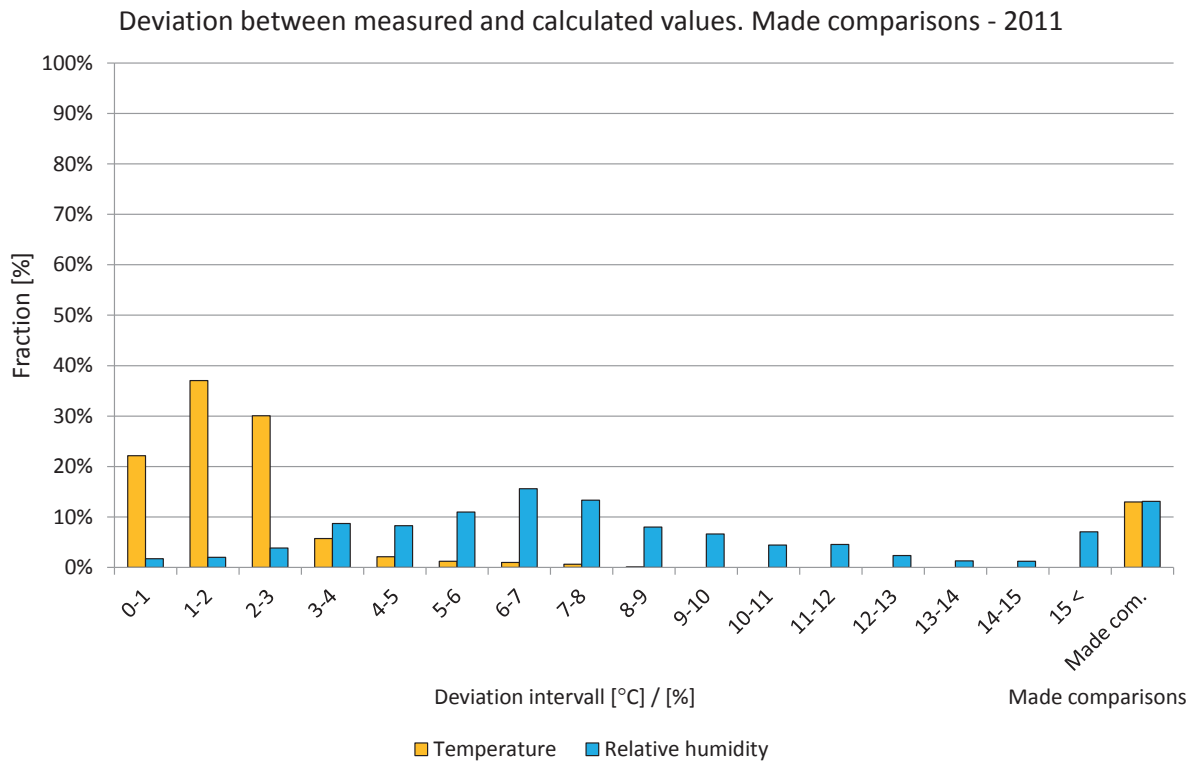


Figure 7.39.20. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.42 Position 42

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

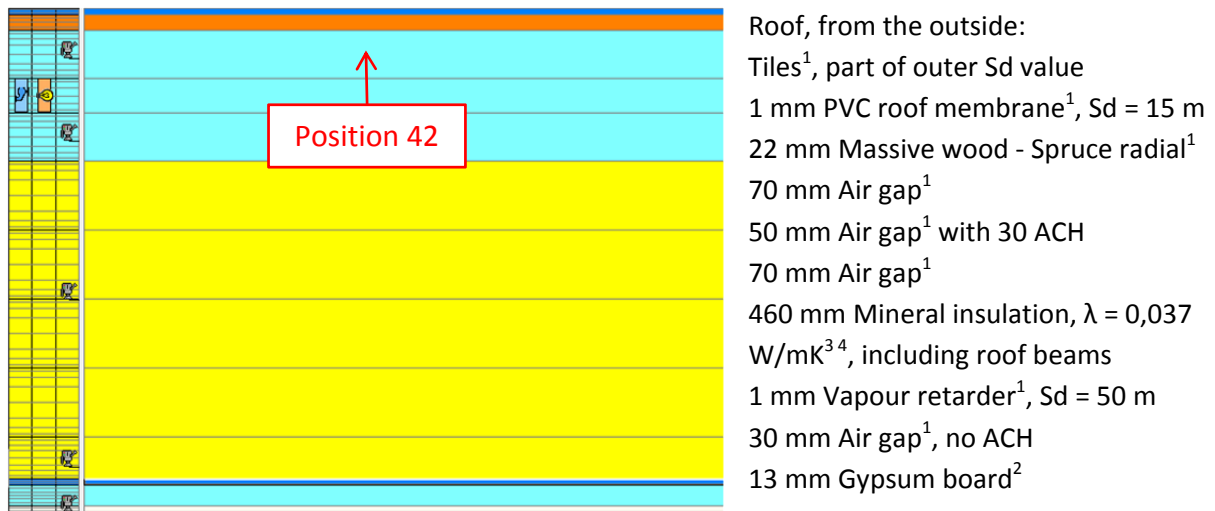


Figure 7.42.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

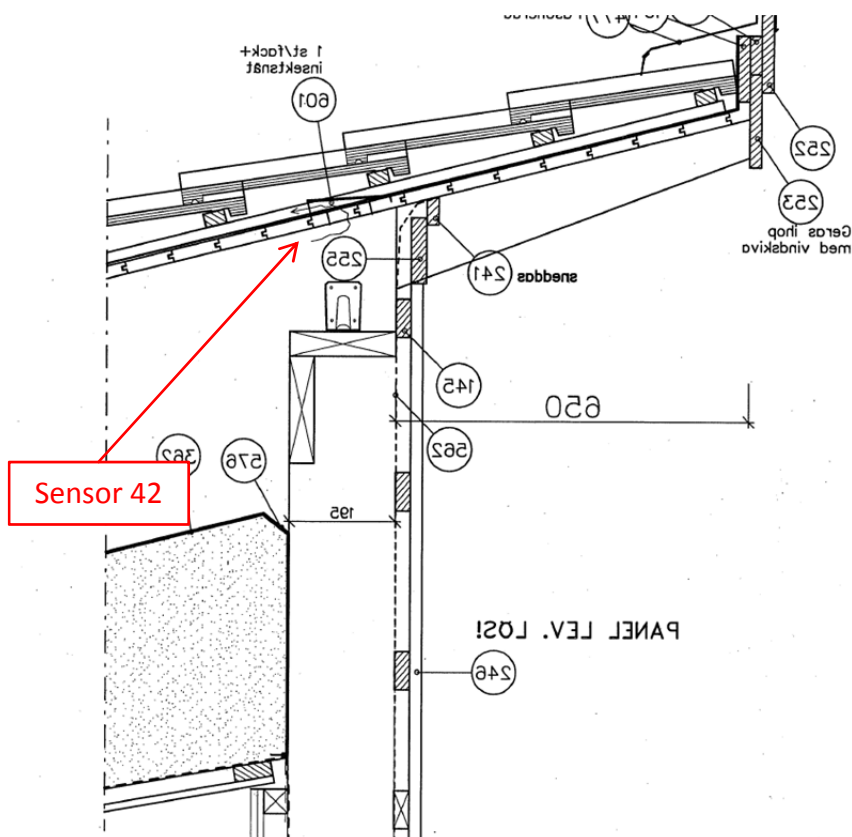


Figure 7.42.2. Location of the studied position.



Figure 7.42.3. Location of the studied position. Photo: SP Trä Skellefteå.

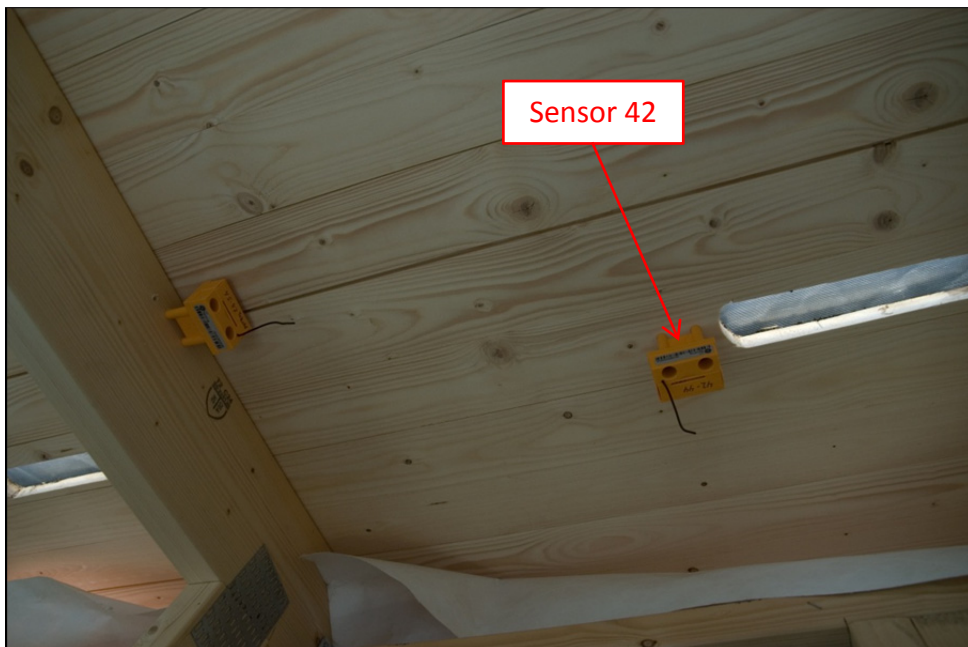


Figure 7.42.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

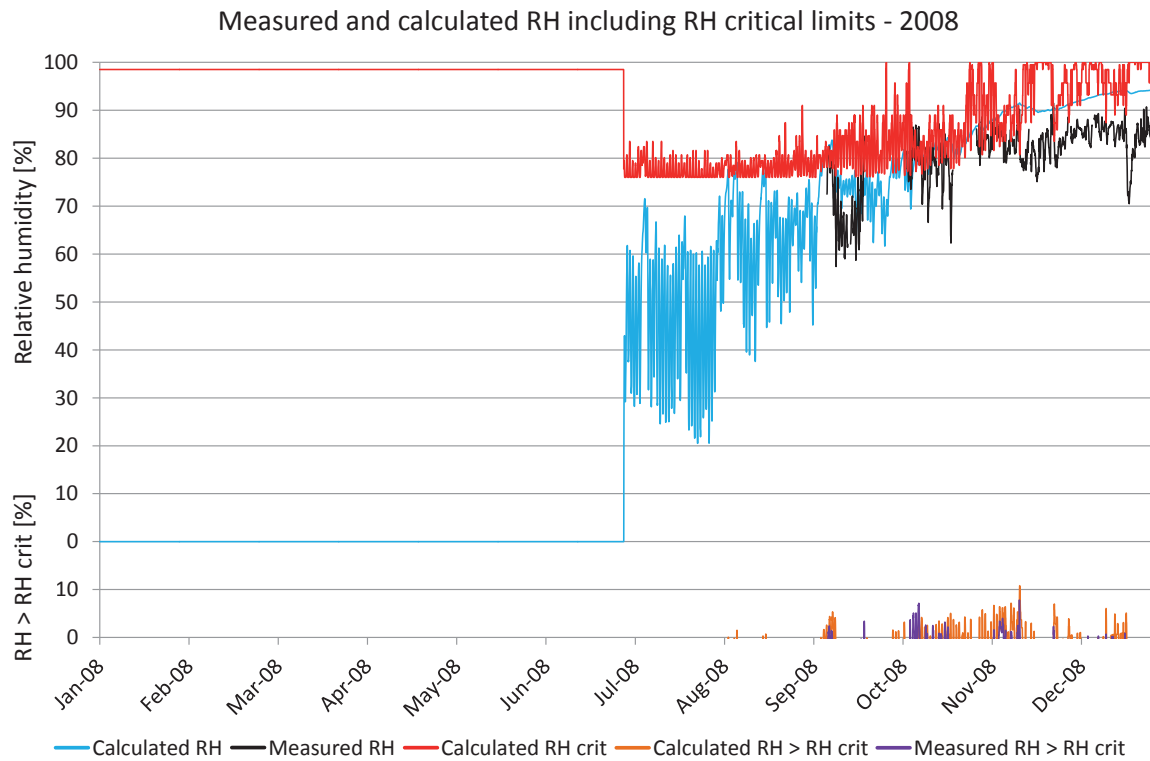


Figure 7.42.5. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

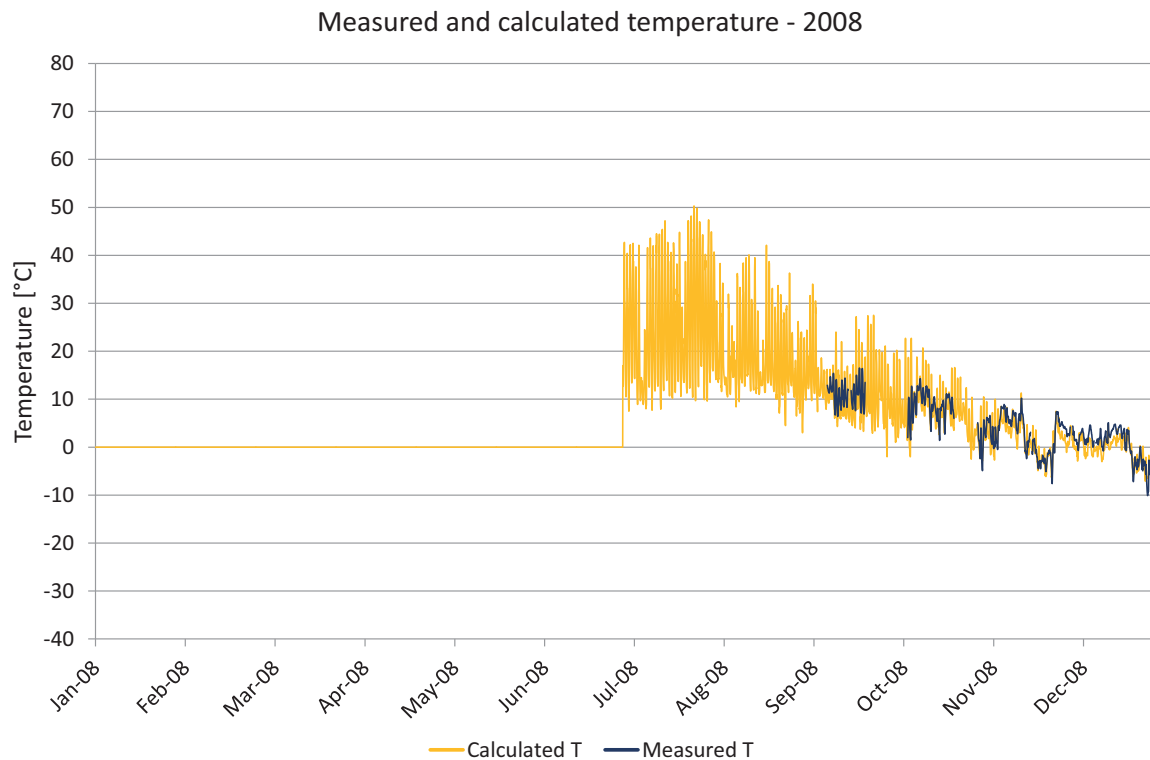


Figure 7.42.6. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

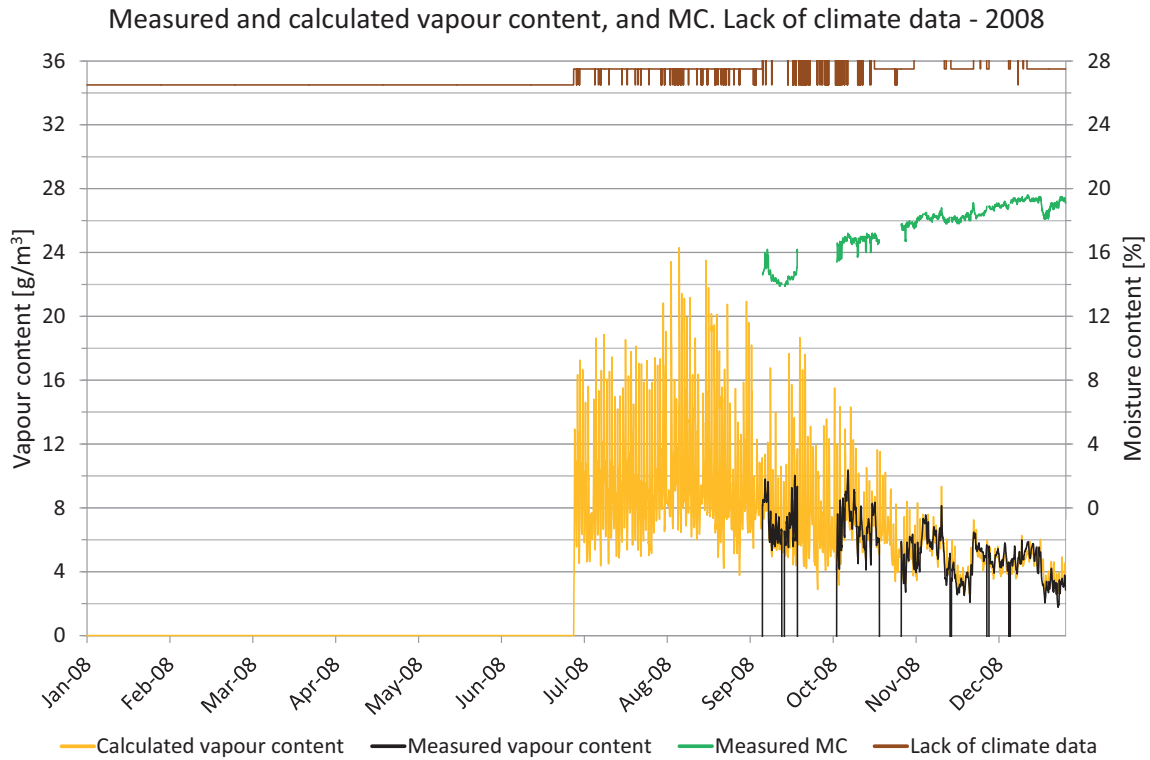


Figure 7.42.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

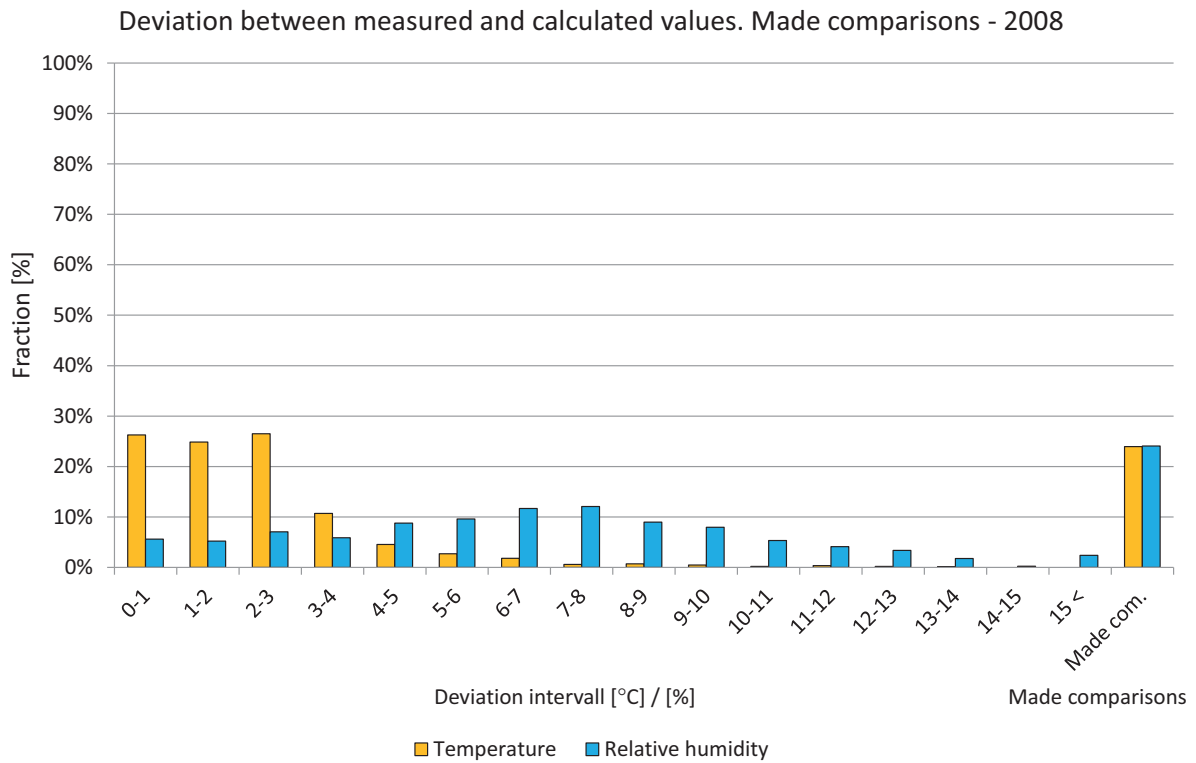


Figure 7.42.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

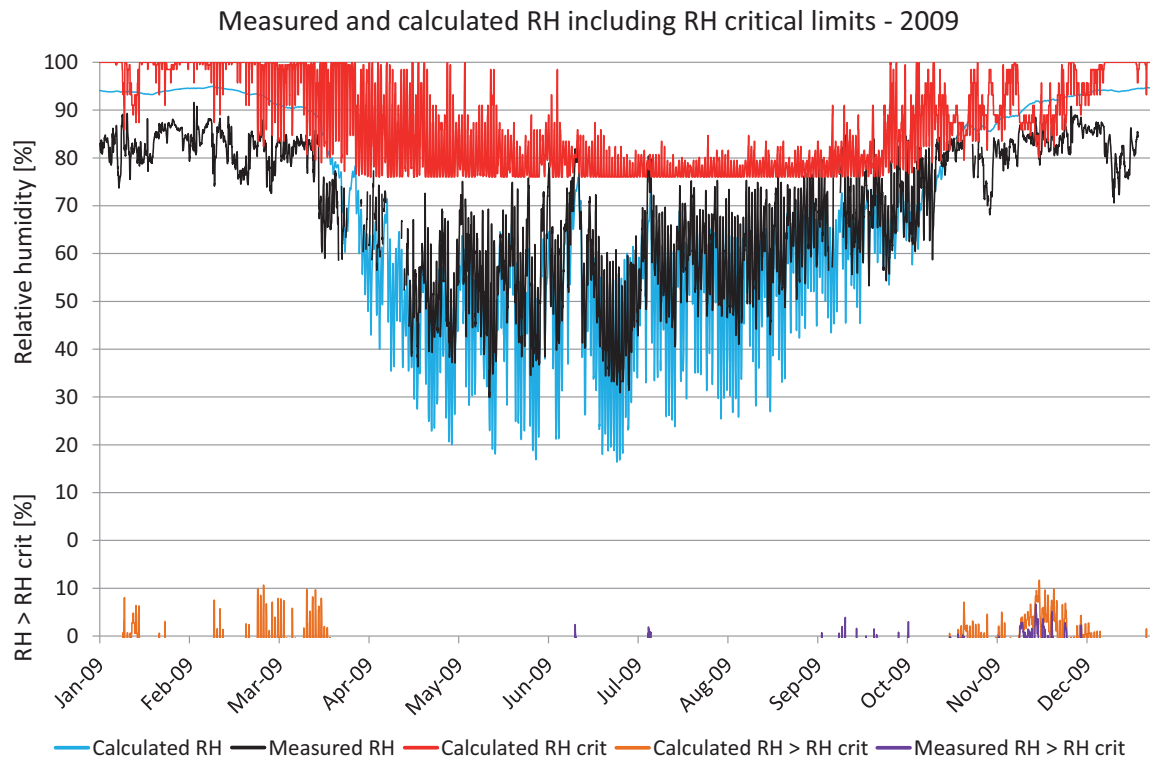


Figure 7.42.9. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

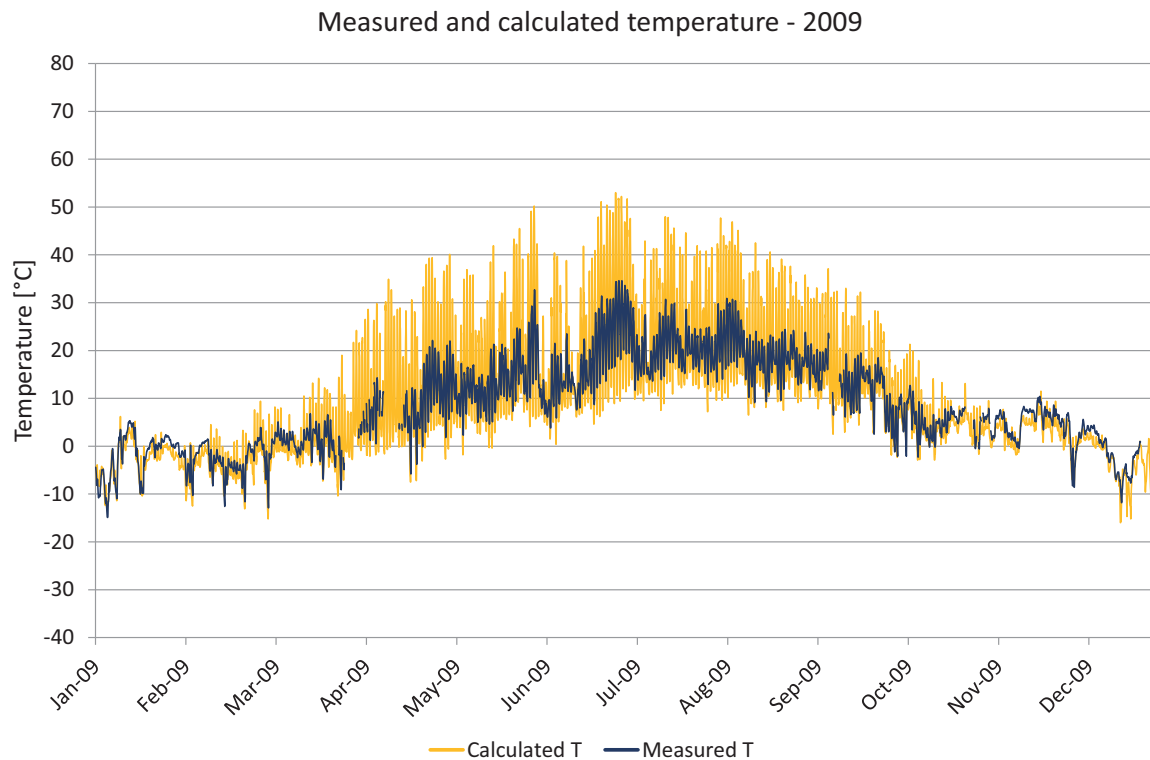


Figure 7.42.10. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

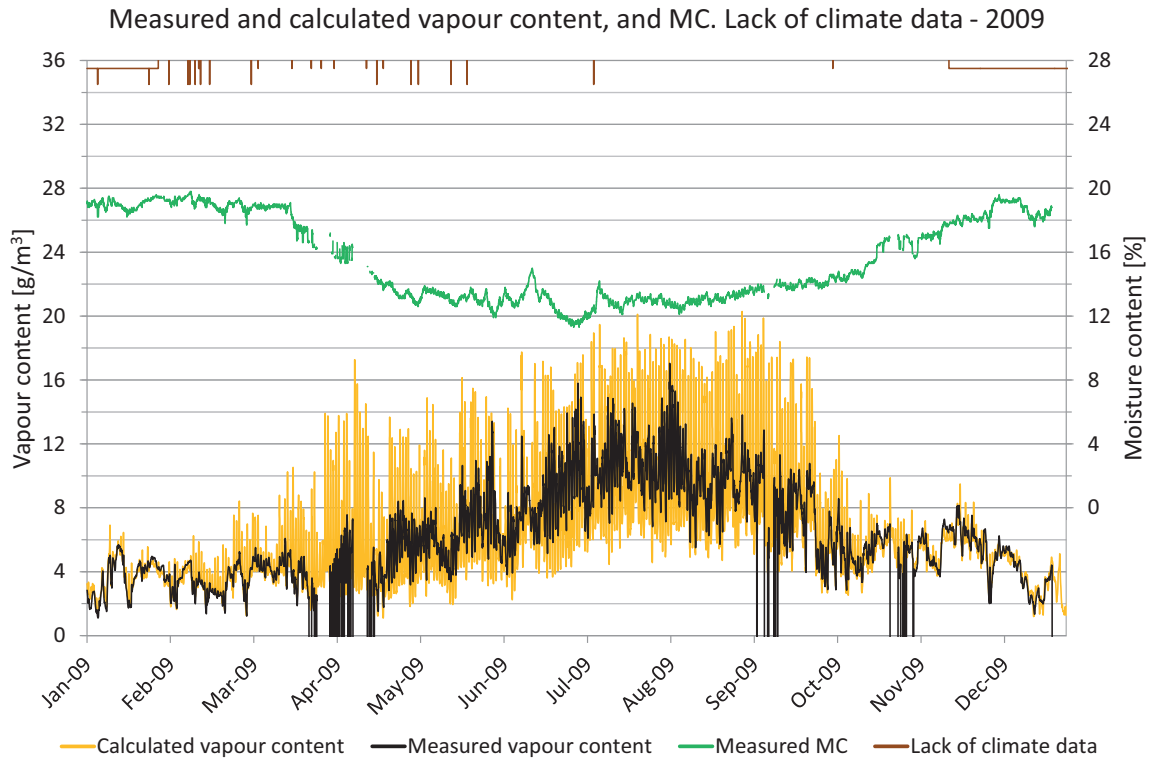


Figure 7.42.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

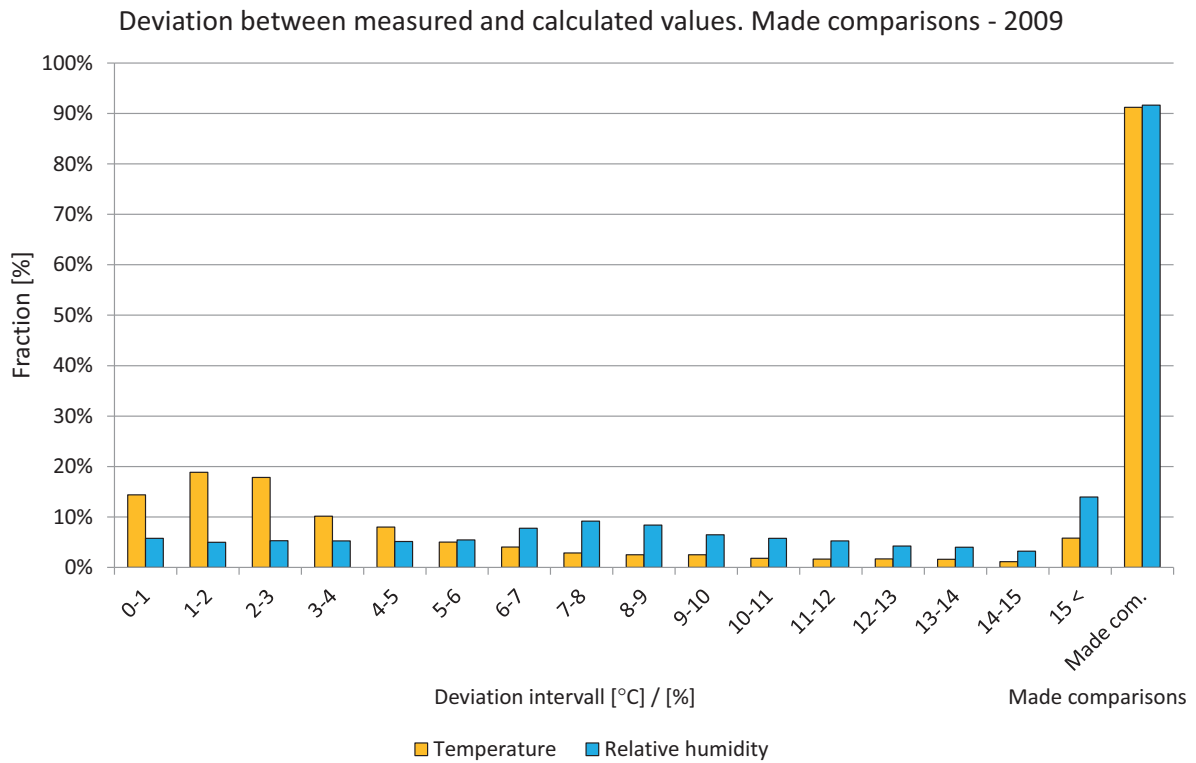


Figure 7.42.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

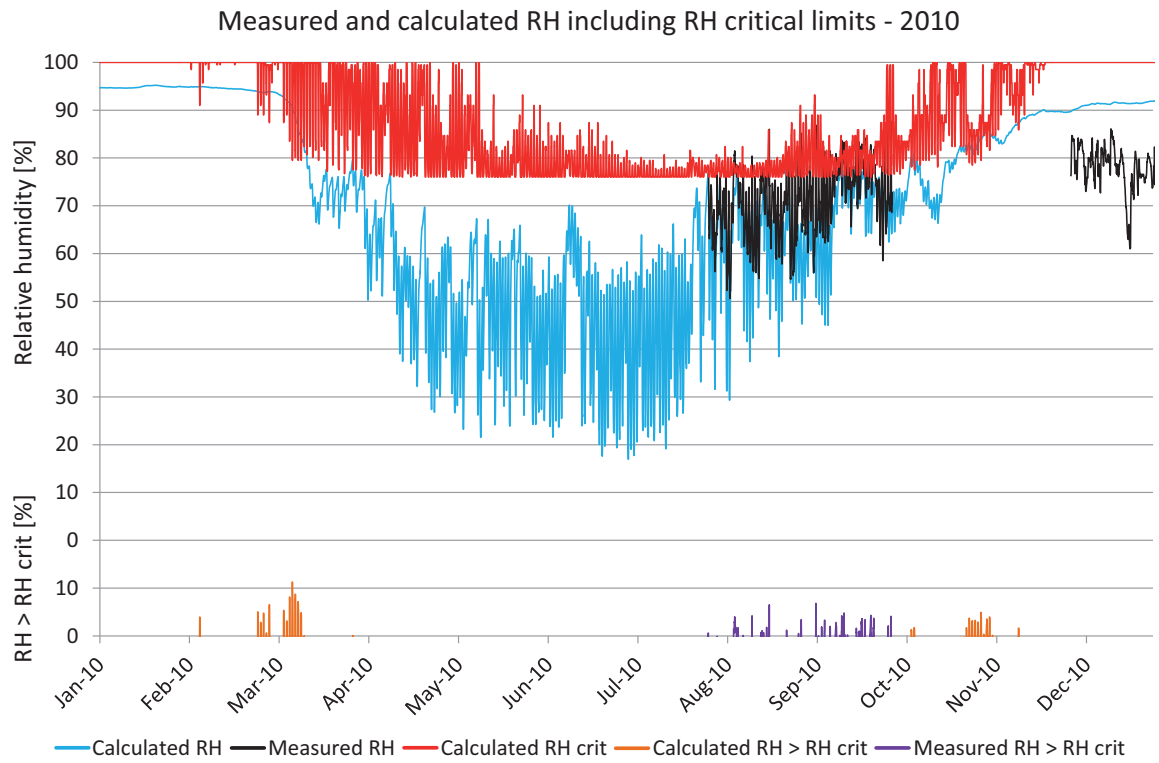


Figure 7.42.13. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

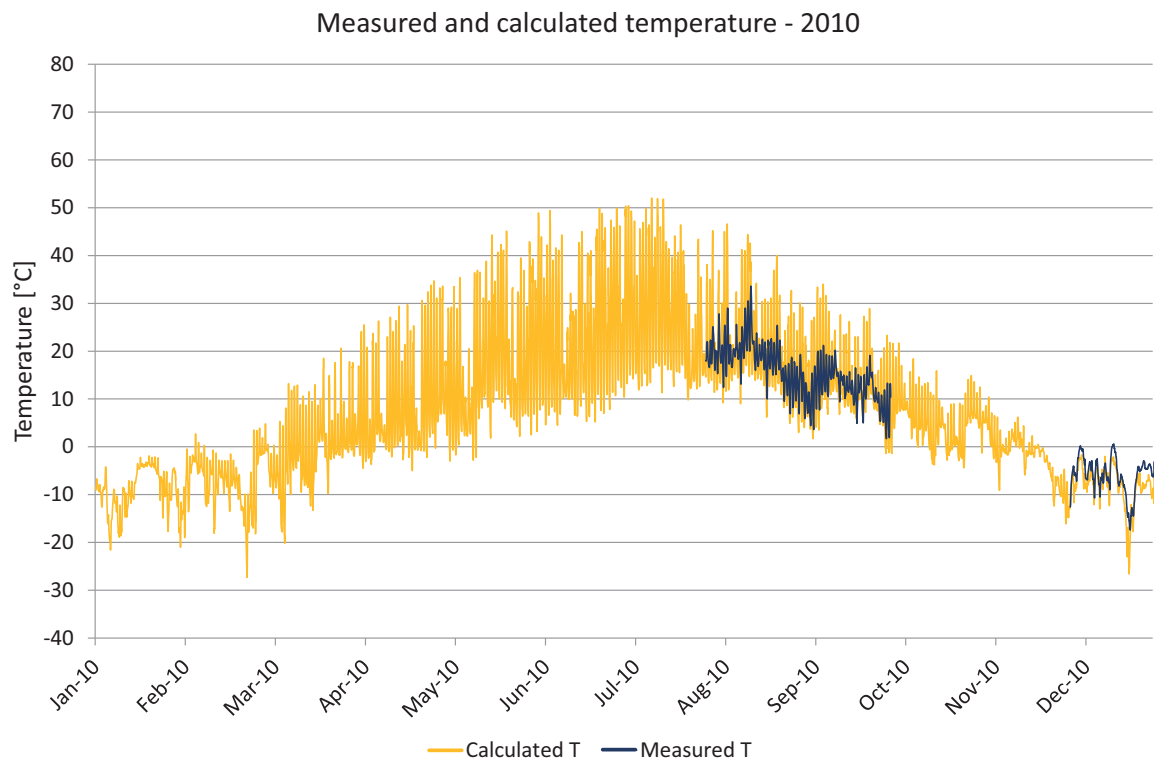


Figure 7.42.14. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

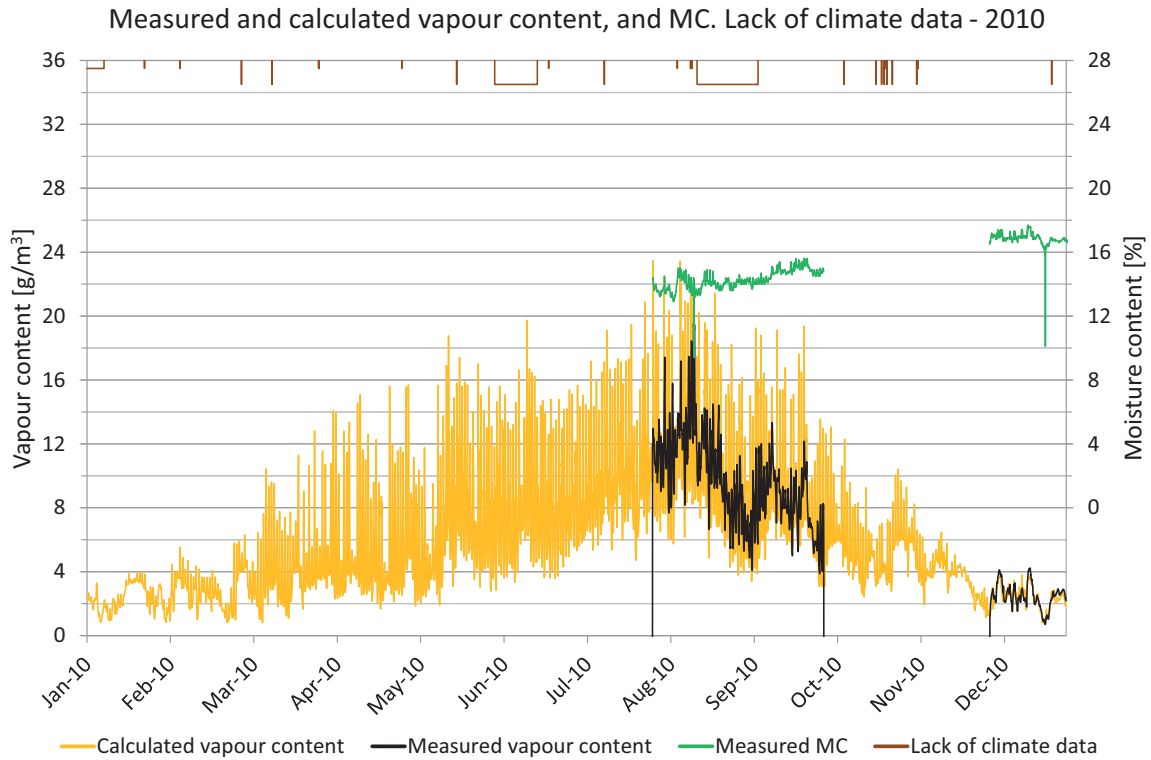


Figure 7.42.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

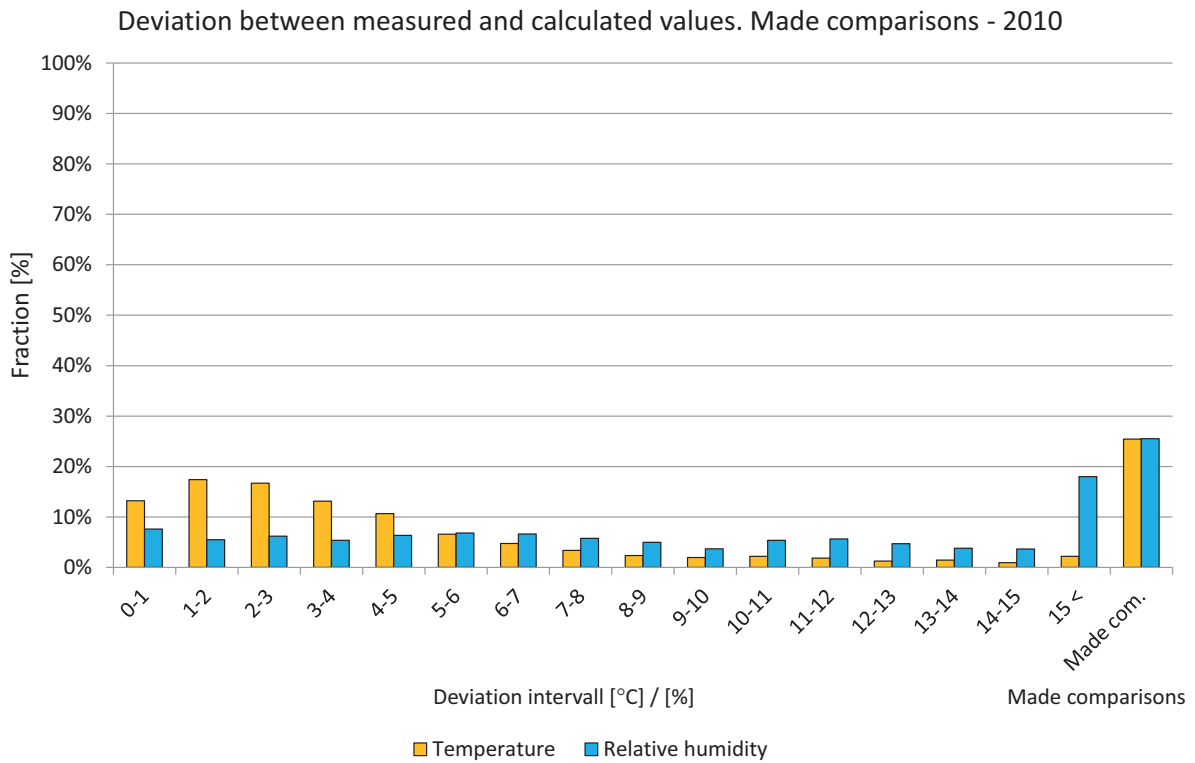


Figure 7.42.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

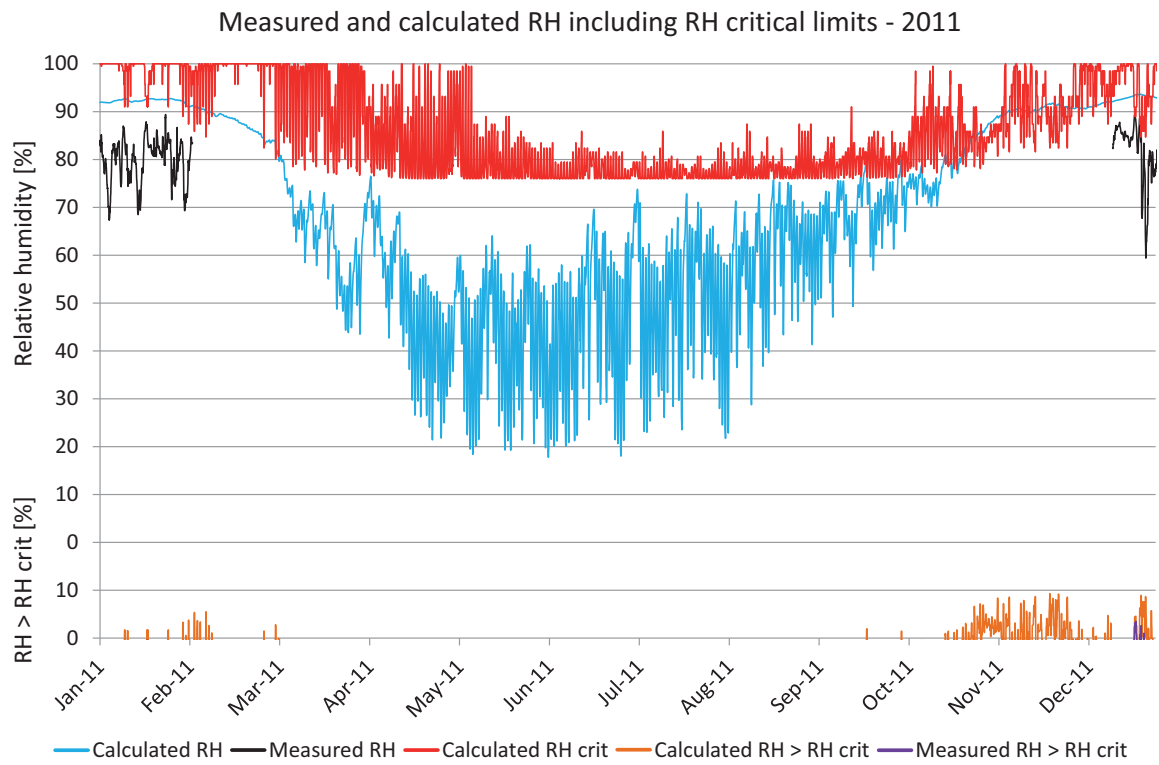


Figure 7.42.17. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

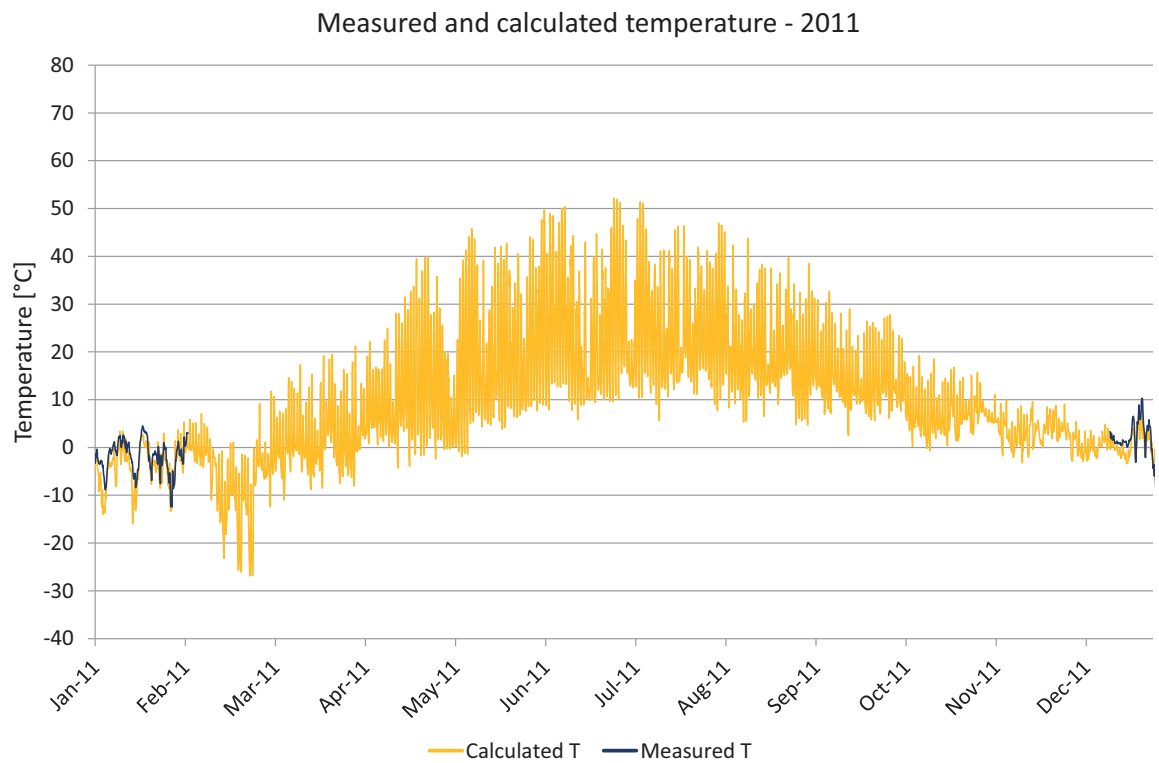


Figure 7.42.18. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

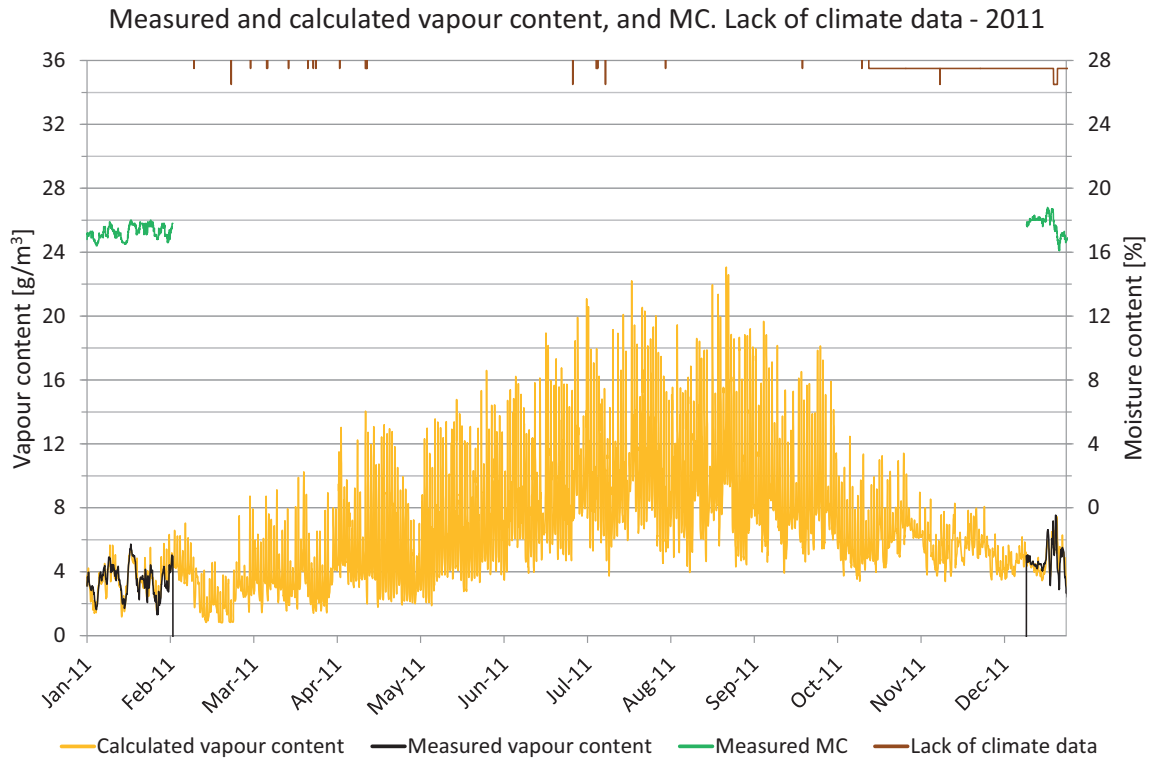


Figure 7.42.19. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

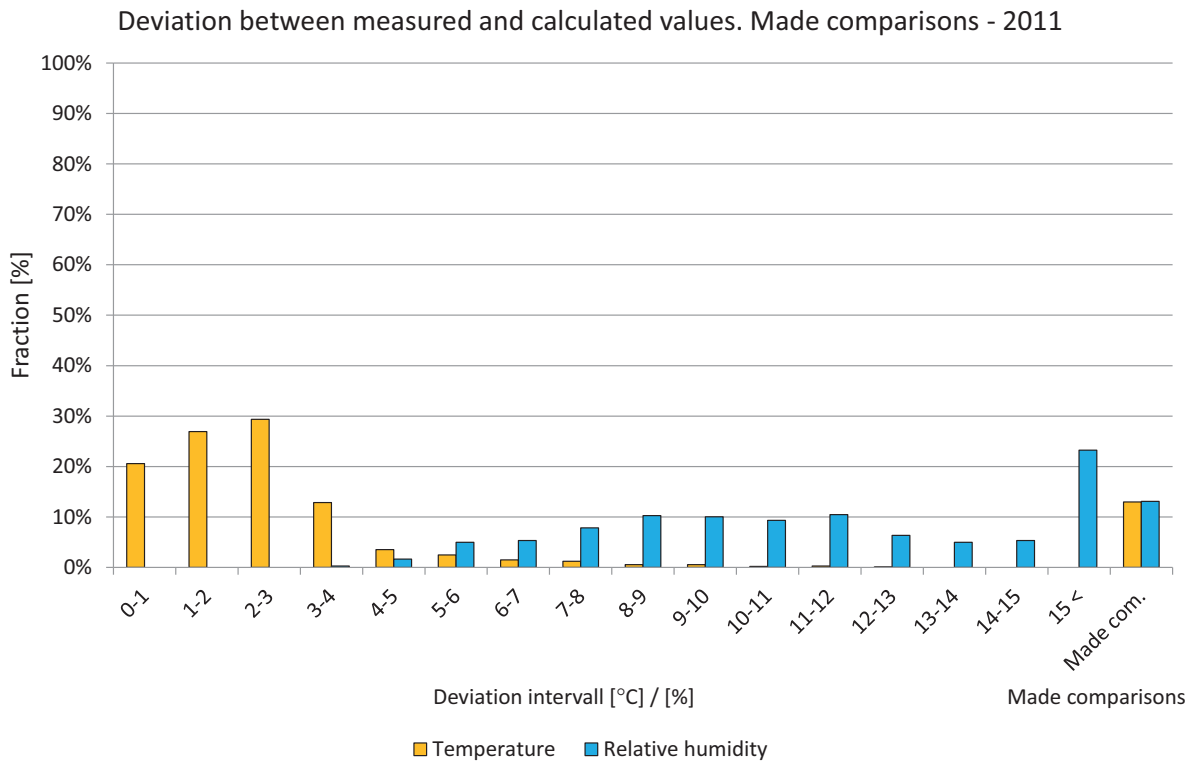


Figure 7.42.20. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.45 Position 45

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

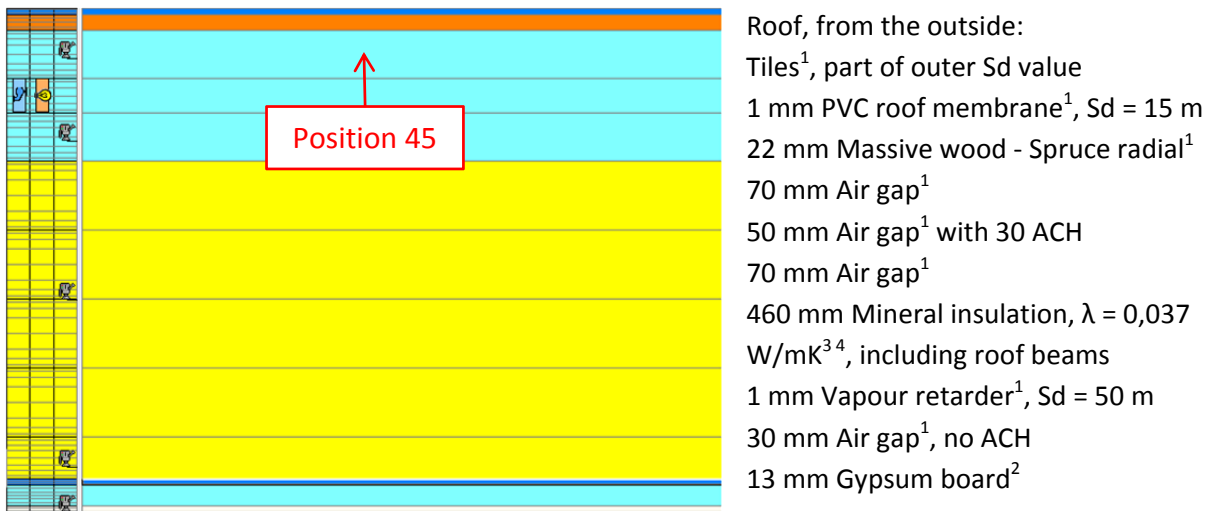


Figure 7.45.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

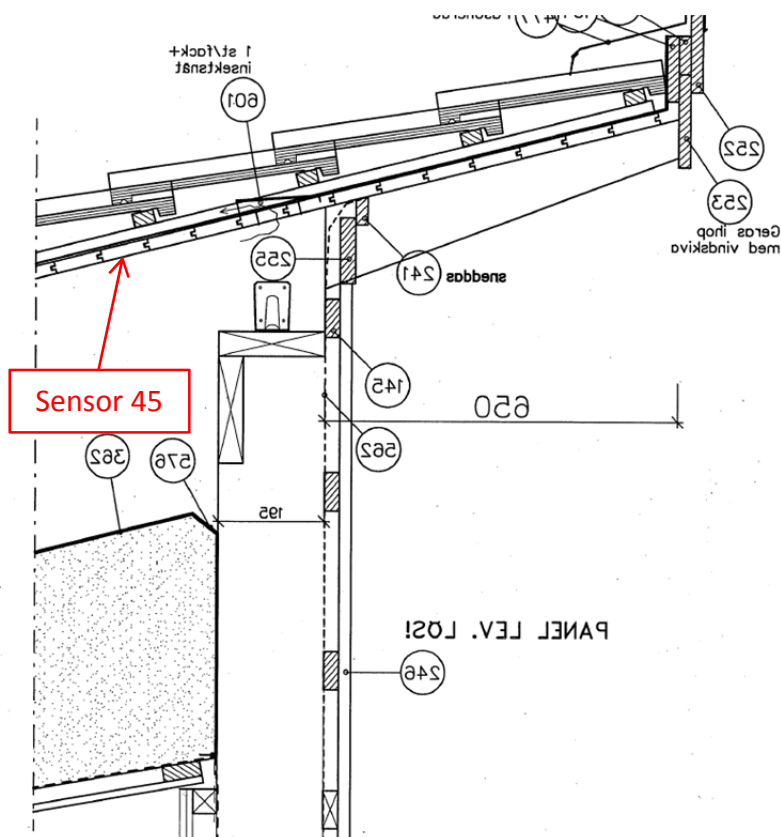


Figure 7.45.2. Location of the studied position.



Figure 7.45.3. Location of the studied position. Photo: SP Trä Skellefteå.



Figure 7.45.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

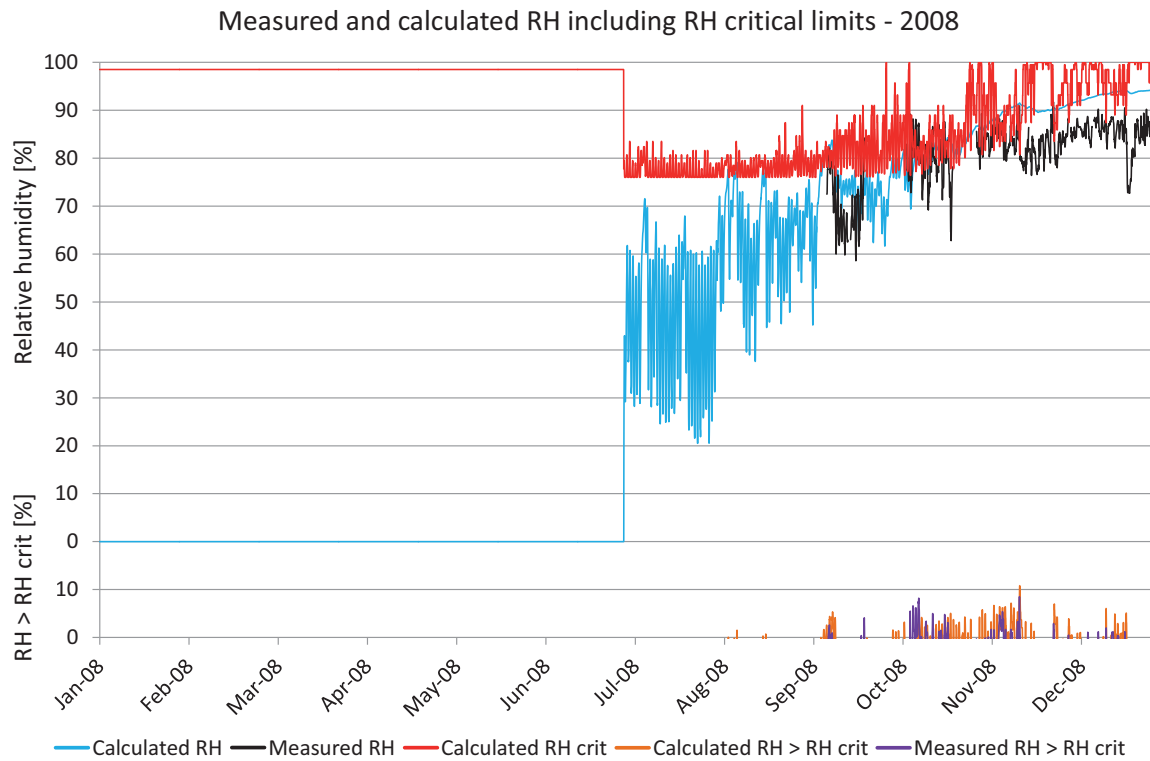


Figure 7.45.5. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

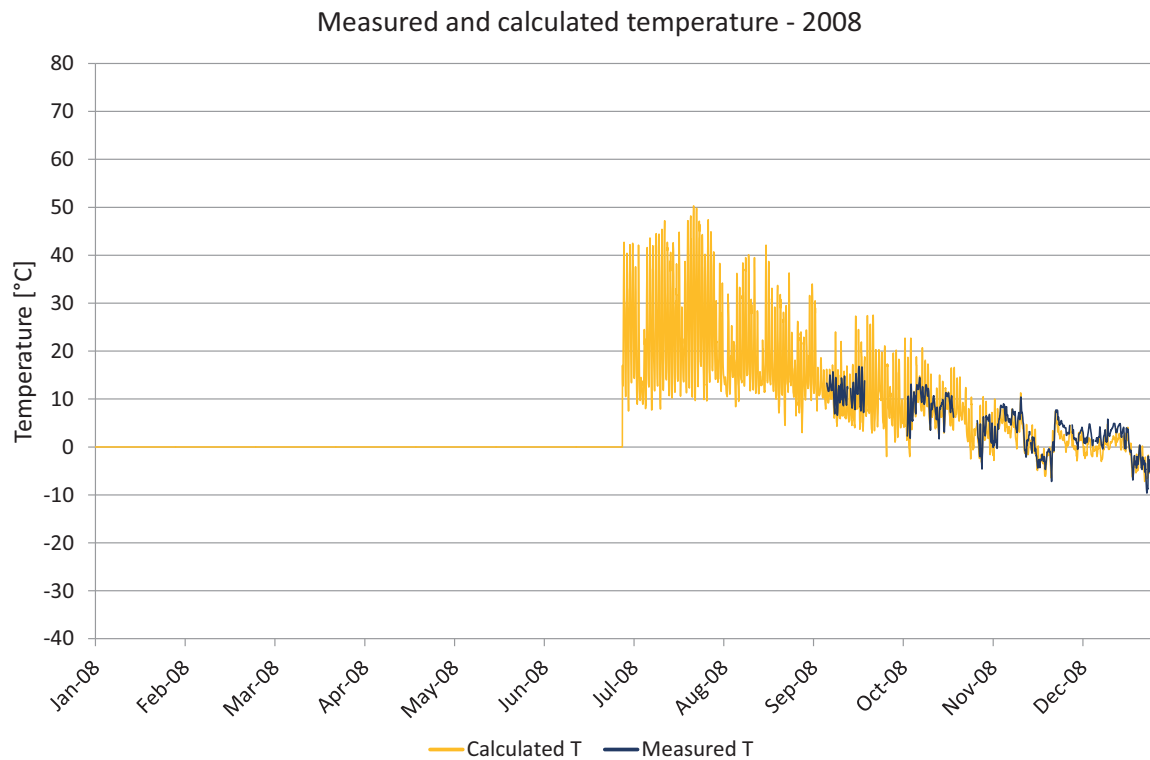


Figure 7.45.6. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

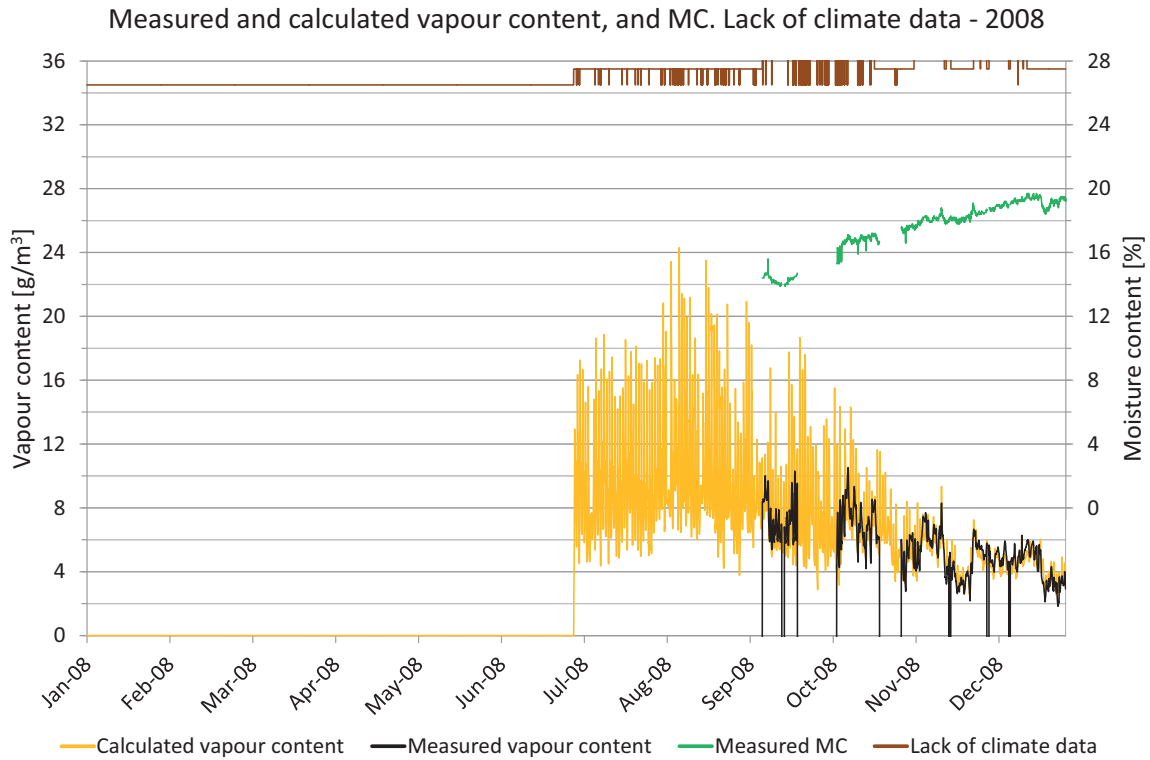


Figure 7.45.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

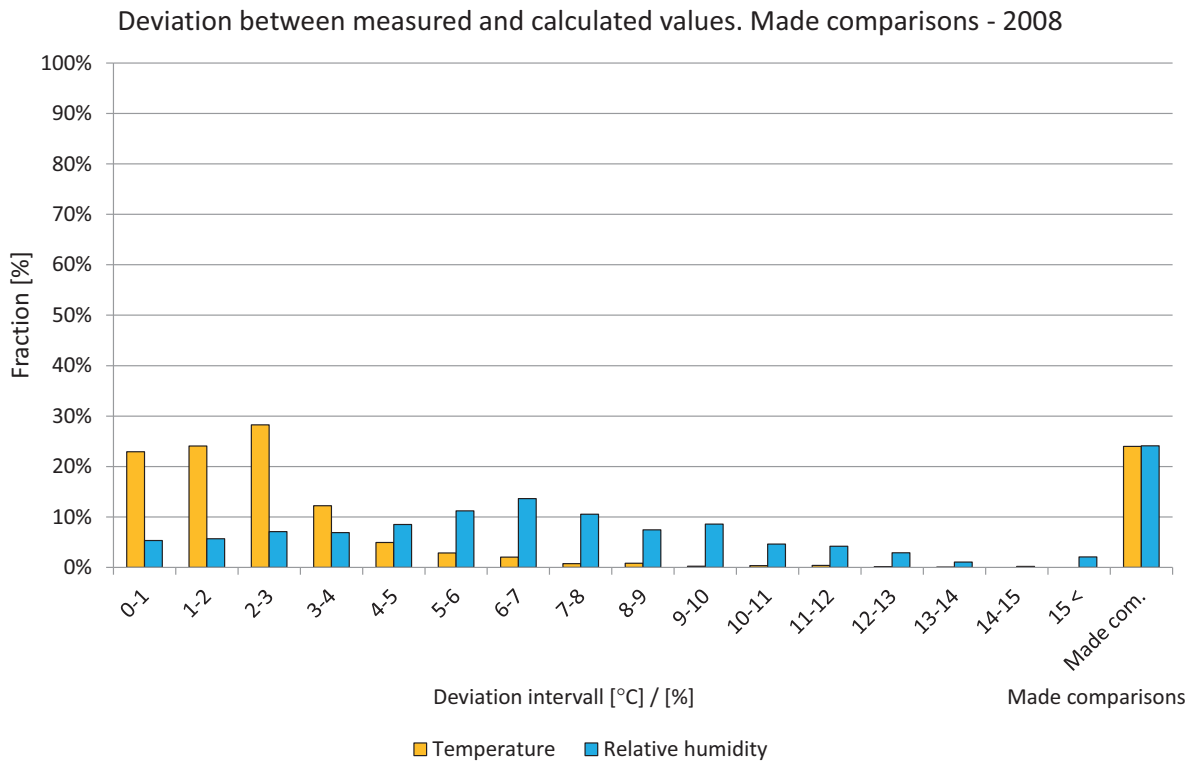


Figure 7.45.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

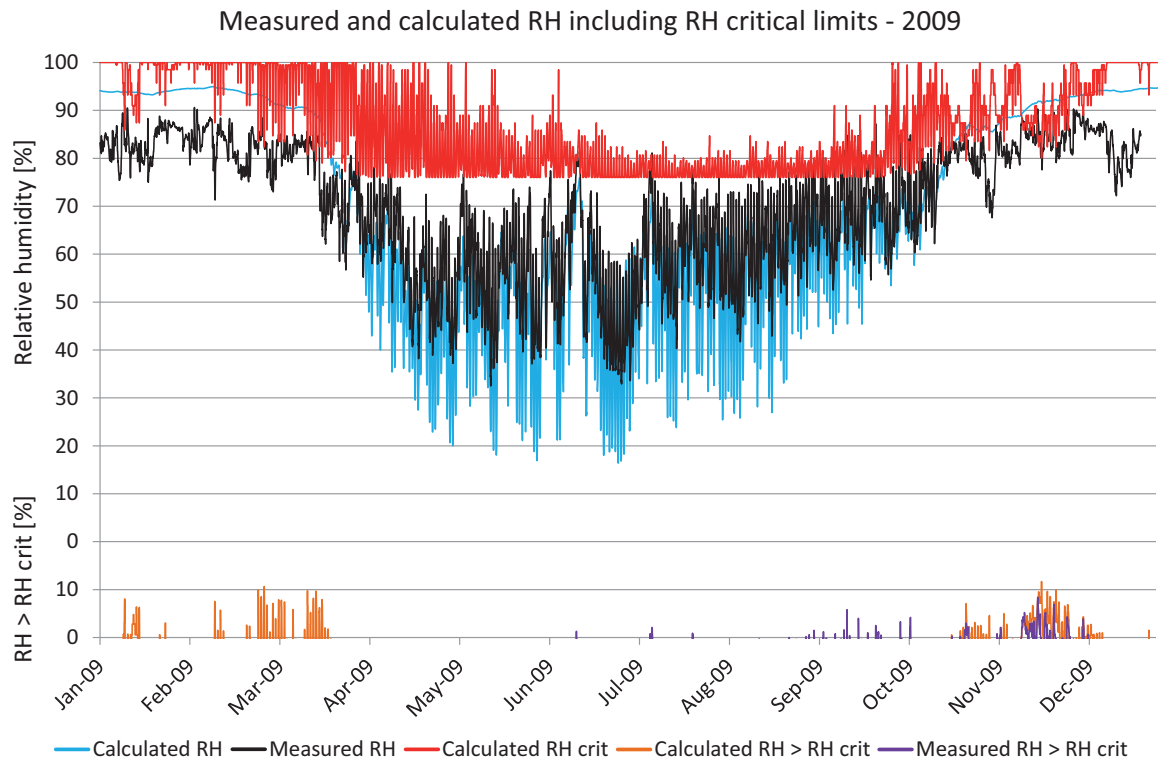


Figure 7.45.9. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

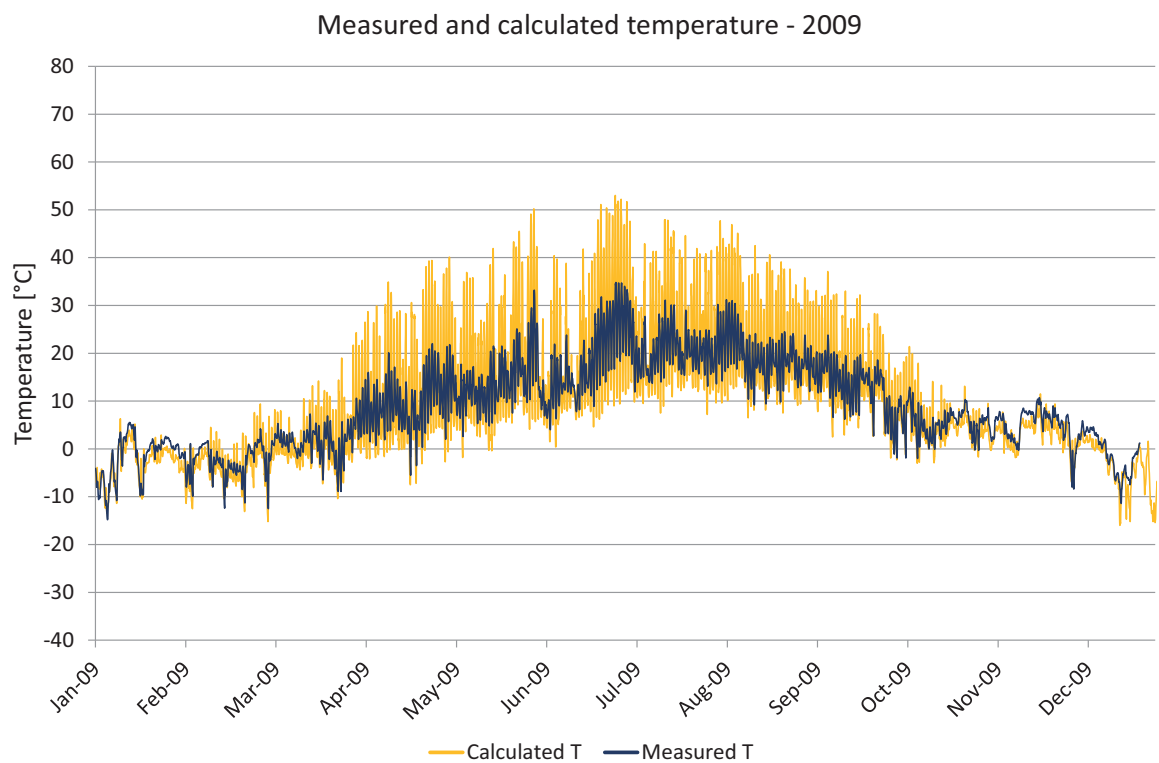


Figure 7.45.10. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

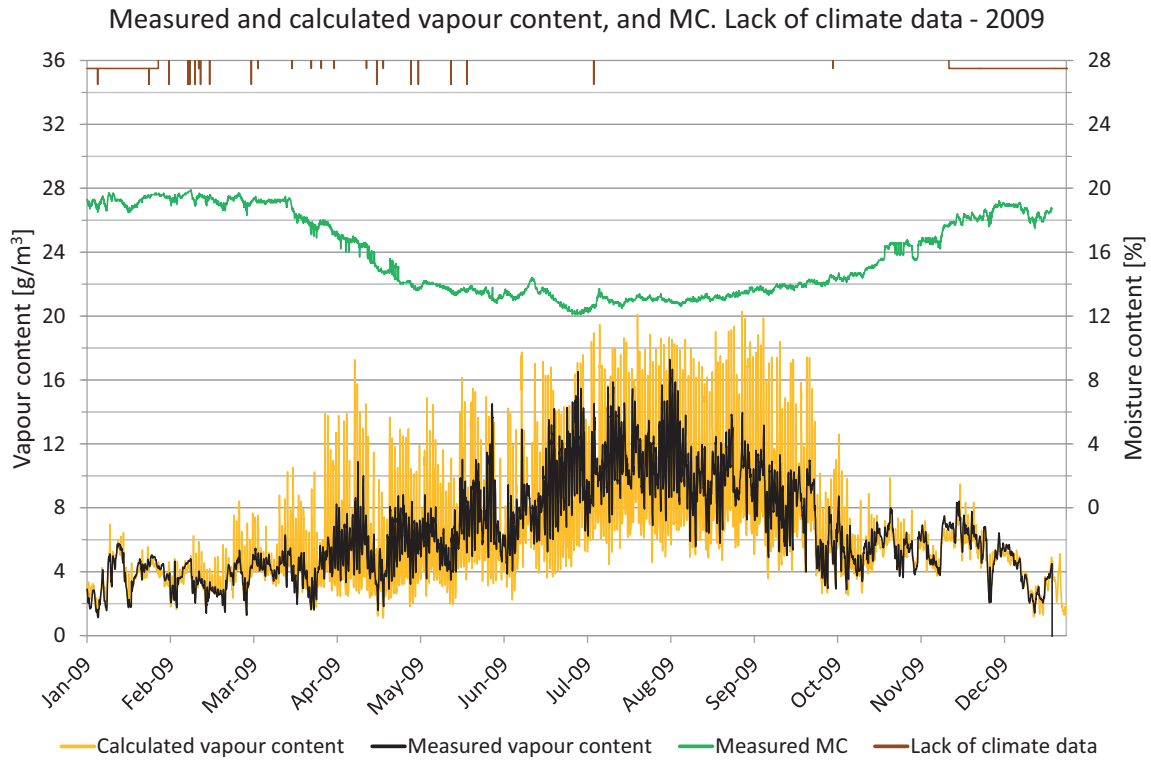


Figure 7.45.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

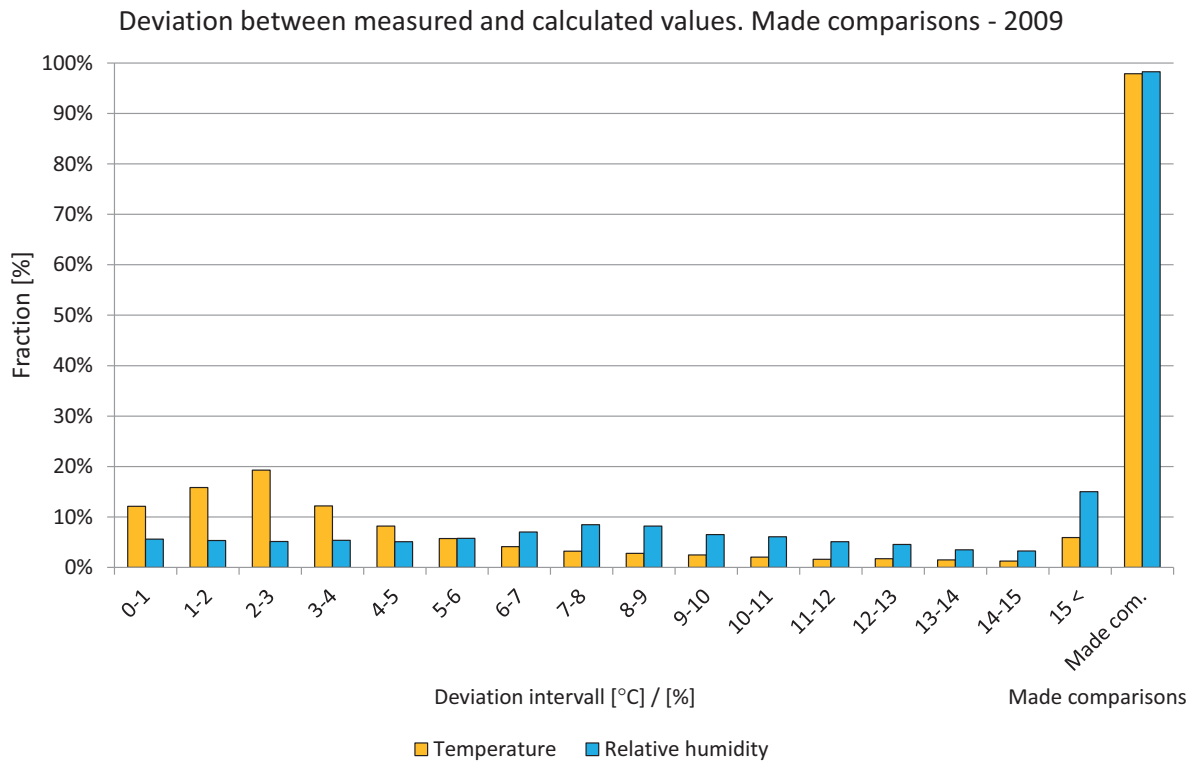


Figure 7.45.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

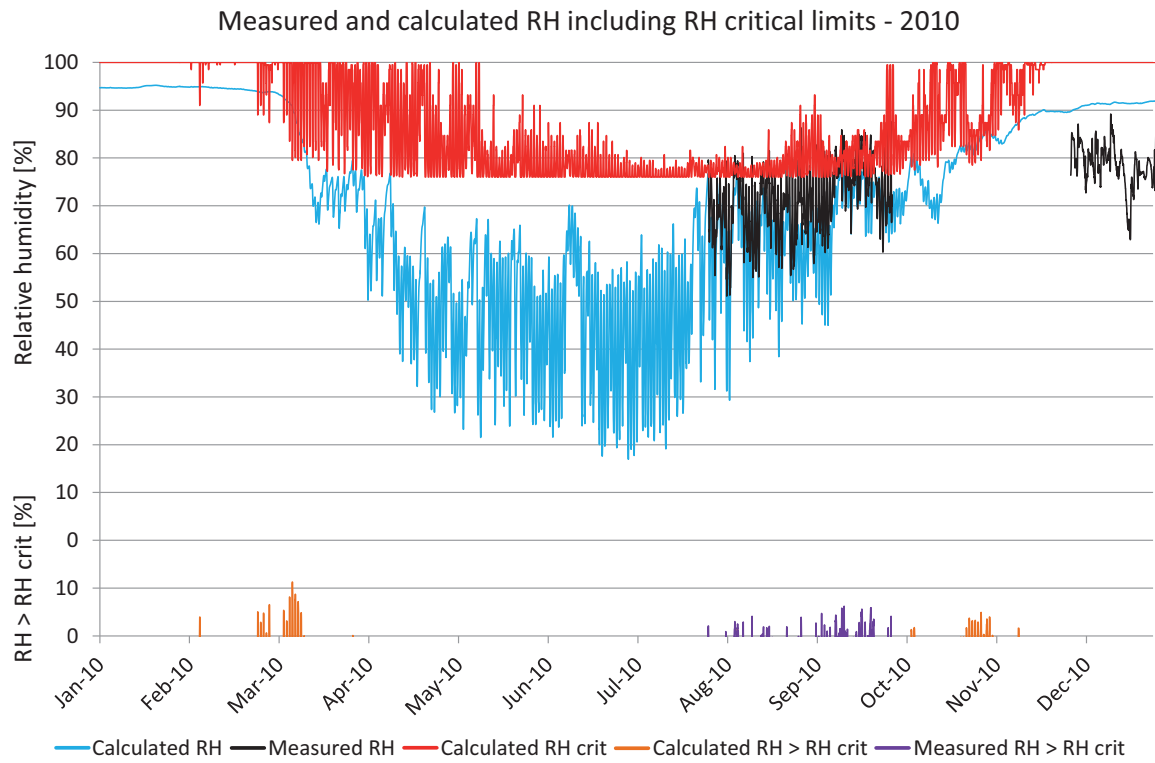


Figure 7.45.13. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

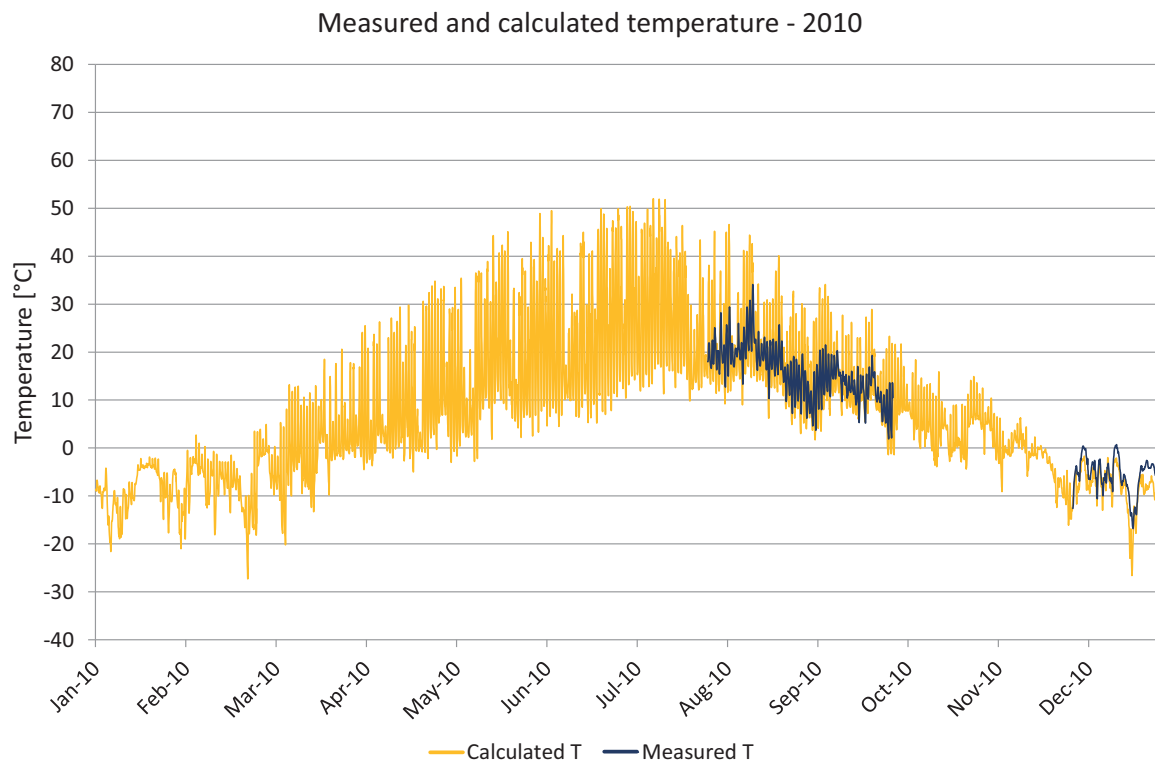


Figure 7.45.14. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

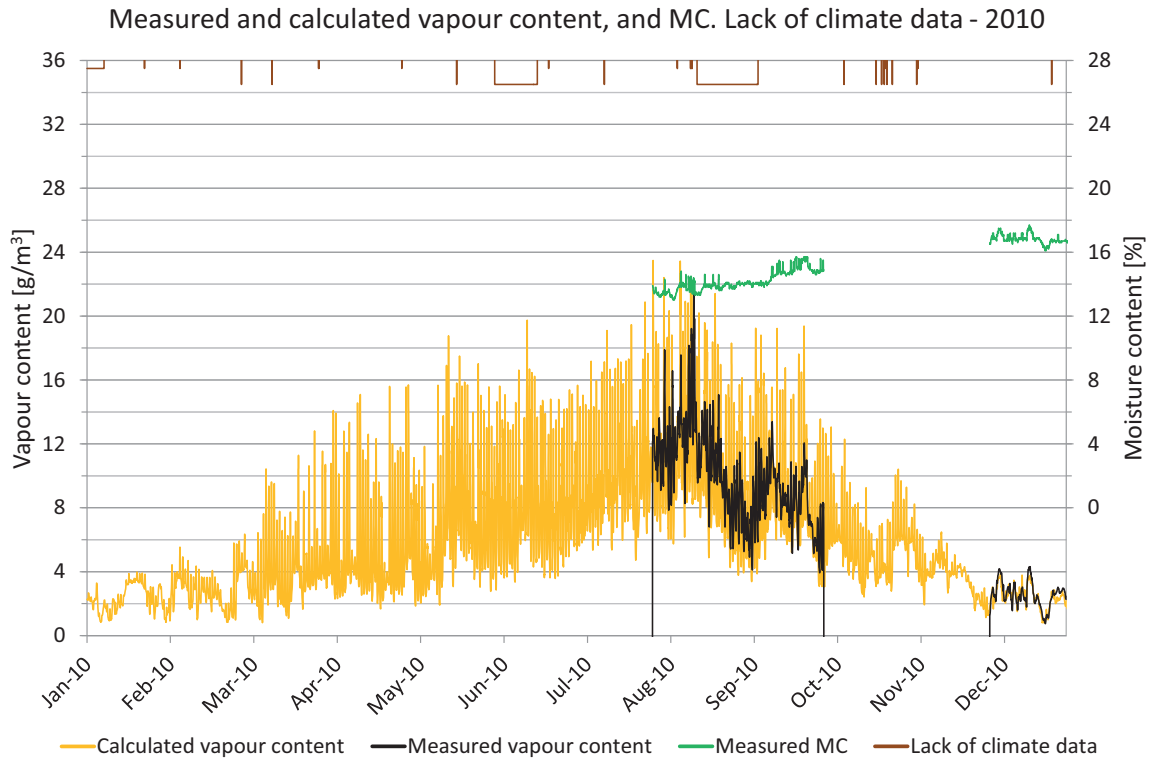


Figure 7.45.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

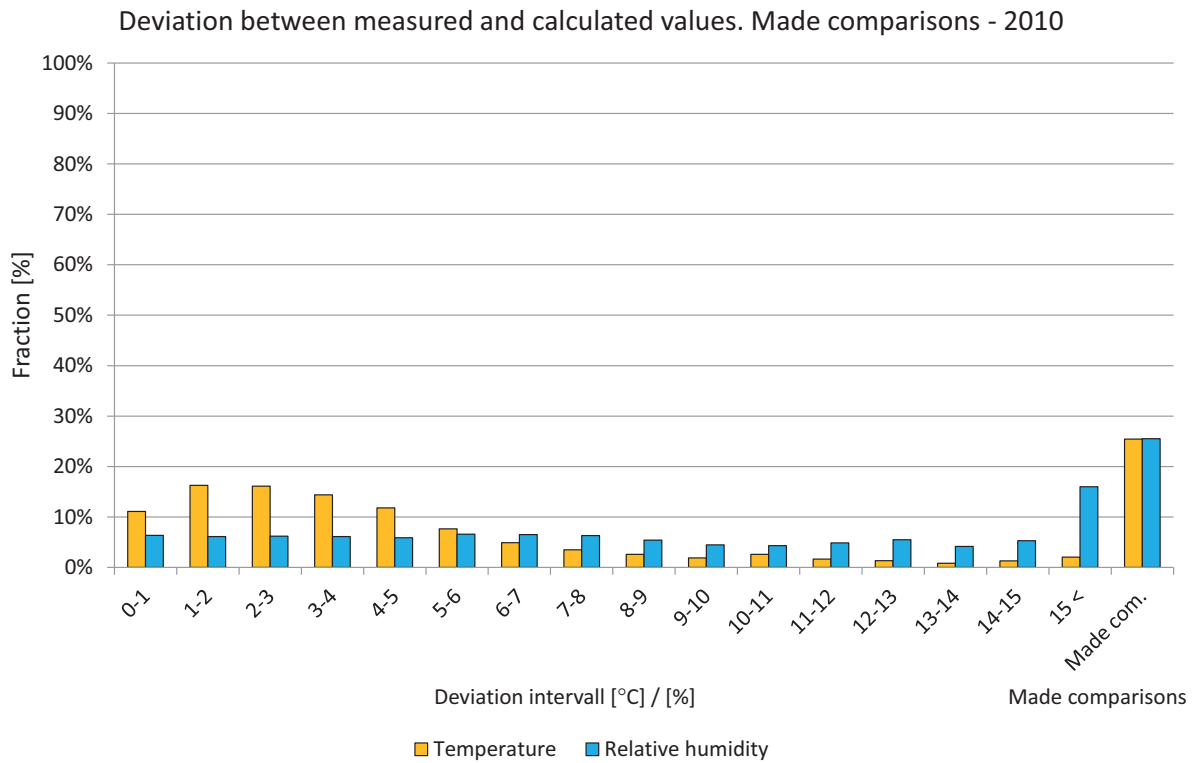


Figure 7.45.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

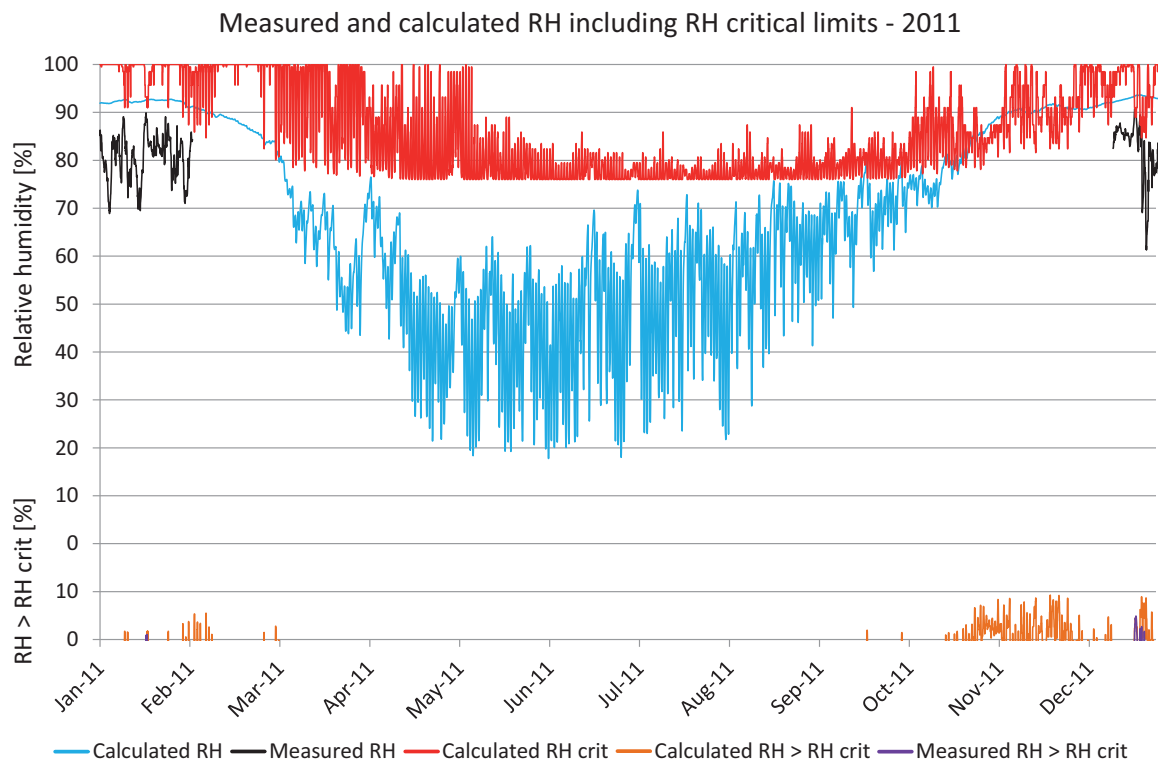


Figure 7.45.17. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

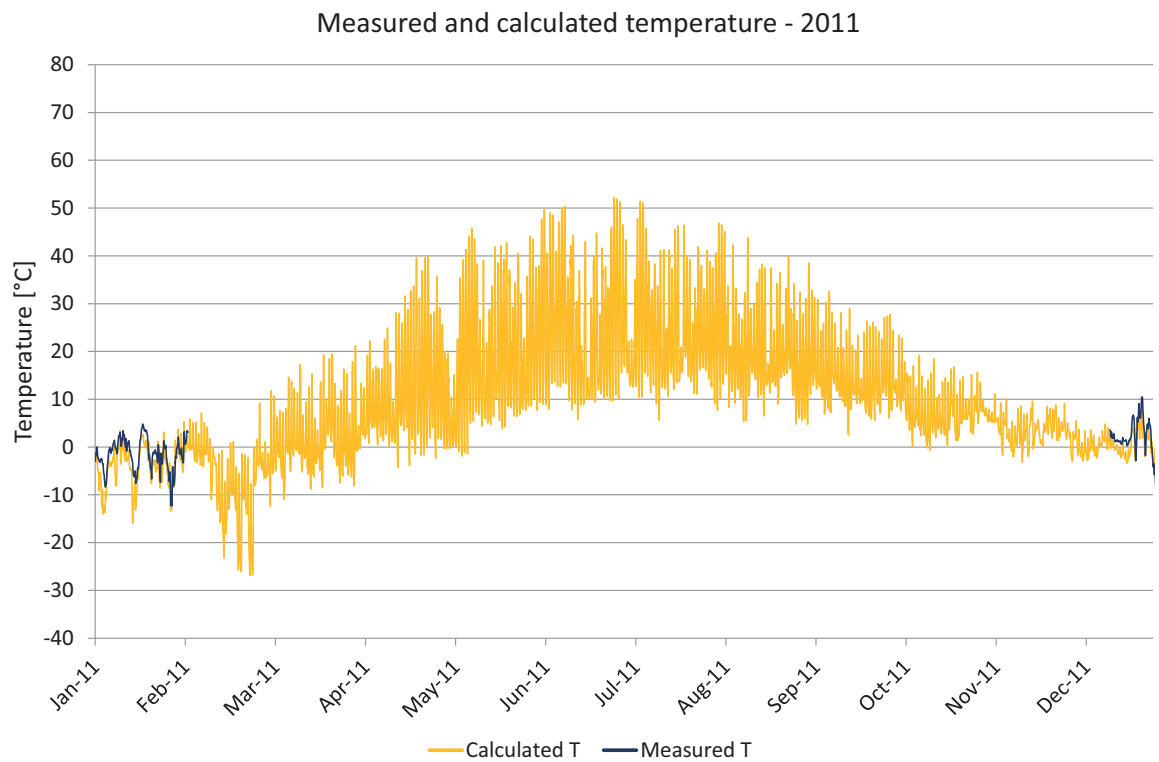


Figure 7.45.18. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

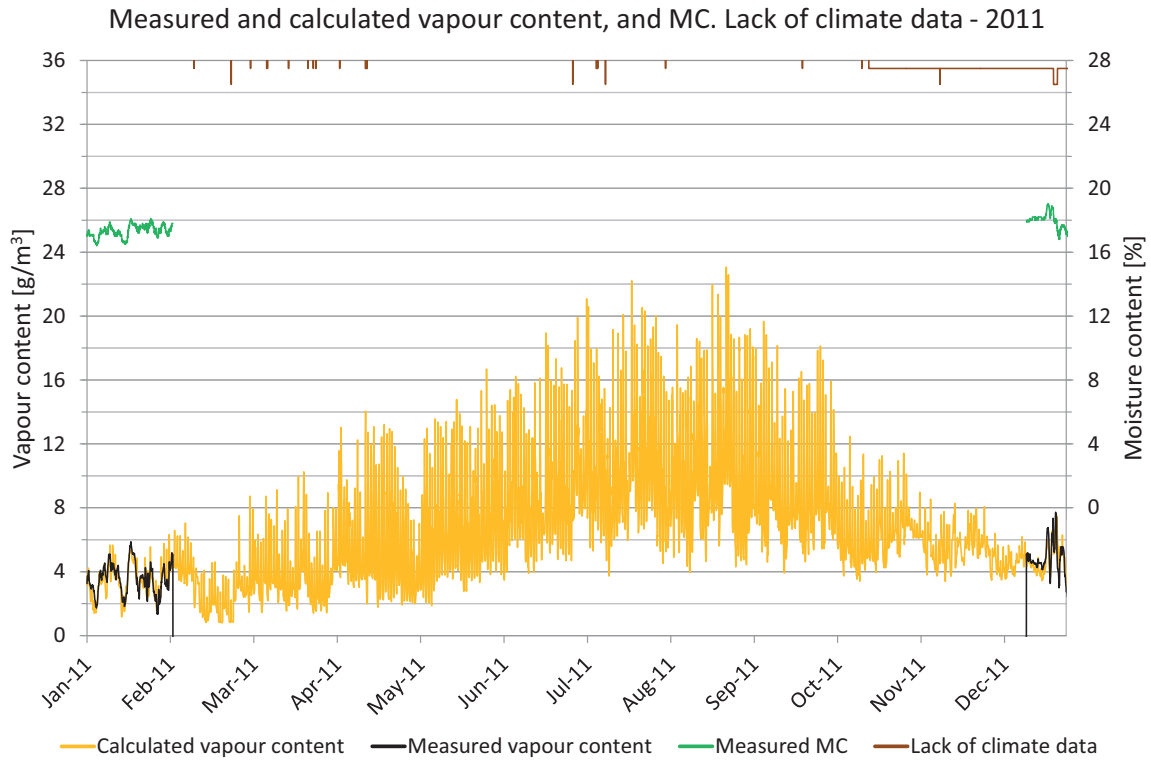


Figure 7.45.19. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

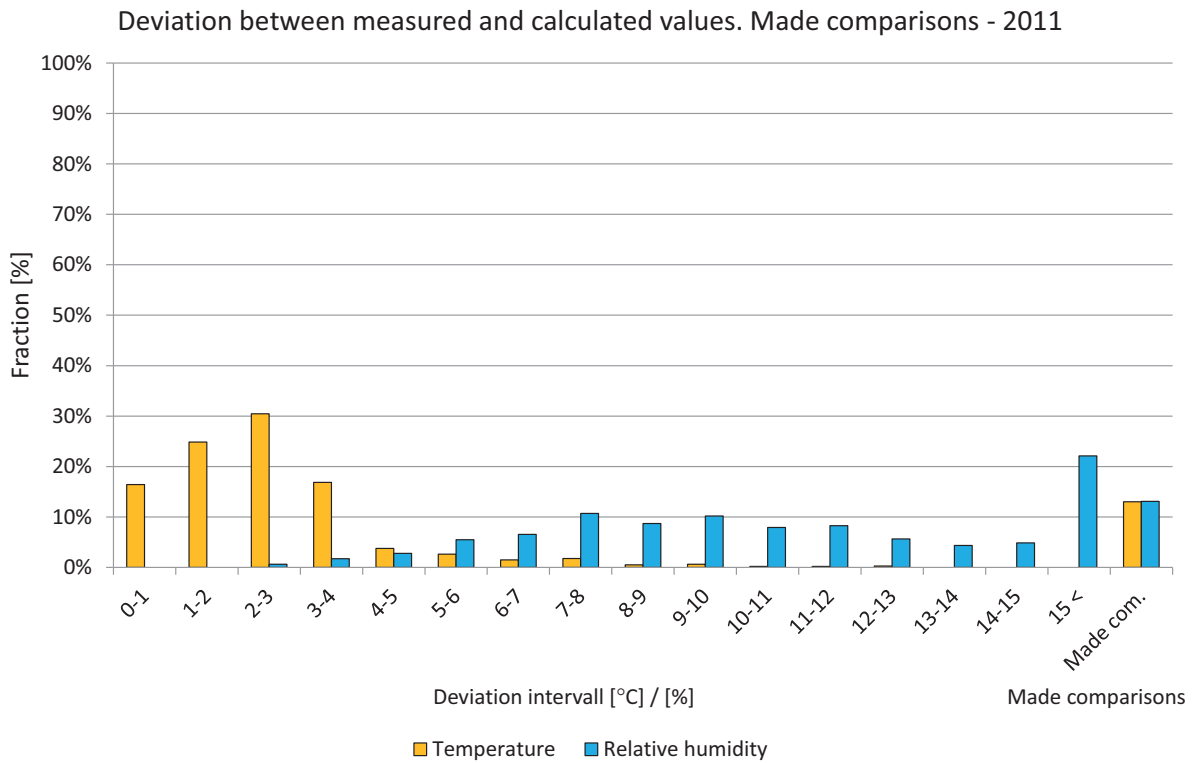


Figure 7.45.20. Deviations in made comparisons sorted into intervals from 0 to 15. Temperature (yellow) and relative humidity (light blue). The right x-axis shows percent of made comparisons during year.

7.48 Position 48

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

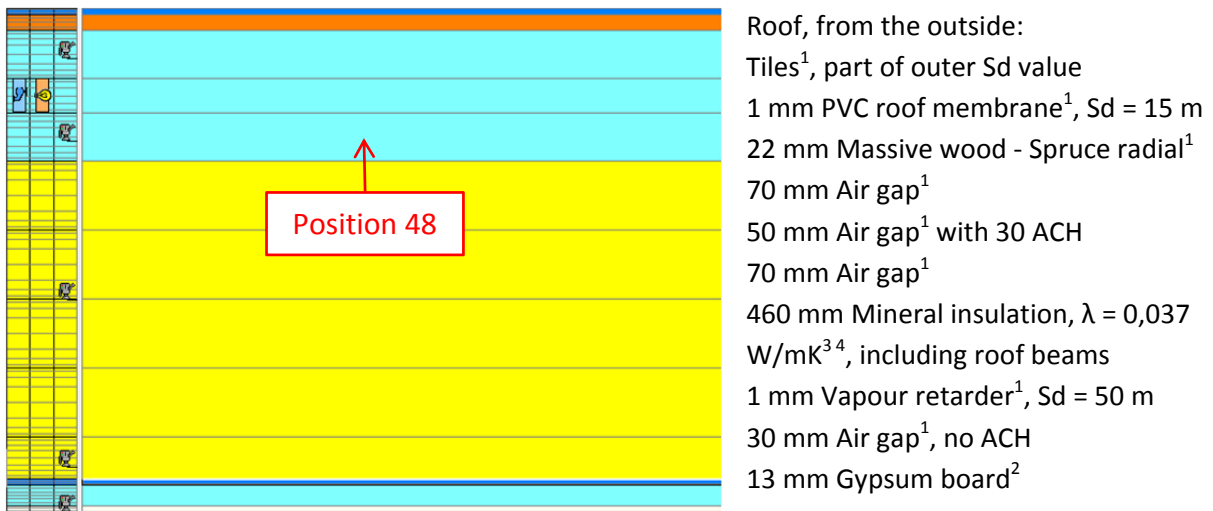


Figure 7.48.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

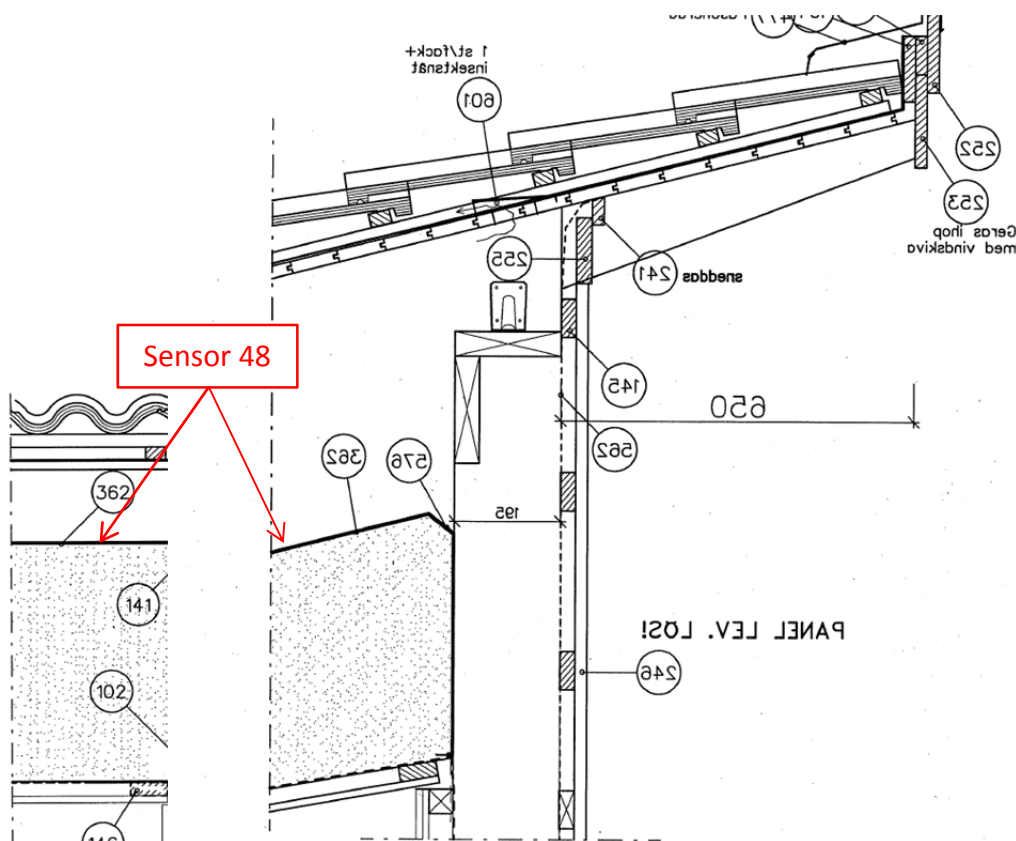


Figure 7.48.2. Location of the studied position.



Figure 7.48.3. Location of the studied position. Photo: SP Trä Skellefteå.

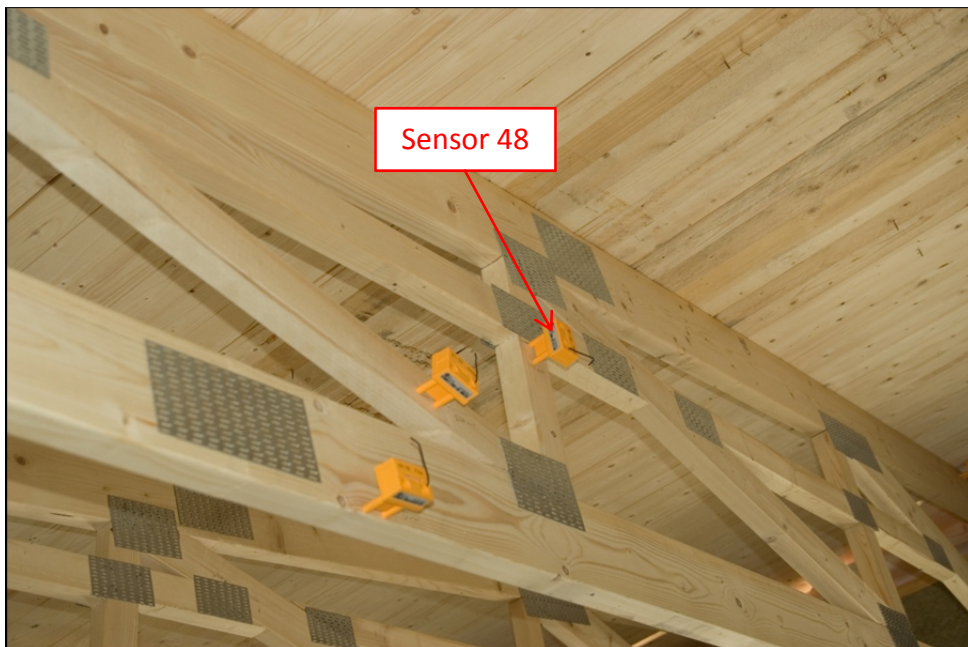


Figure 7.48.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

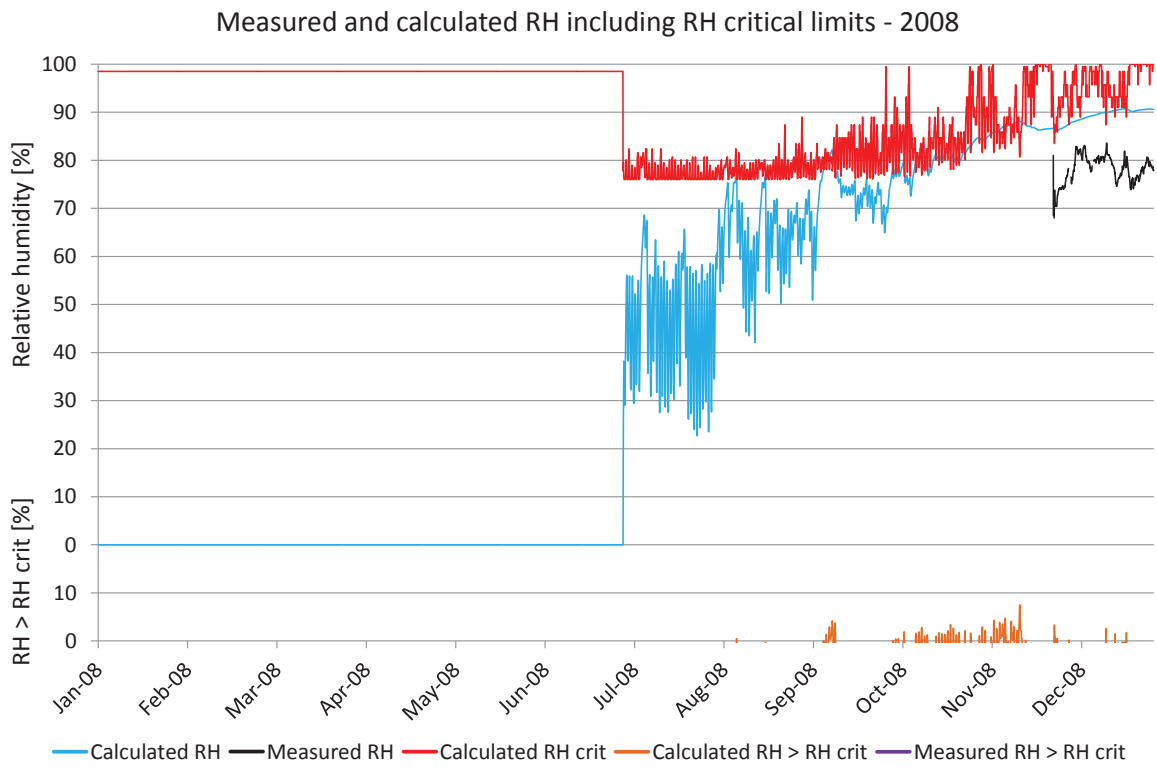


Figure 7.48.5. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

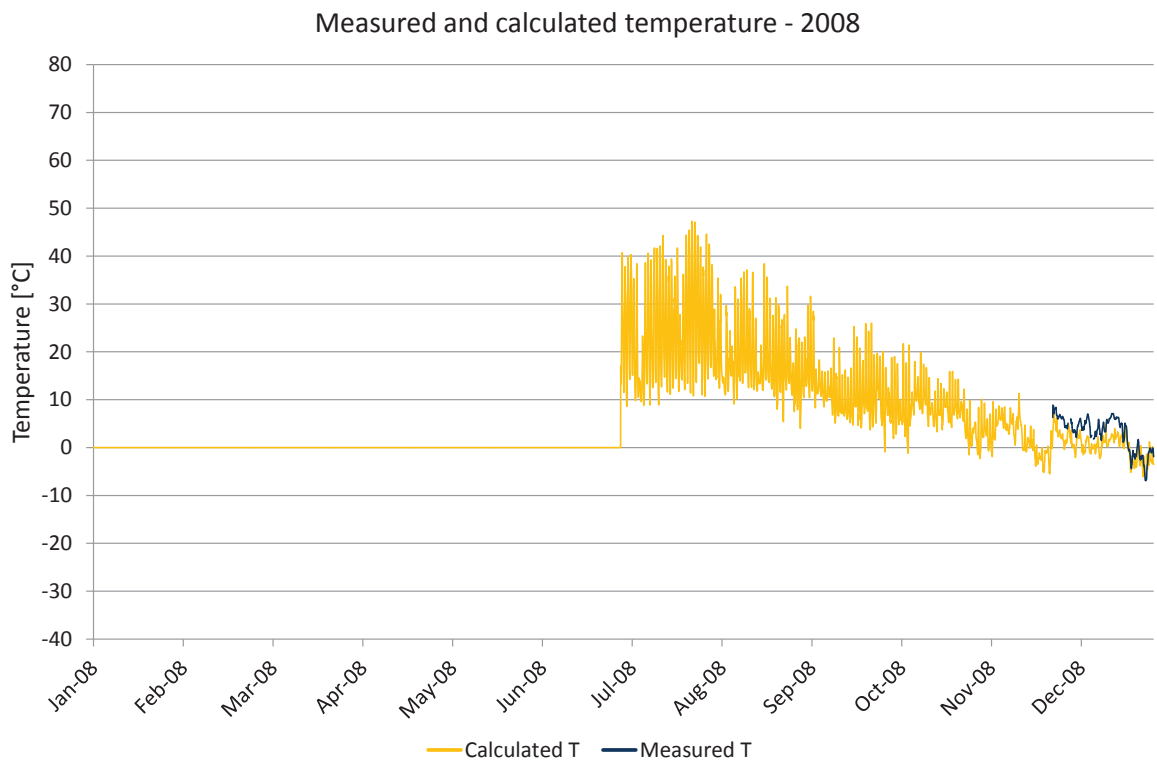


Figure 7.48.6. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

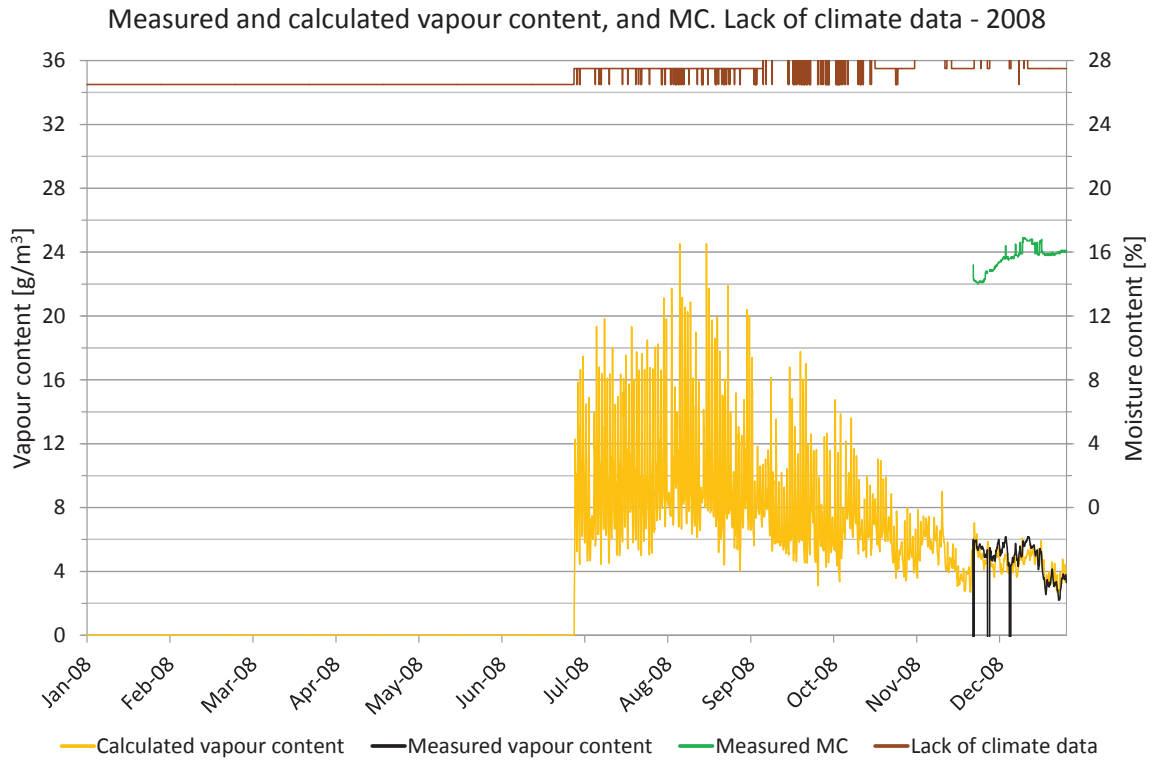


Figure 7.48.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

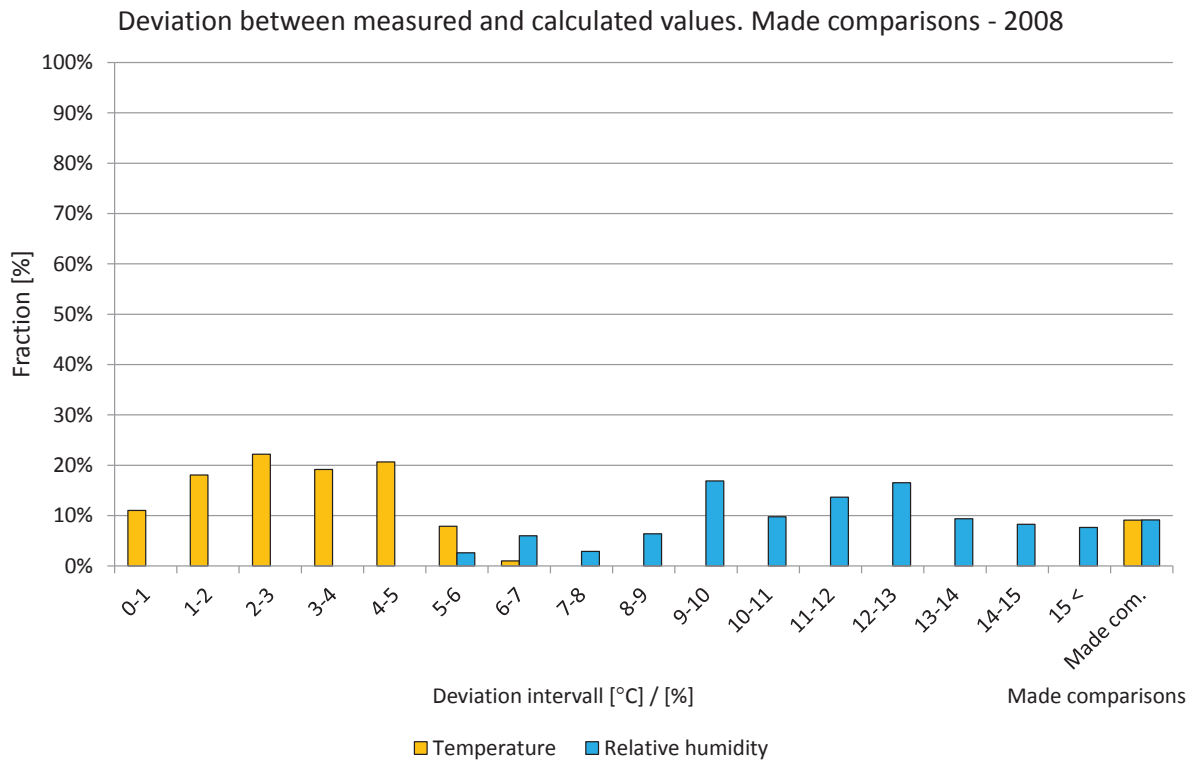


Figure 7.48.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

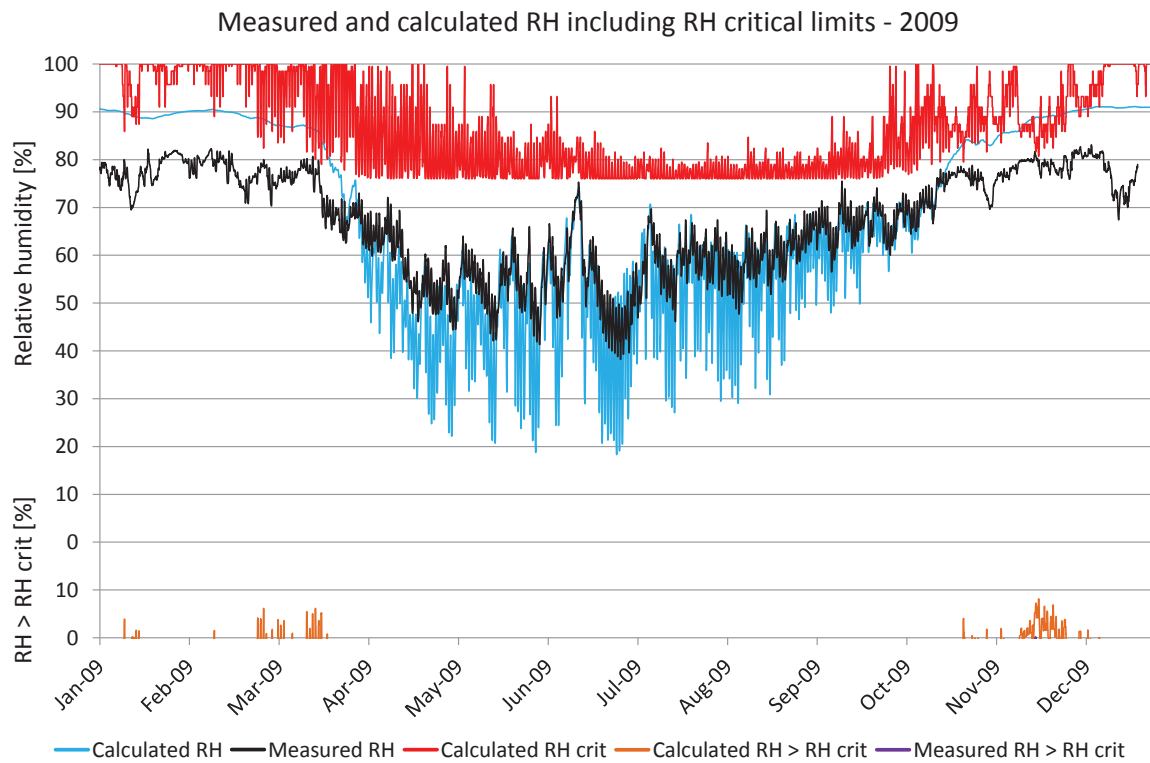


Figure 7.48.9. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

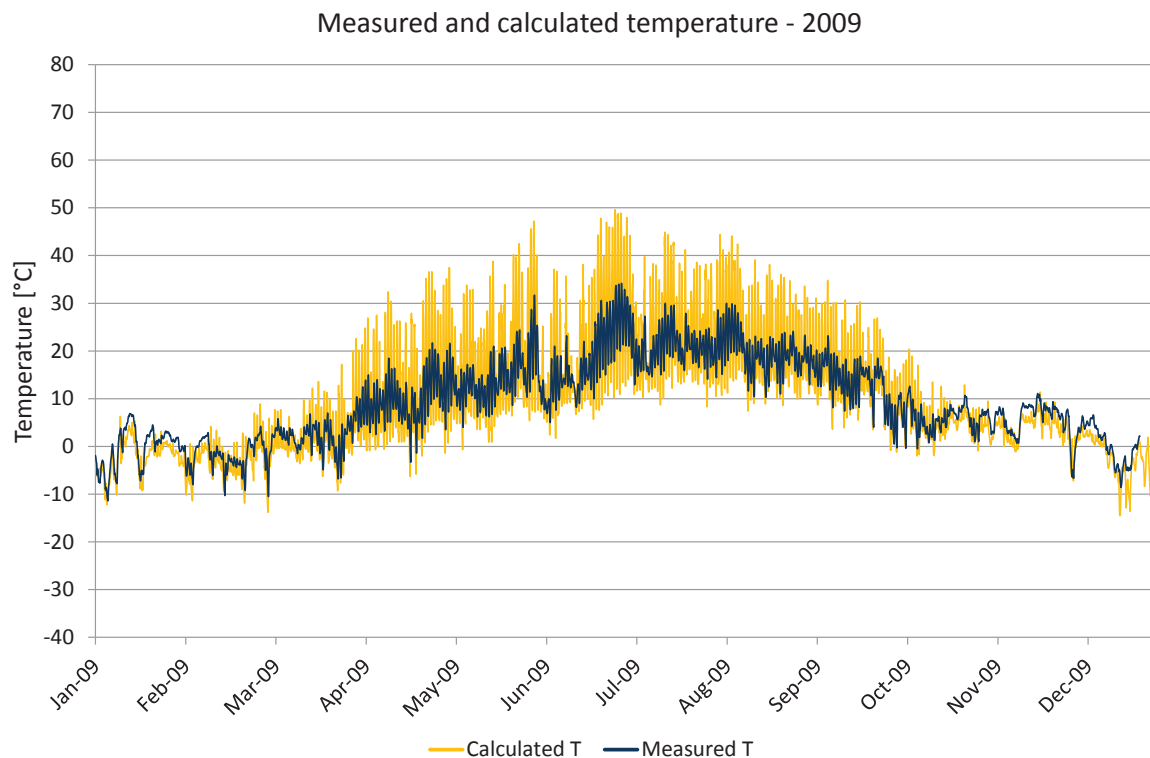


Figure 7.48.10. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

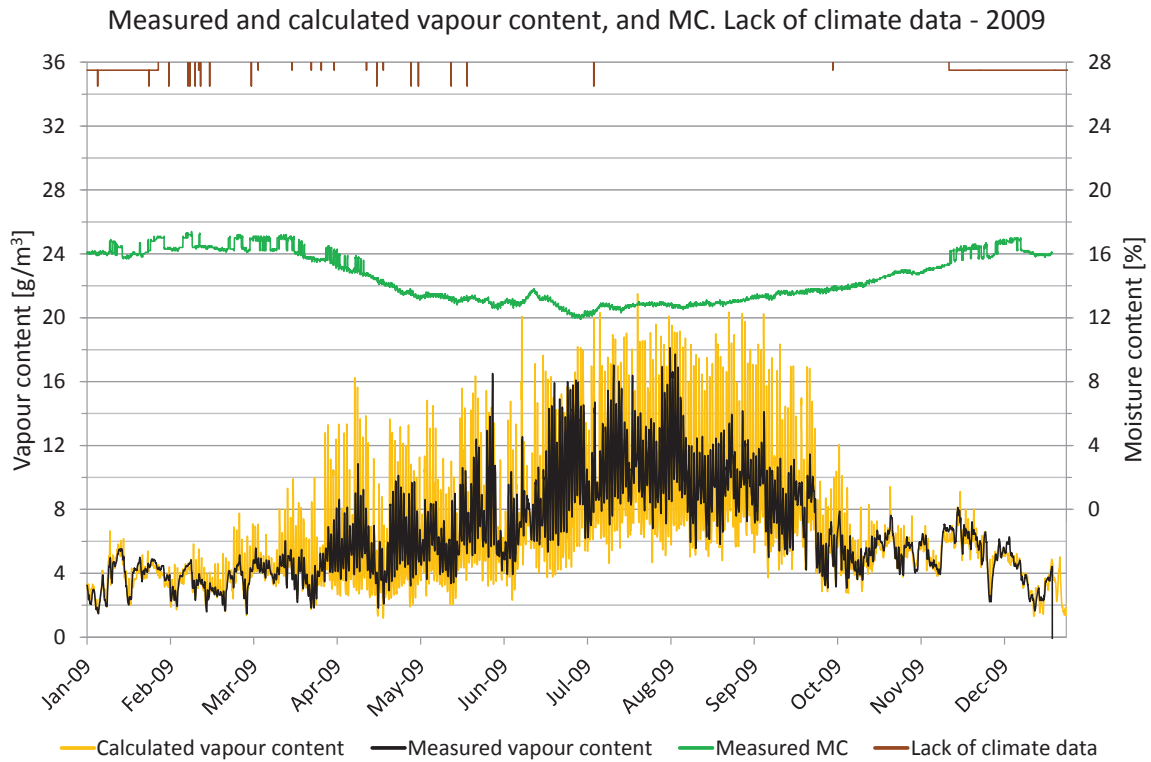


Figure 7.48.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

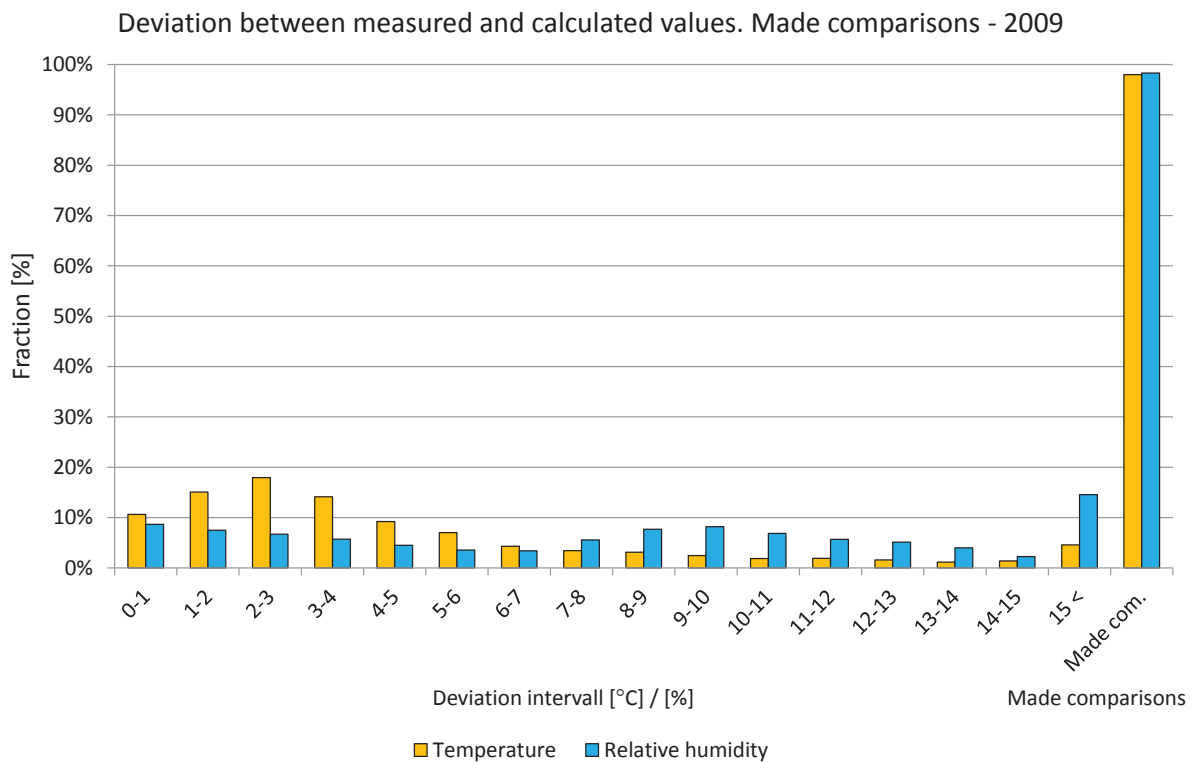


Figure 7.48.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

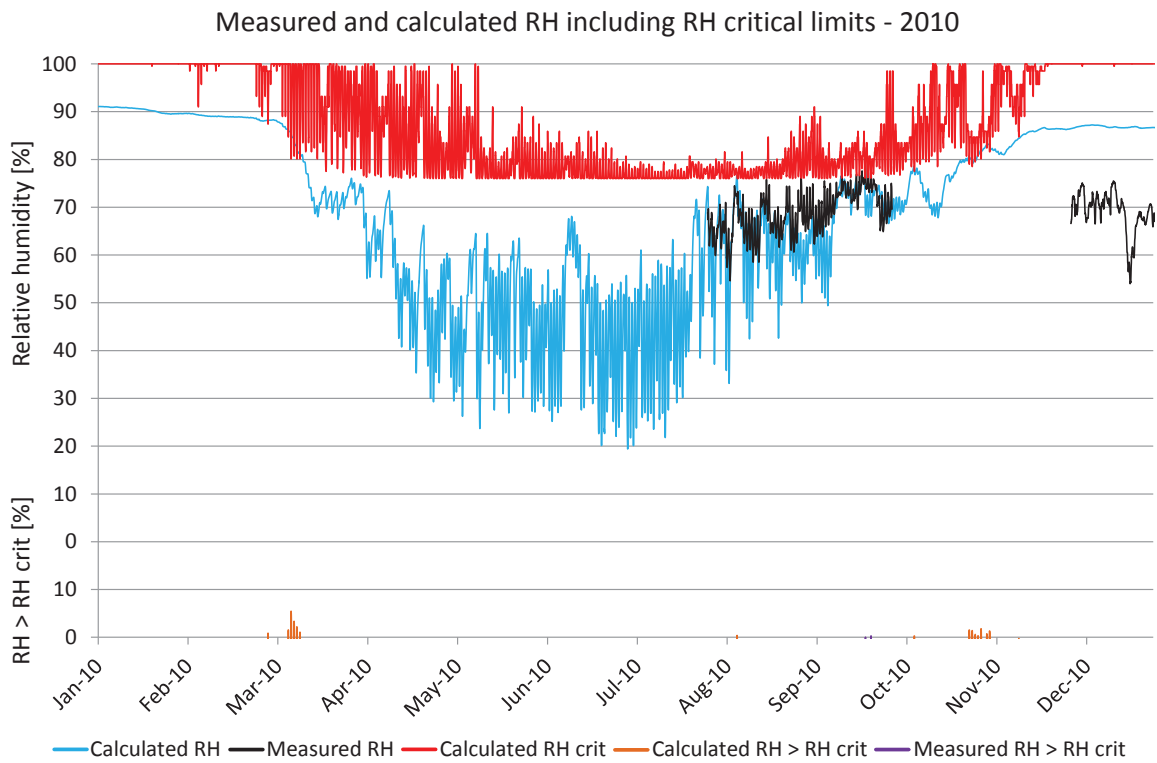


Figure 7.48.13. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

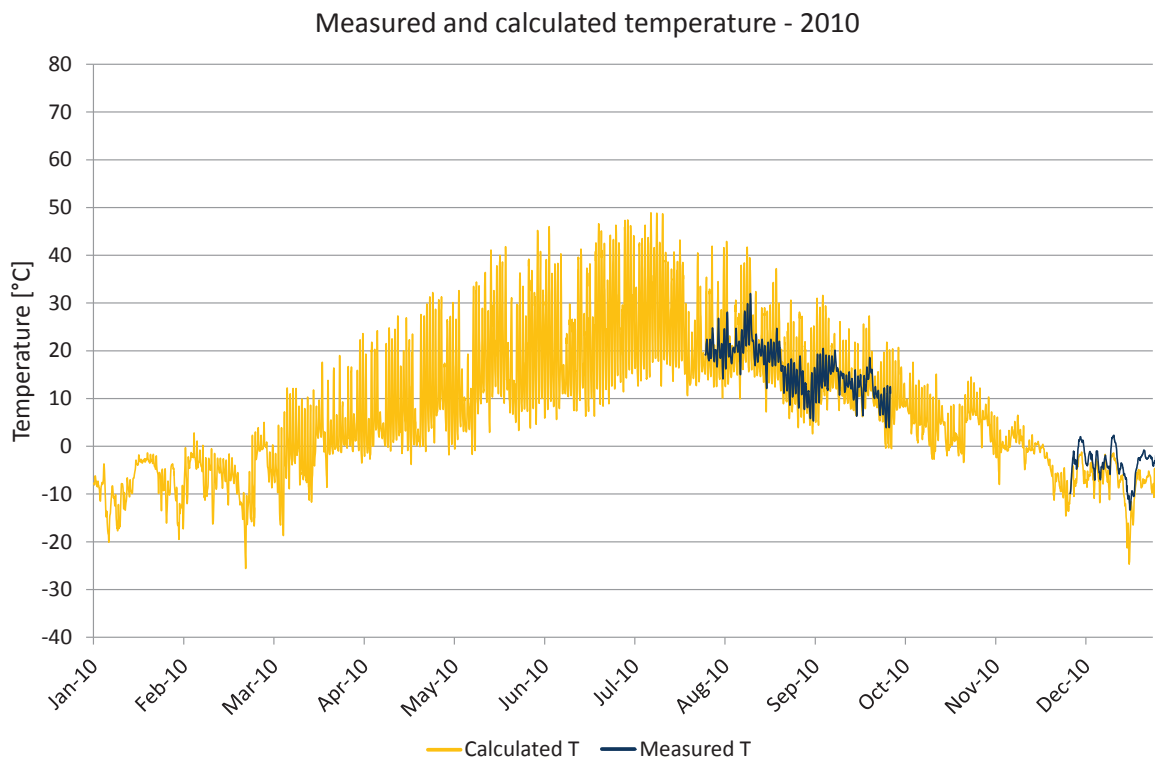


Figure 7.48.14. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

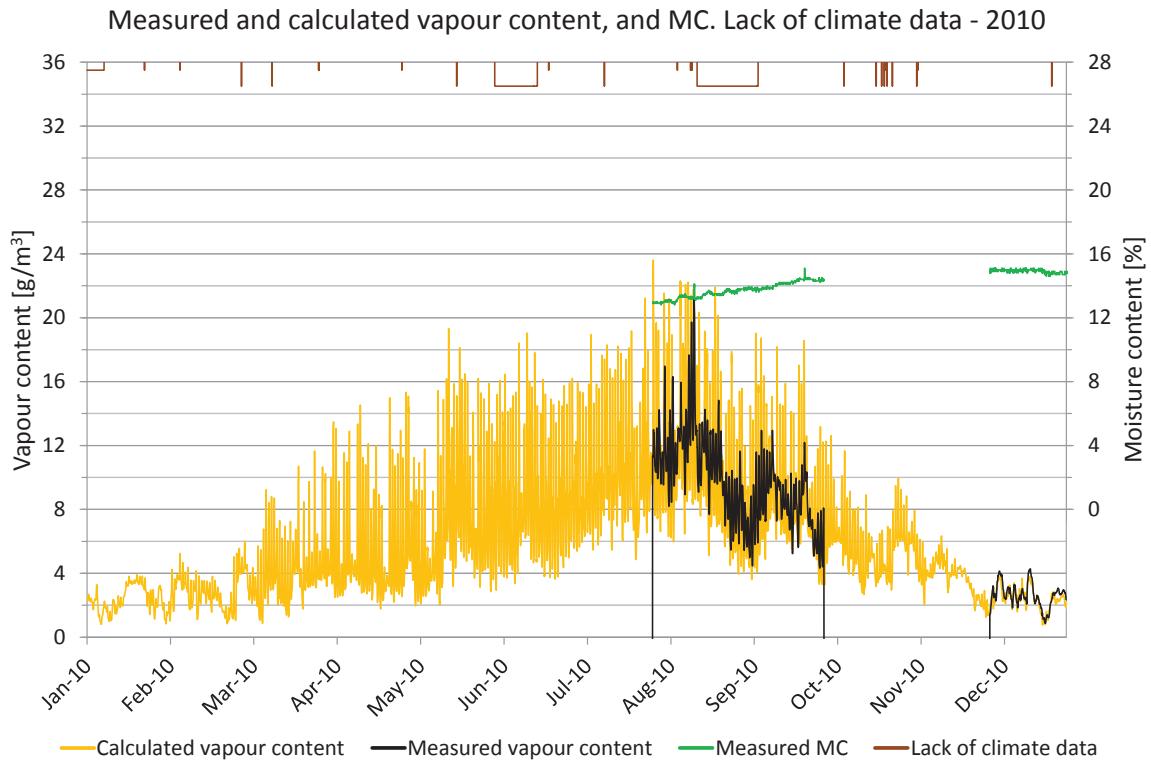


Figure 7.48.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

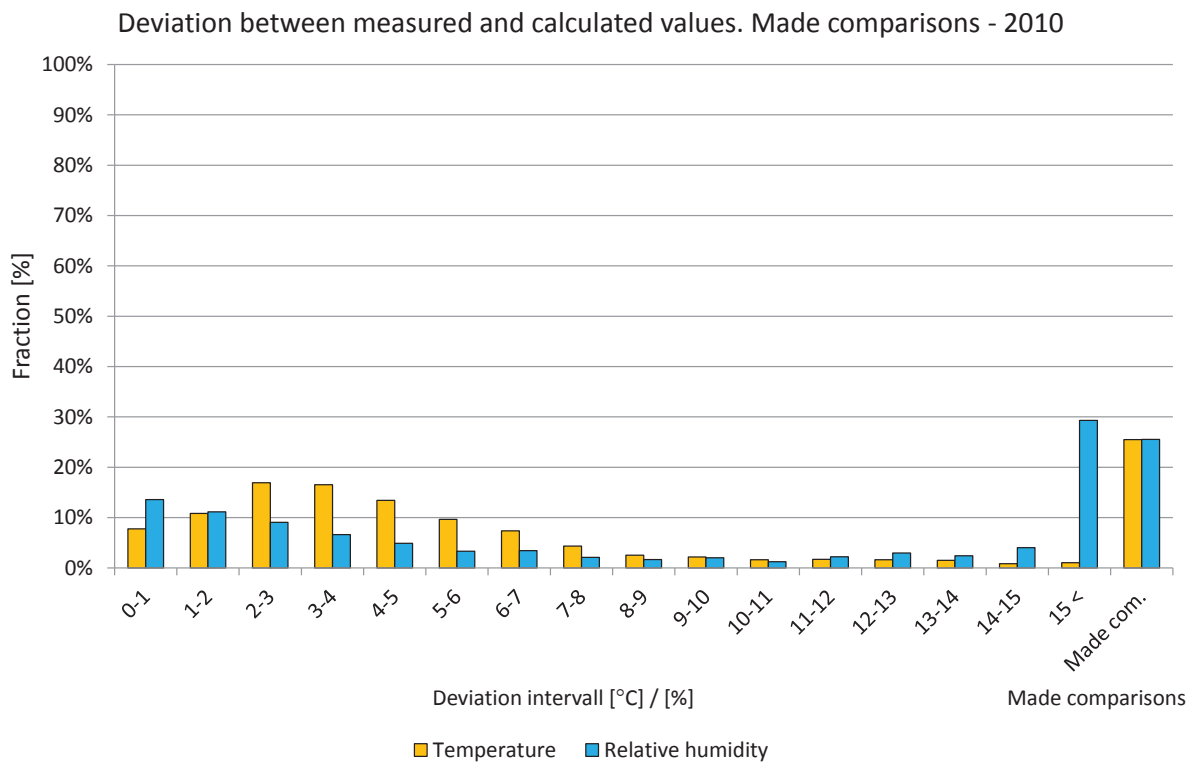


Figure 7.48.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

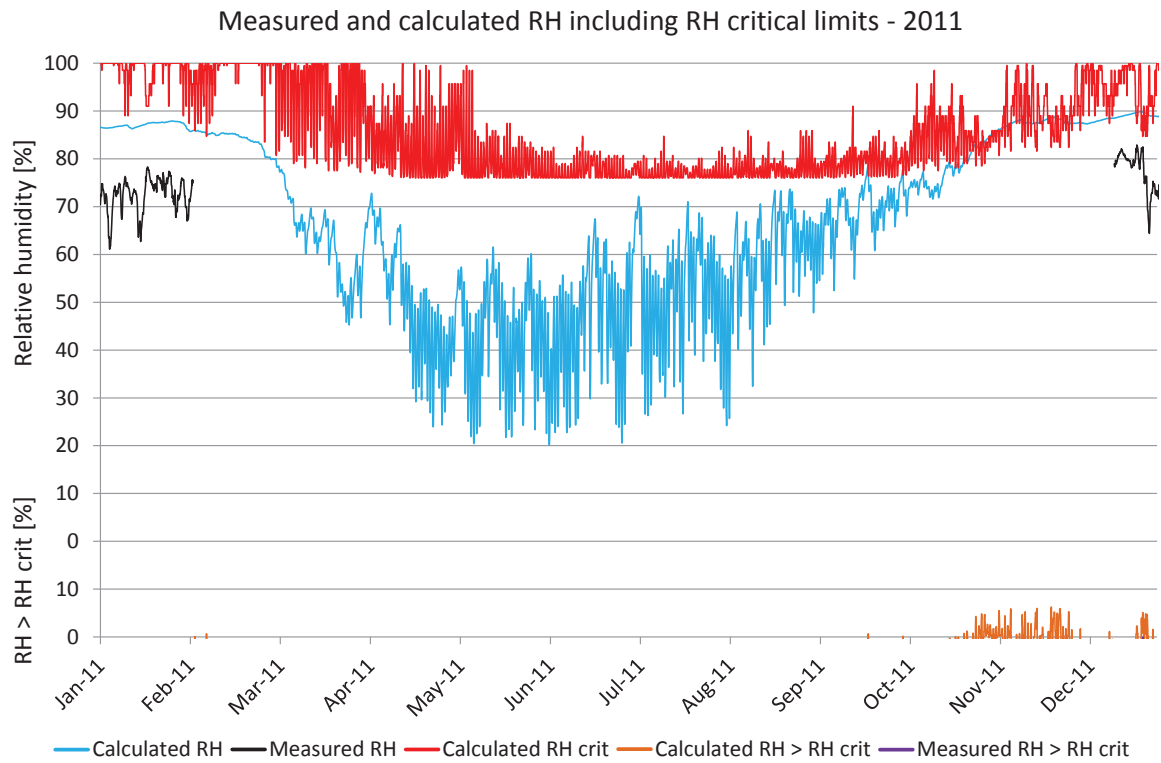


Figure 7.48.17. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

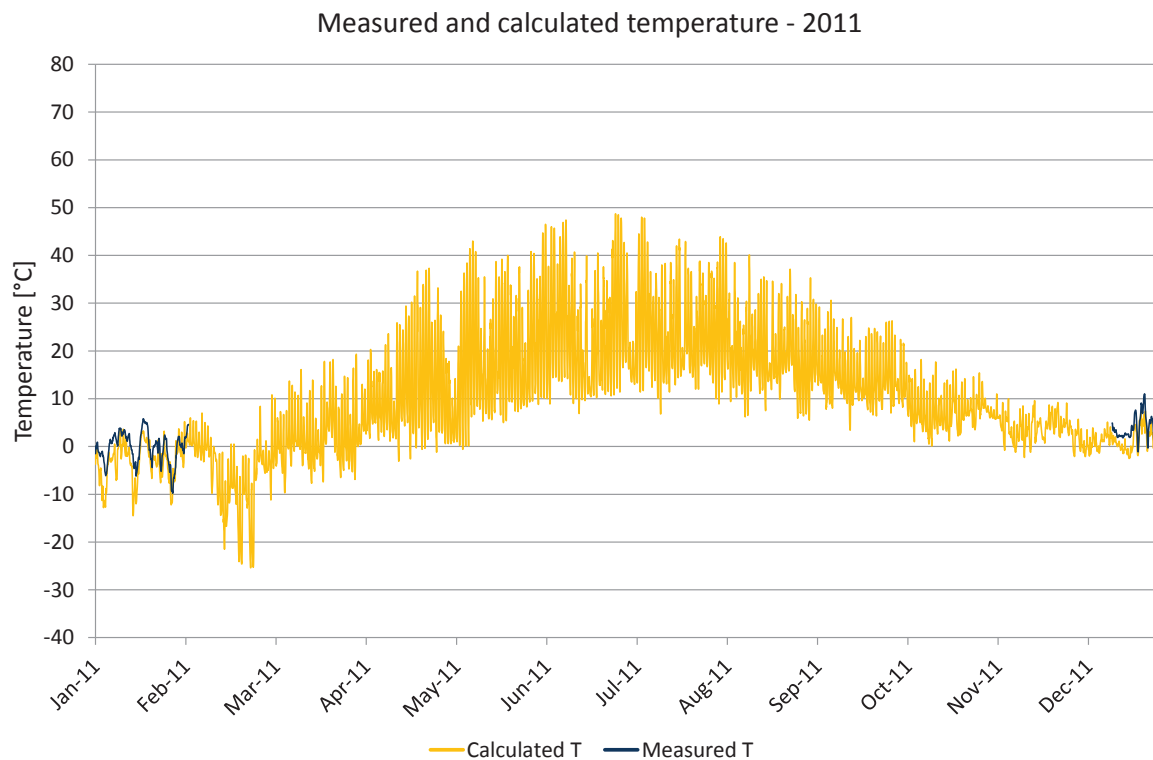


Figure 7.48.18. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

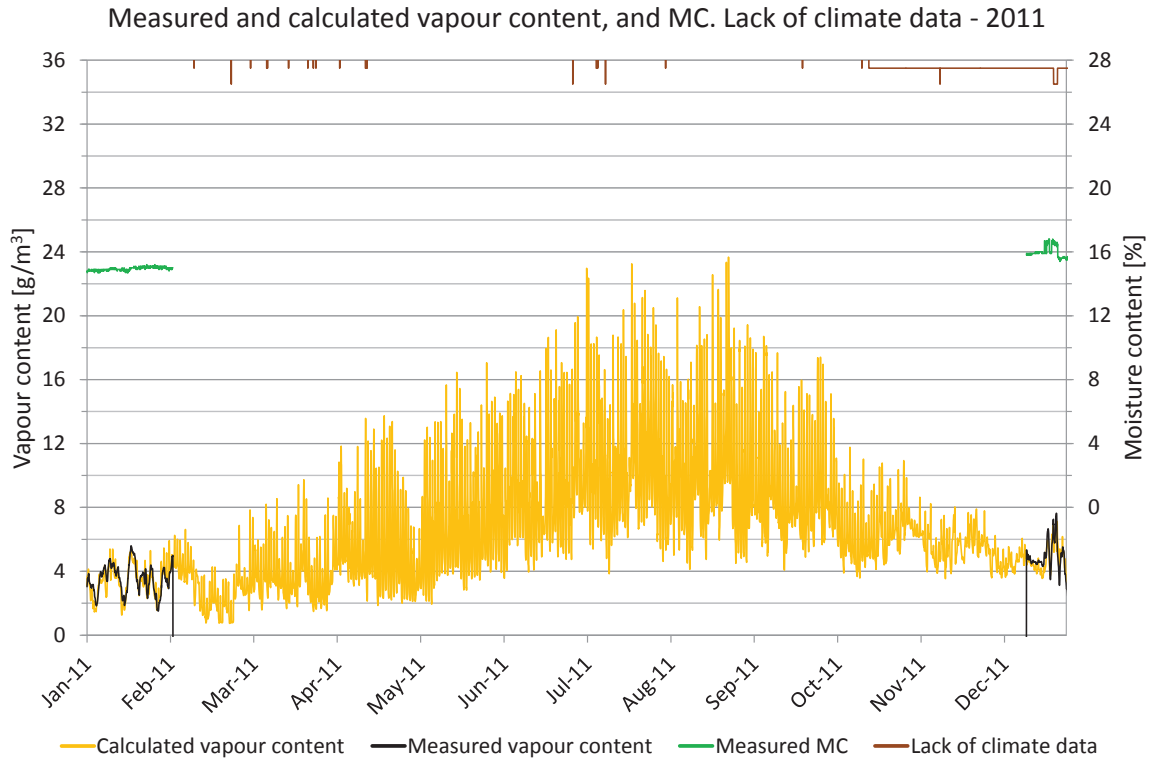


Figure 7.48.19. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

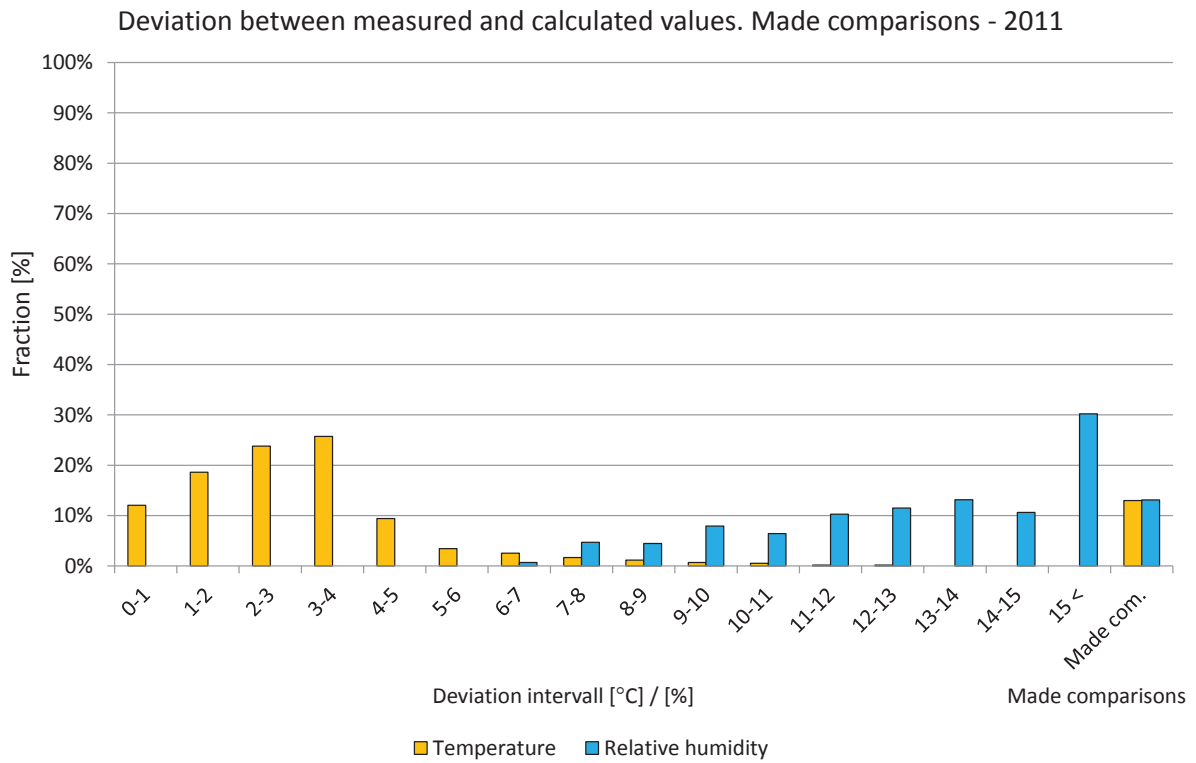


Figure 7.48.20. Deviations in made comparisons sorted into intervals from 0 to 15. Temperature (yellow) and relative humidity (light blue). The right x-axis shows percent of made comparisons during year.

7.51 Position 51

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

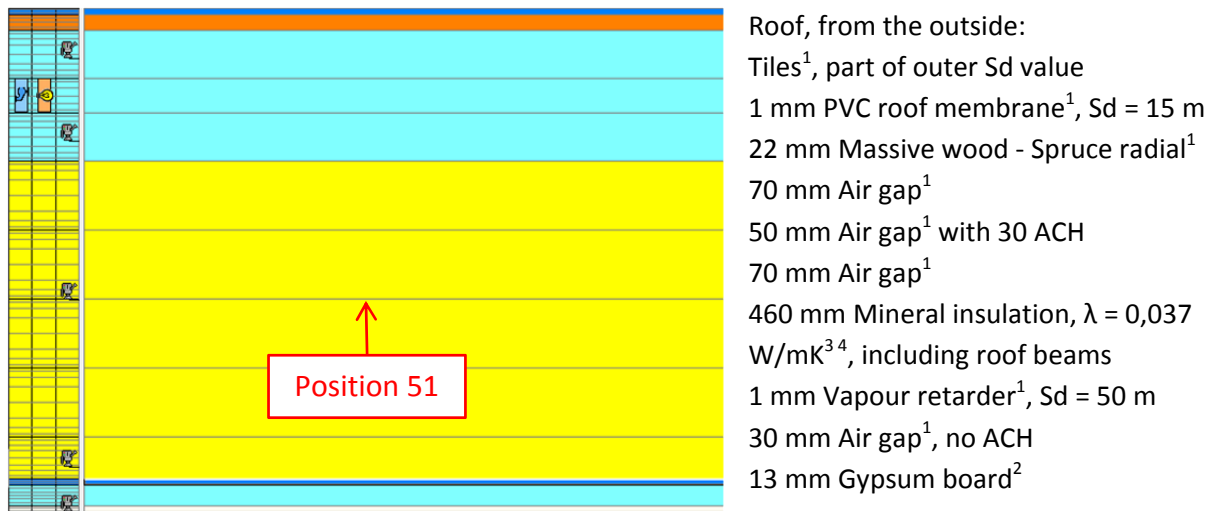


Figure 7.51.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

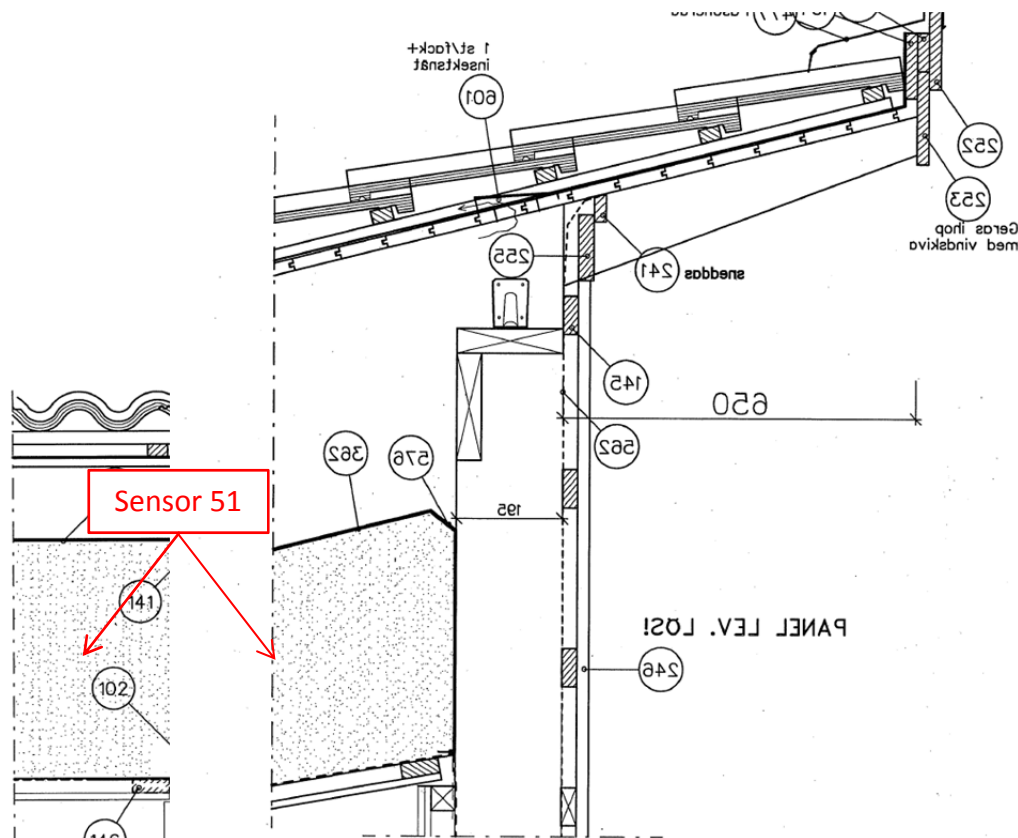


Figure 7.51.2. Location of the studied position.



Figure 7.51.3. Location of the studied position. Photo: SP Trä Skellefteå.

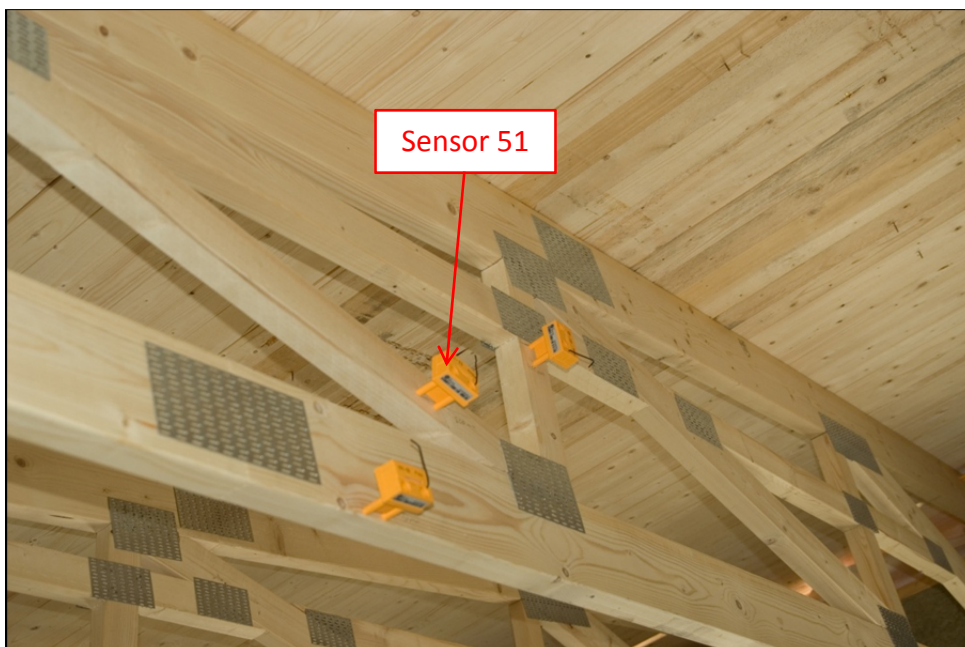


Figure 7.51.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

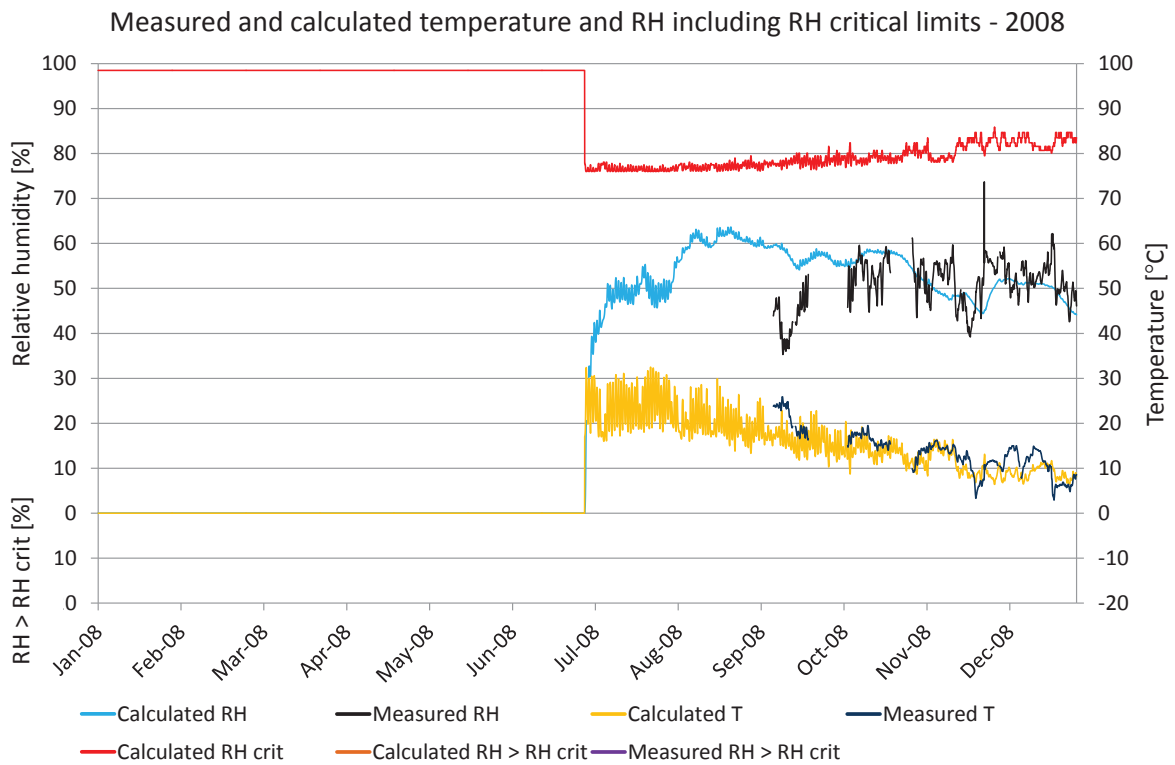


Figure 7.51.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

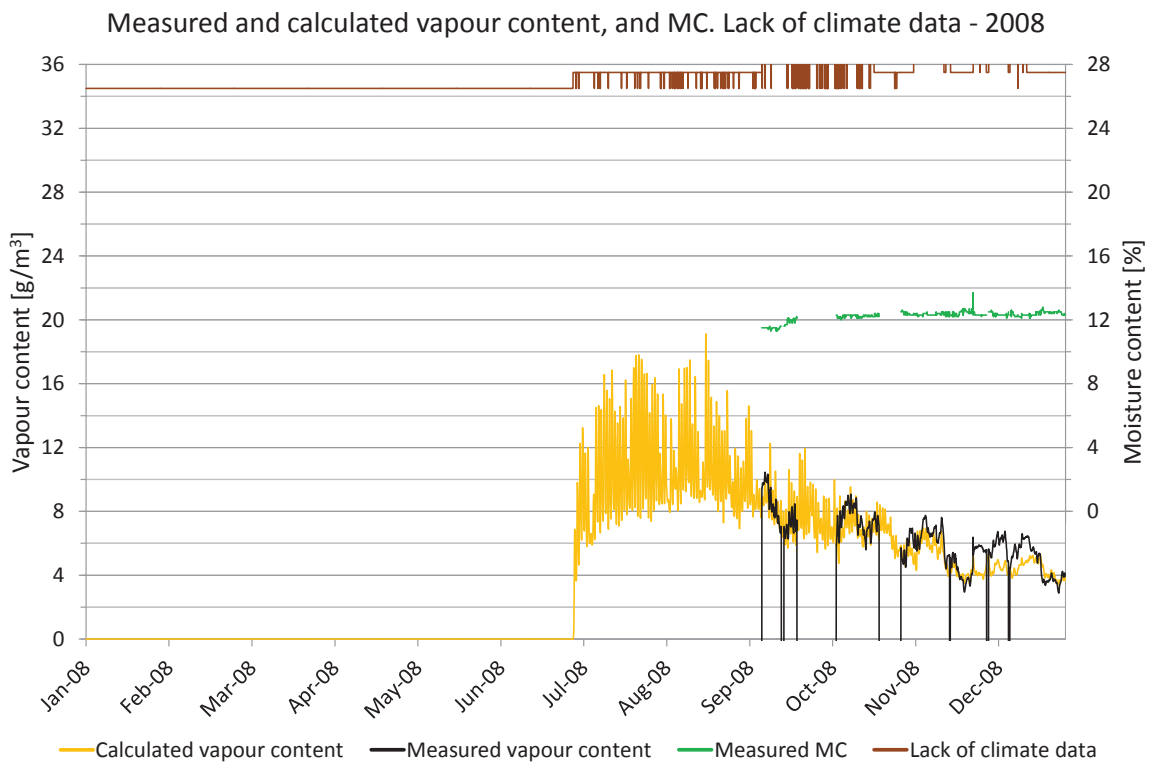


Figure 7.51.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

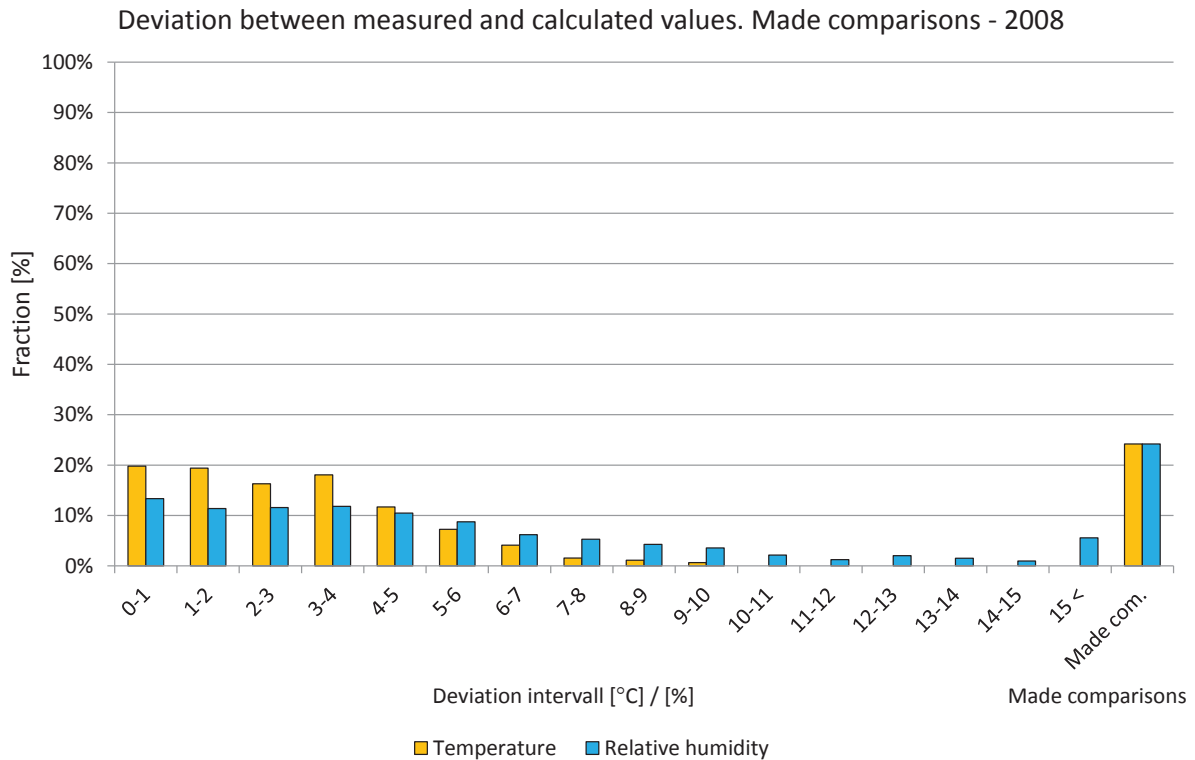


Figure 7.51.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

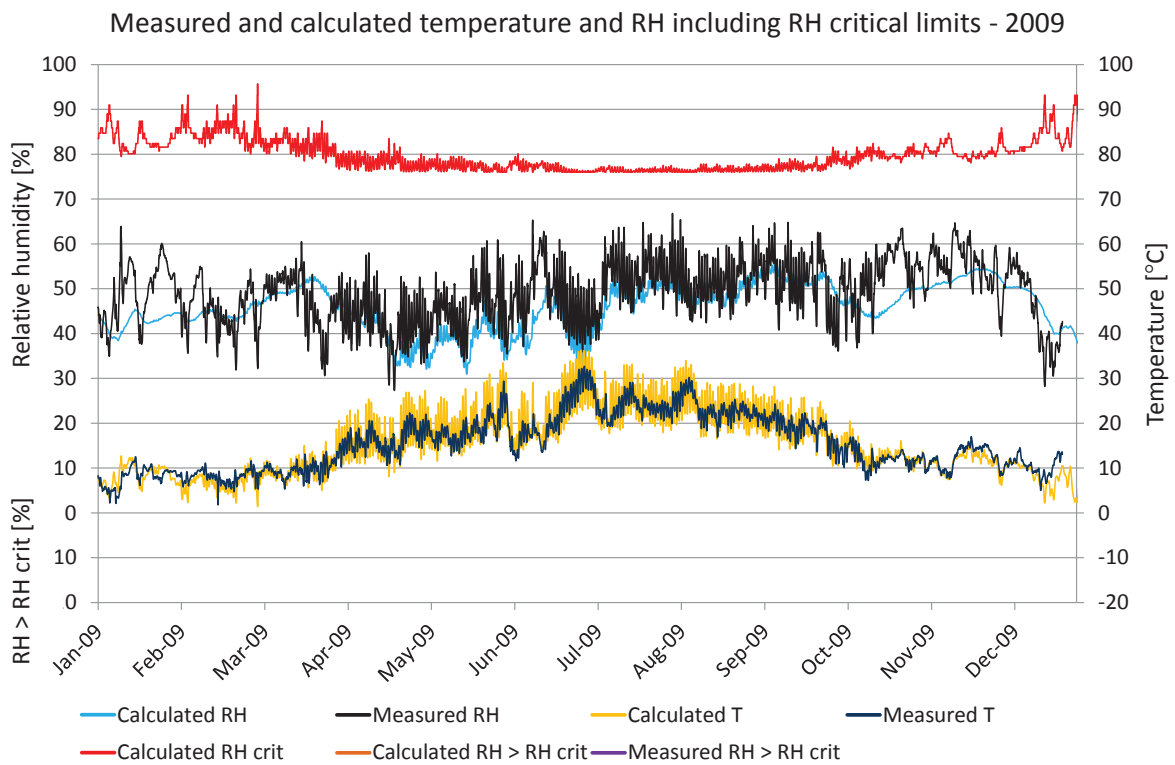


Figure 7.51.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

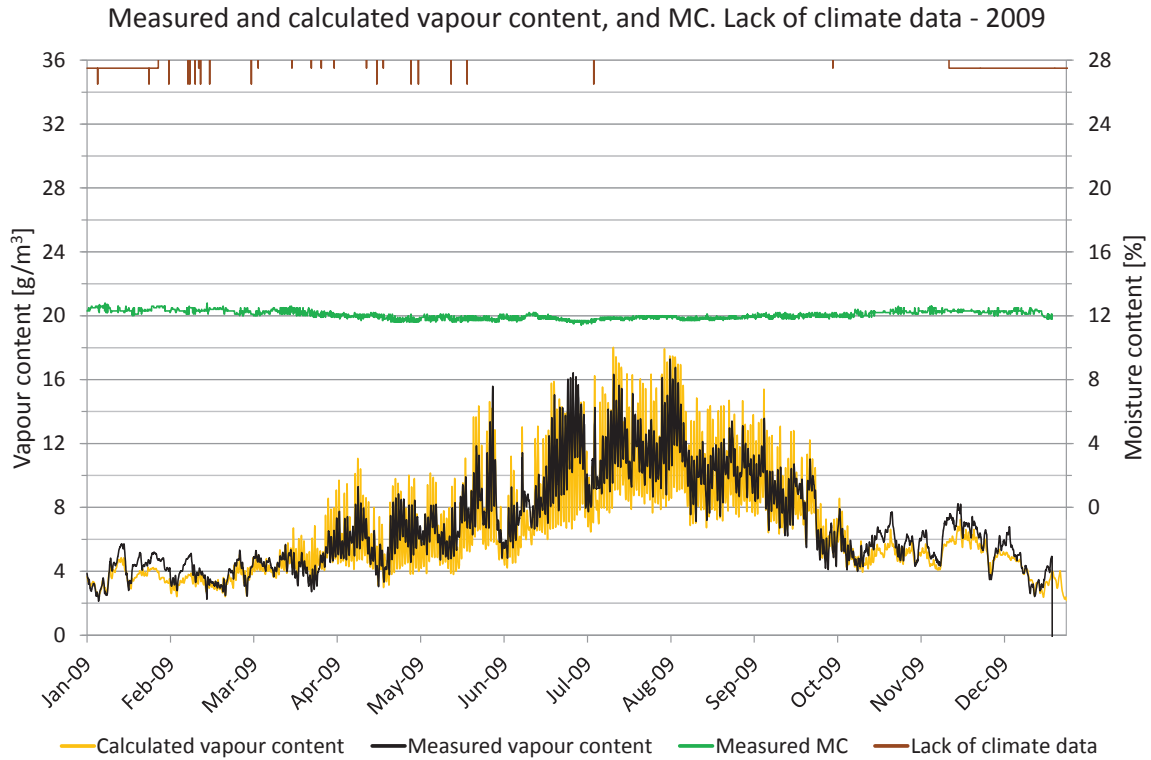


Figure 7.51.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

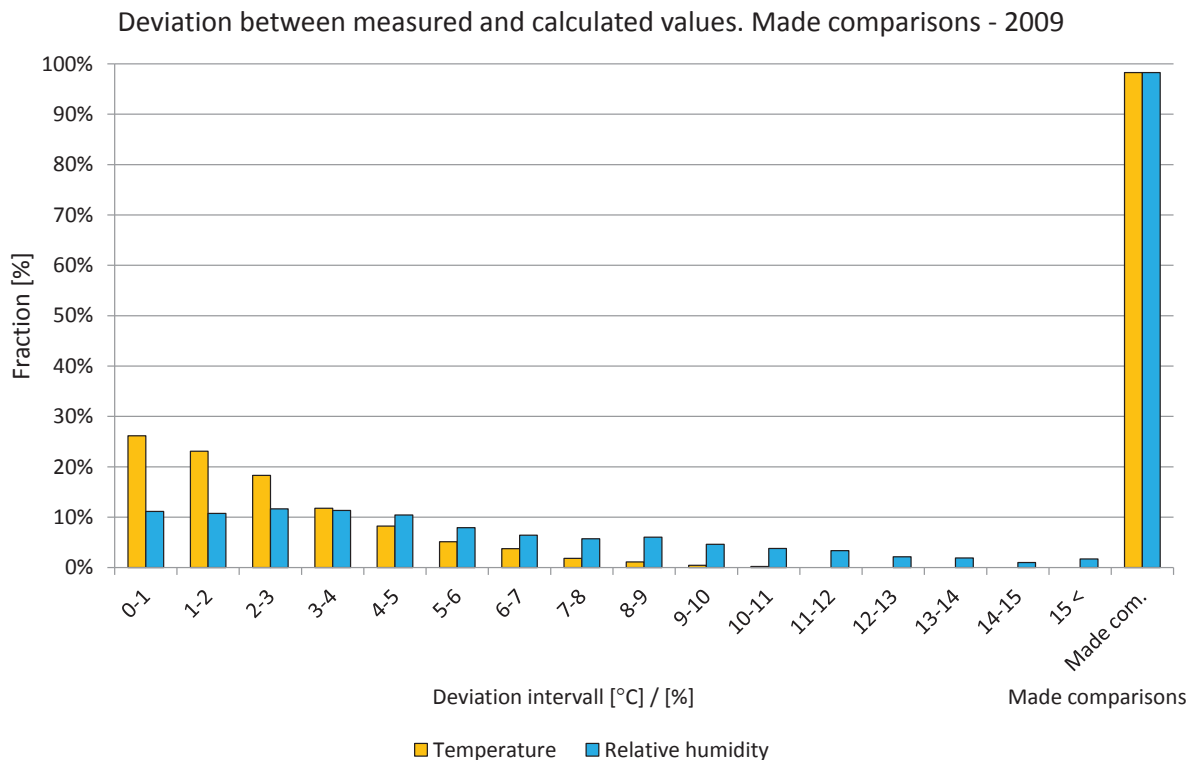


Figure 7.51.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

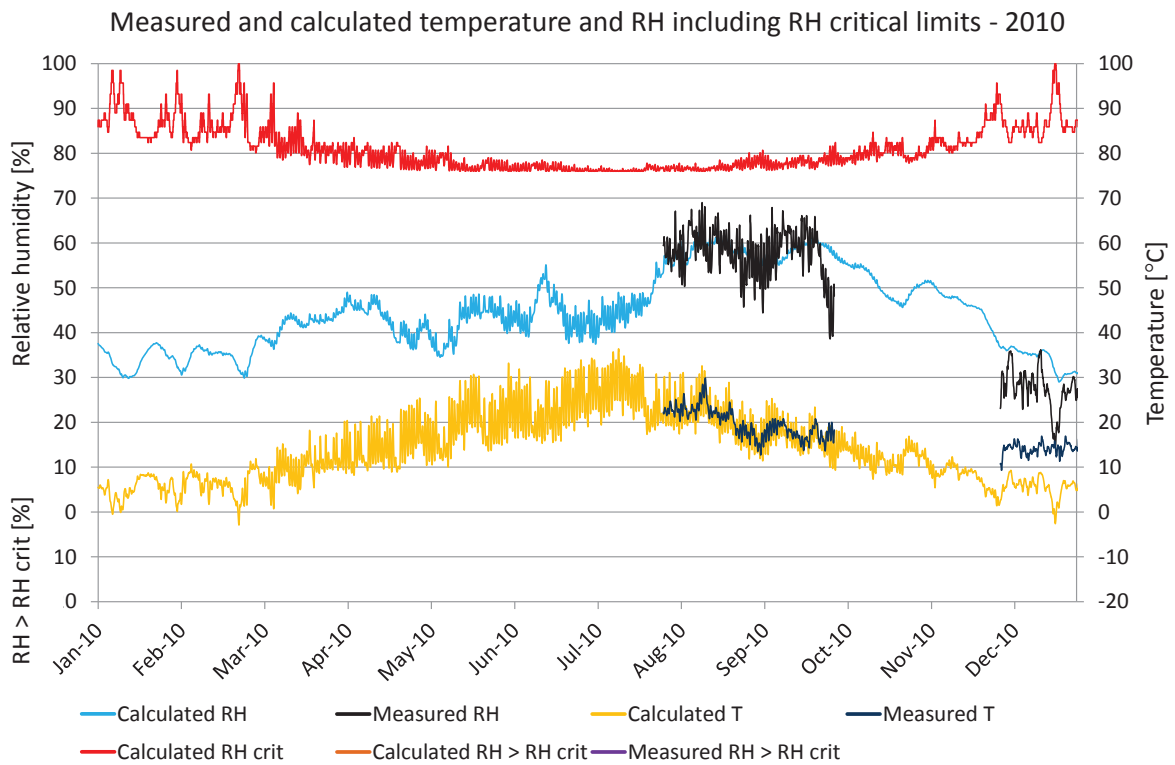


Figure 7.51.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

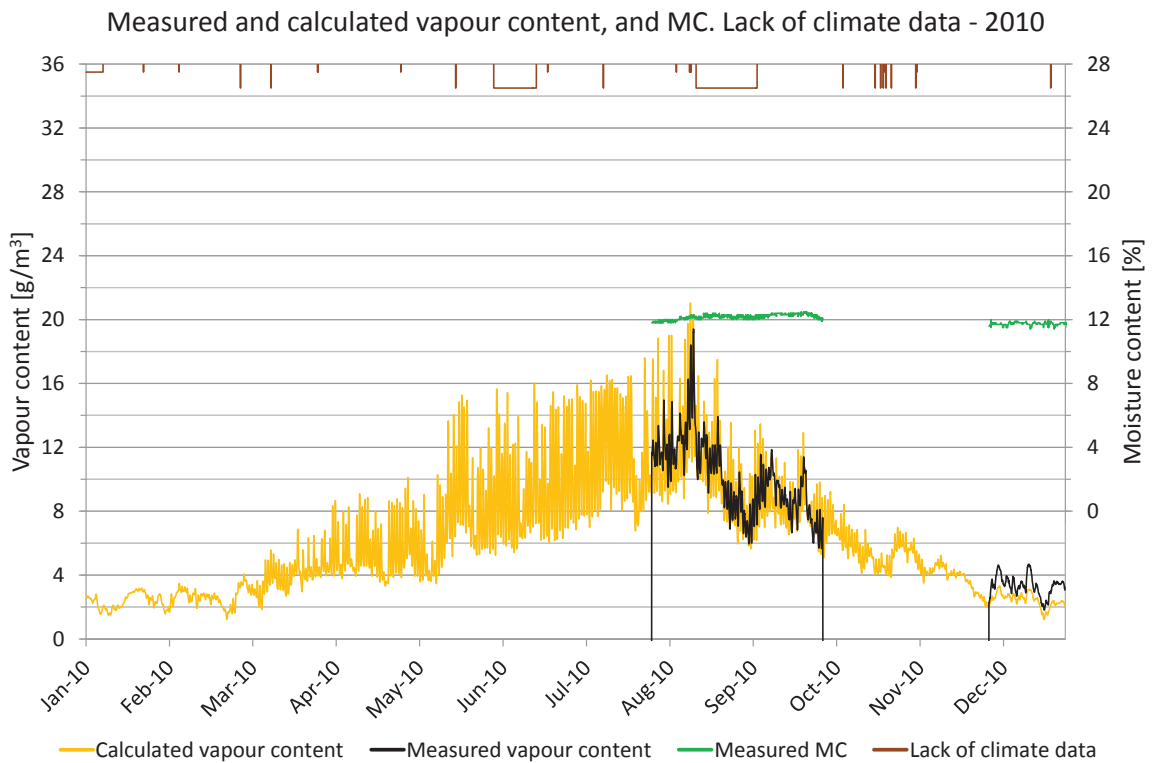


Figure 7.51.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

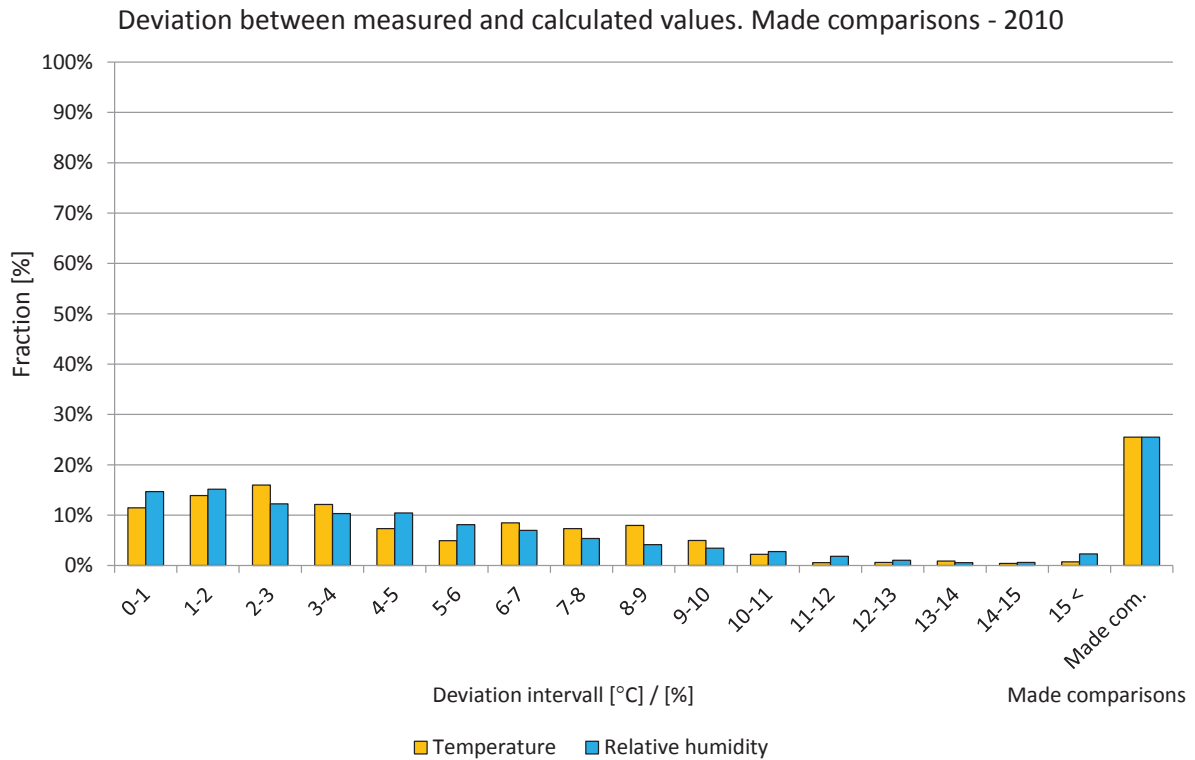


Figure 7.51.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

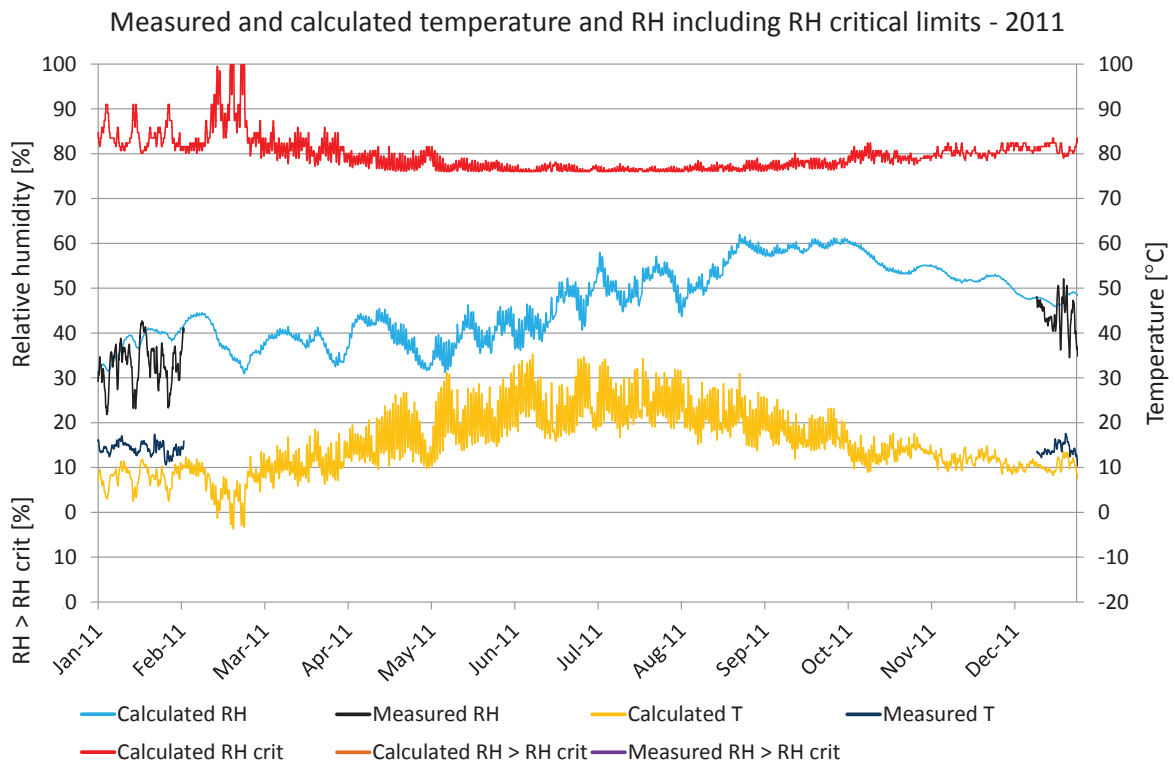


Figure 7.51.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

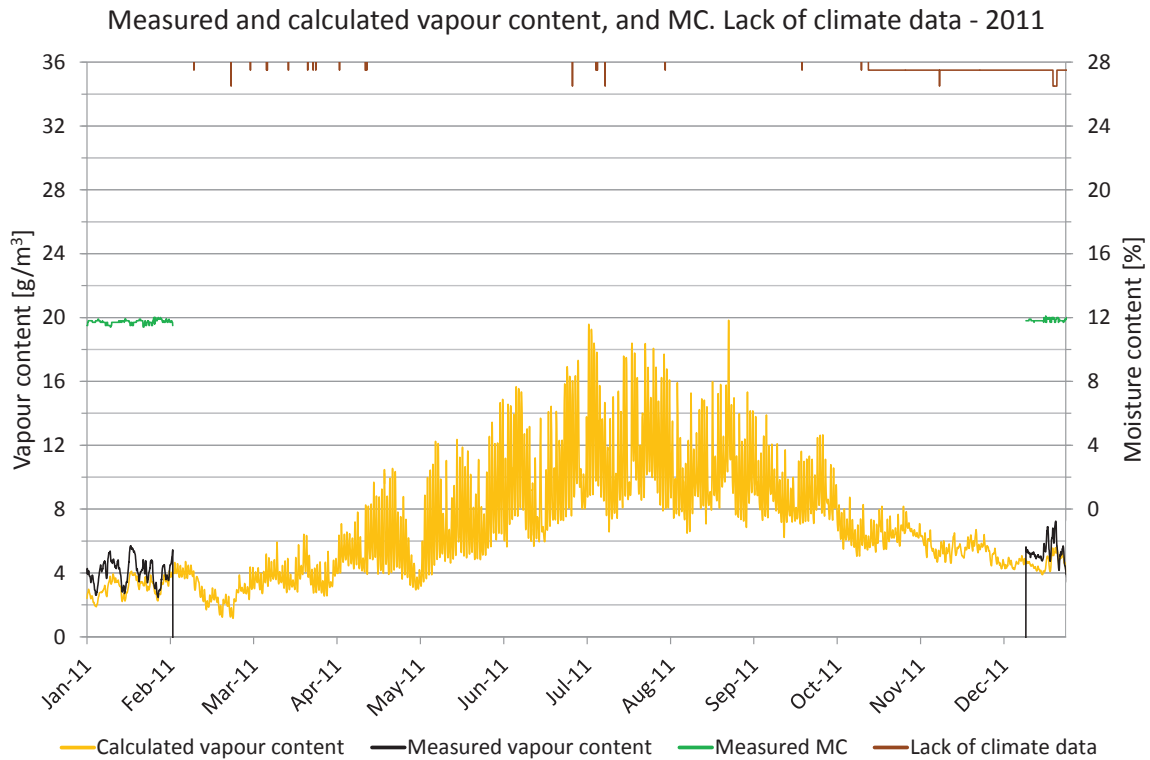


Figure 7.51.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

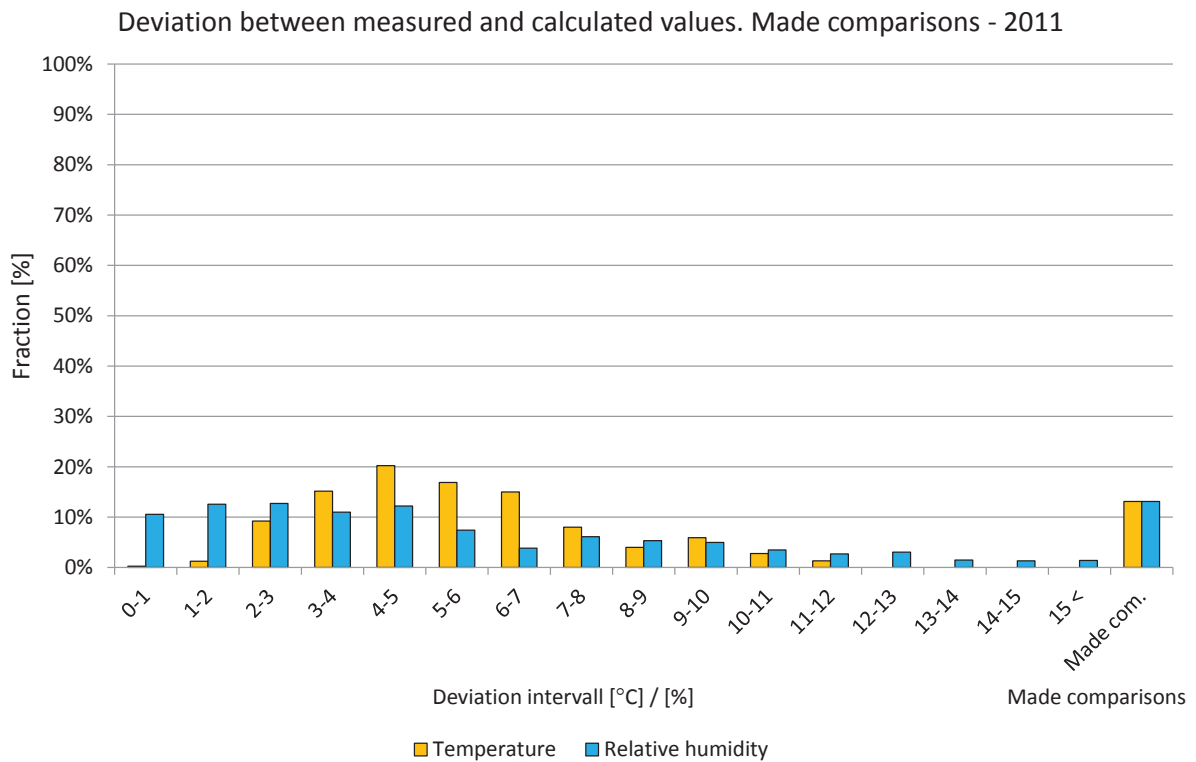


Figure 7.51.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.54 Position 54

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in the roof.

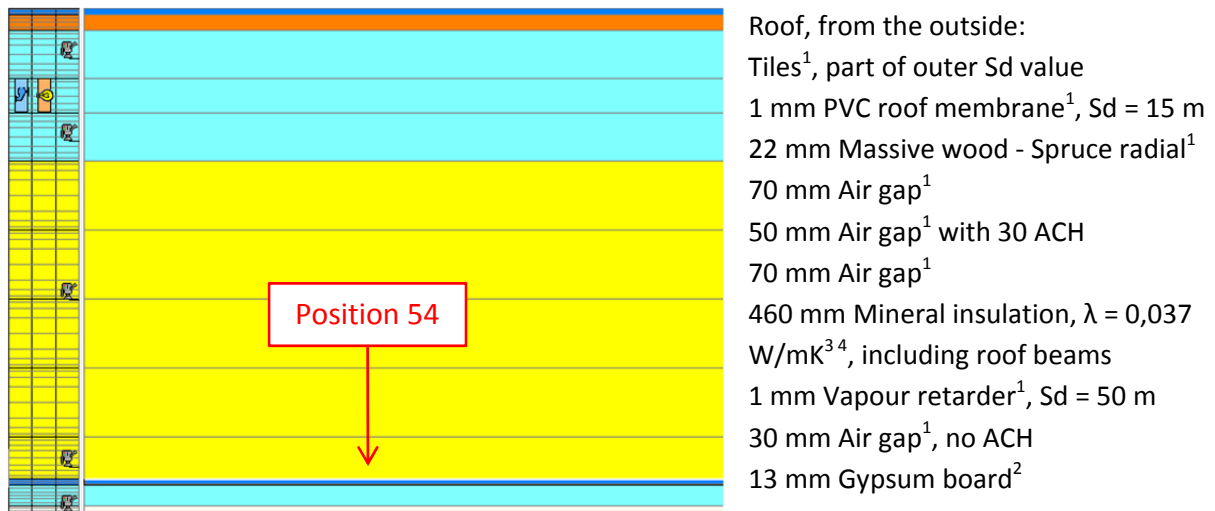


Figure 7.54.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

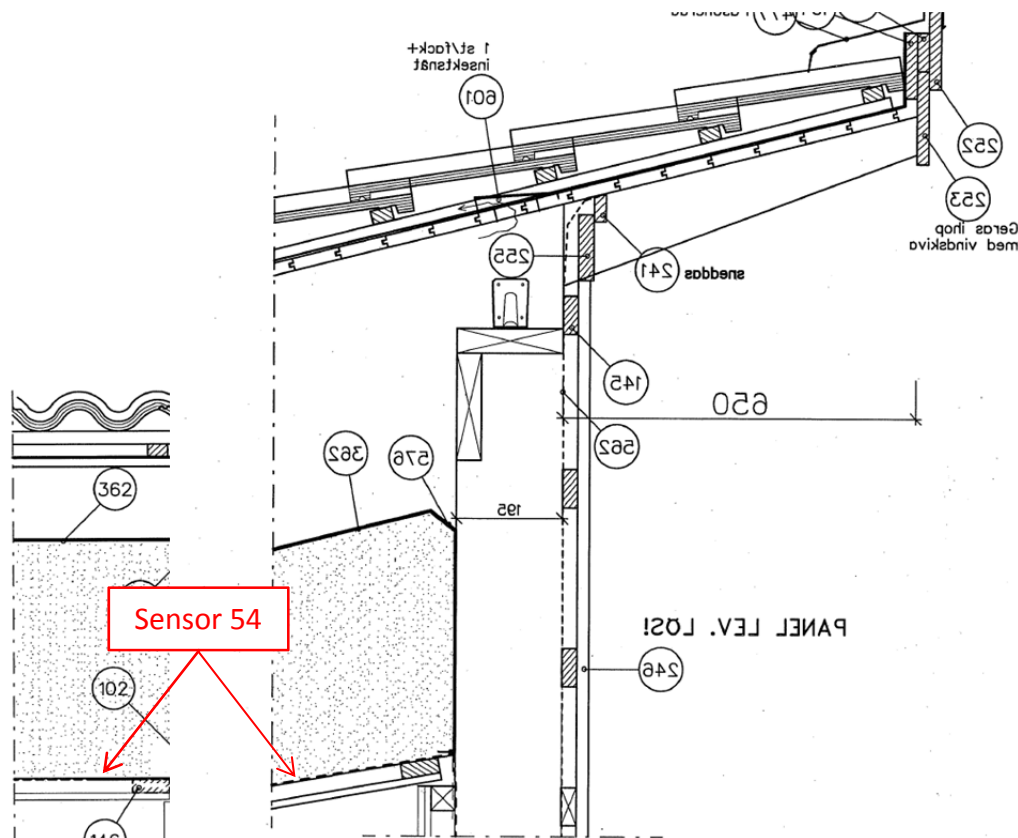


Figure 7.54.2. Location of the studied position.



Figure 7.54.3. Location of the studied position. Photo: SP Trä Skellefteå.

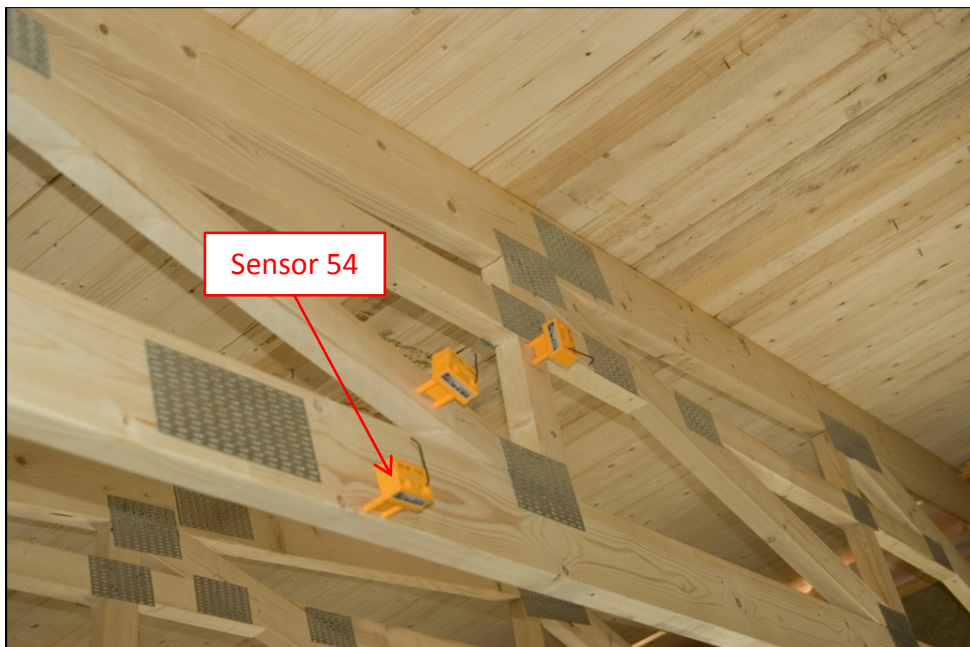


Figure 7.54.4. Location of the studied position. Photo: SP Trä Skellefteå.

A perfect match between the measured and calculated values cannot be expected due to e.g. the influence of two- and three-dimensional effects and the accuracy of the sensors.

Year 2008

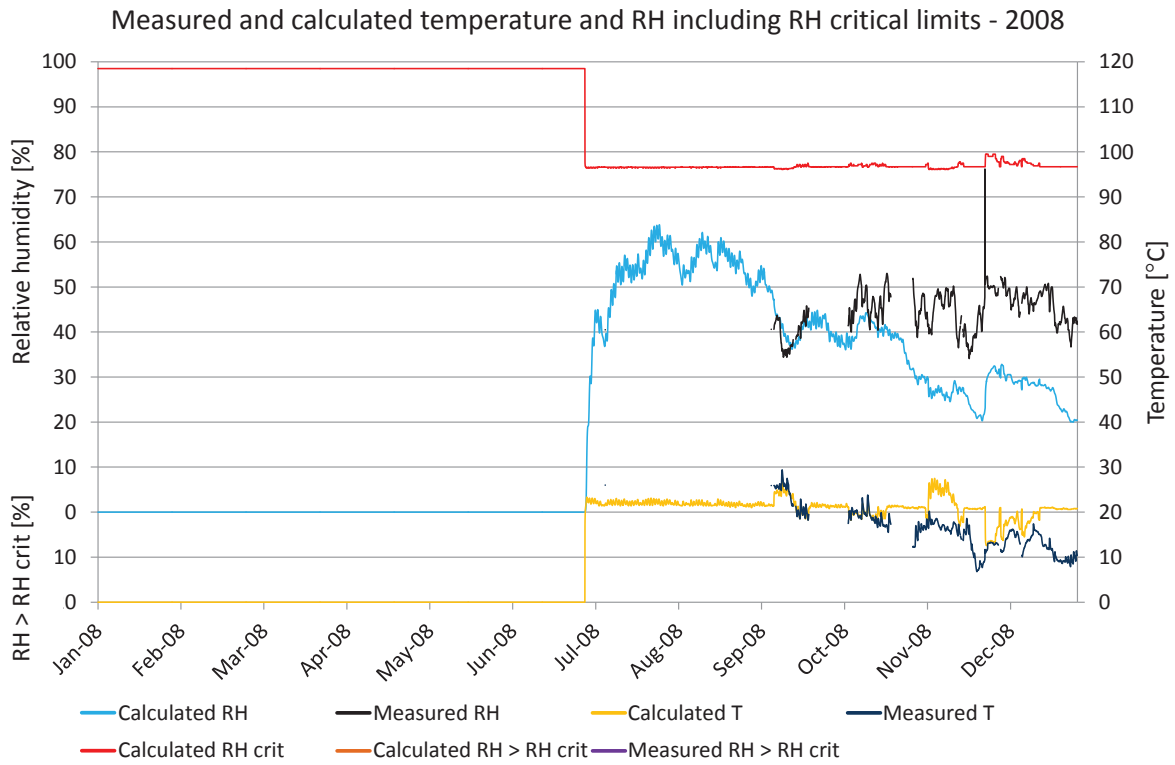


Figure 7.54.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

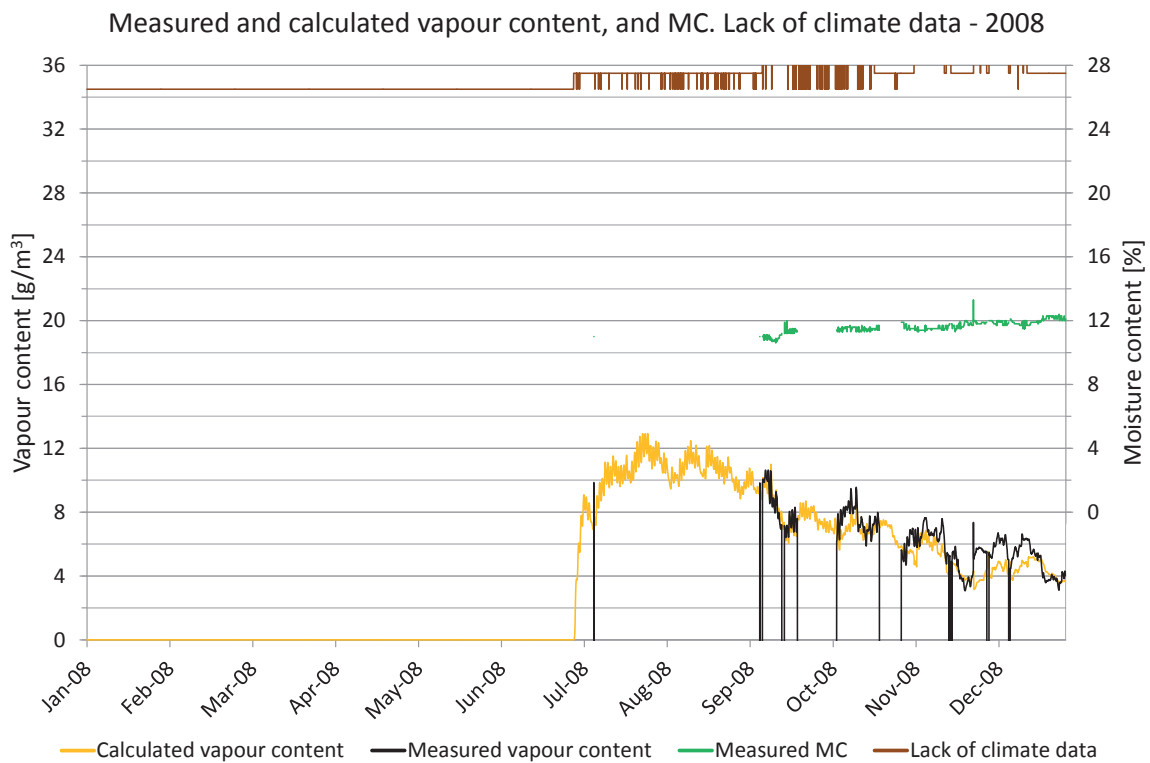


Figure 7.54.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

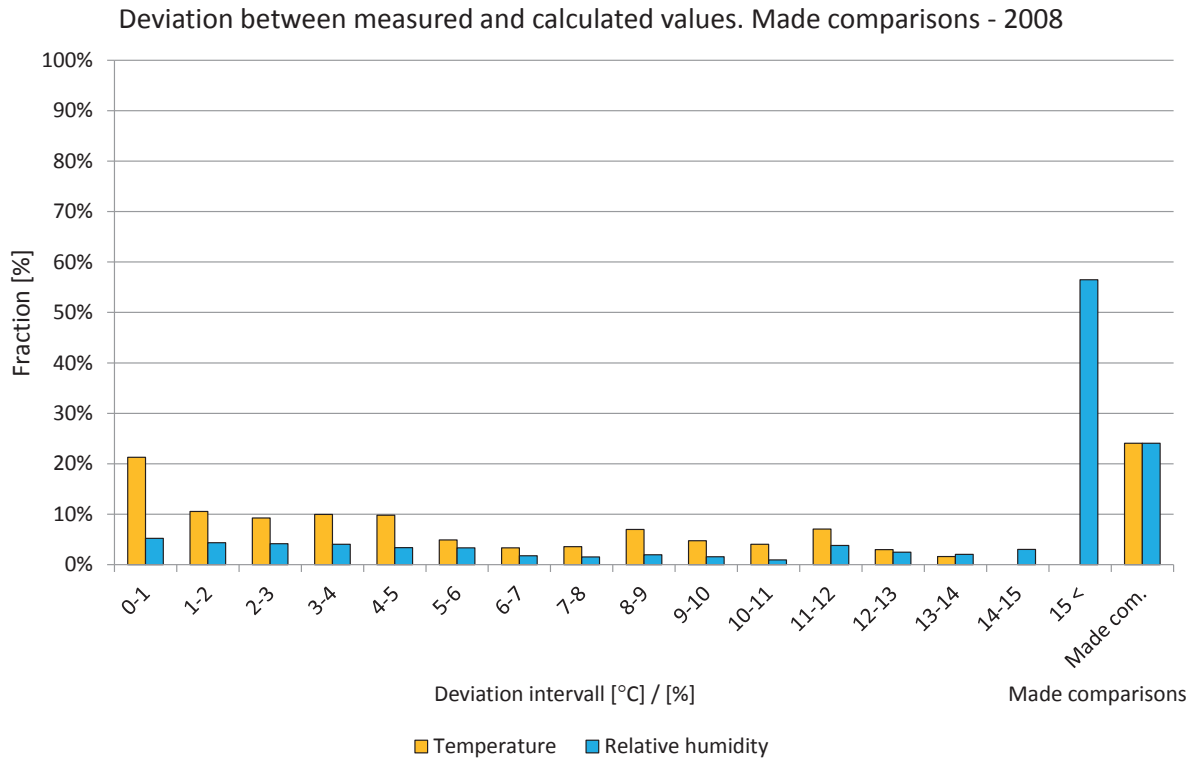


Figure 7.54.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2009

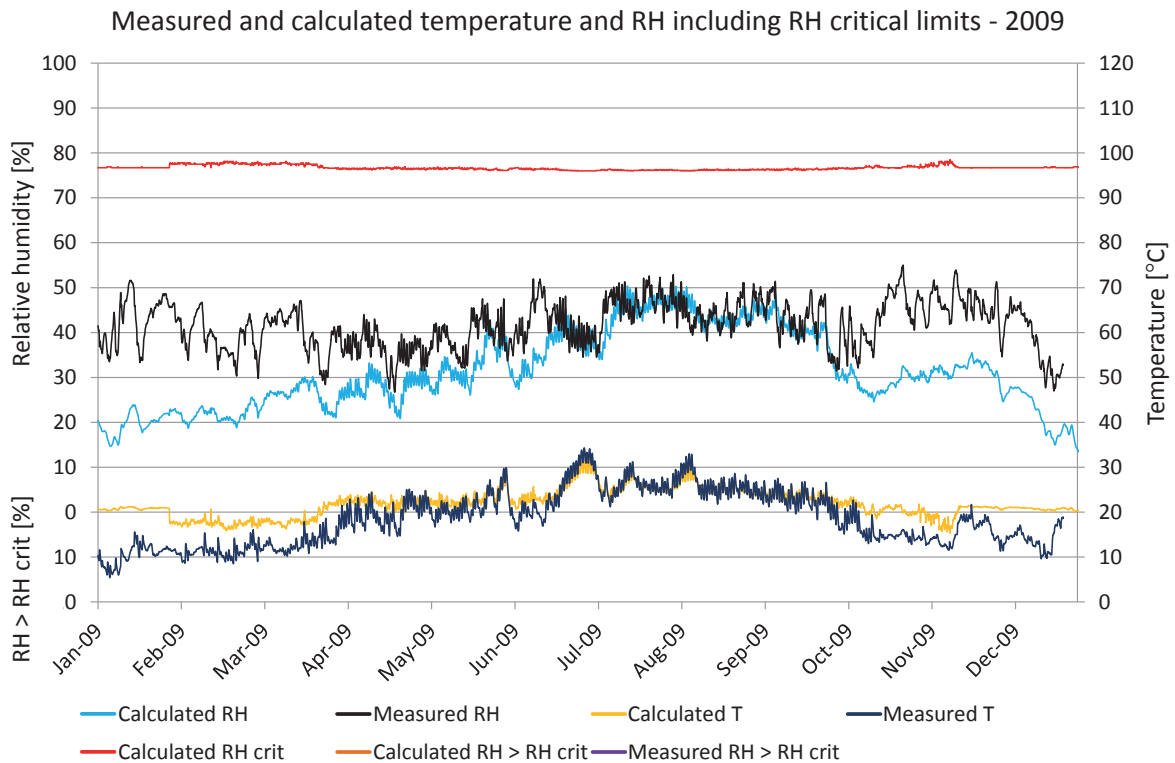


Figure 7.54.8. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

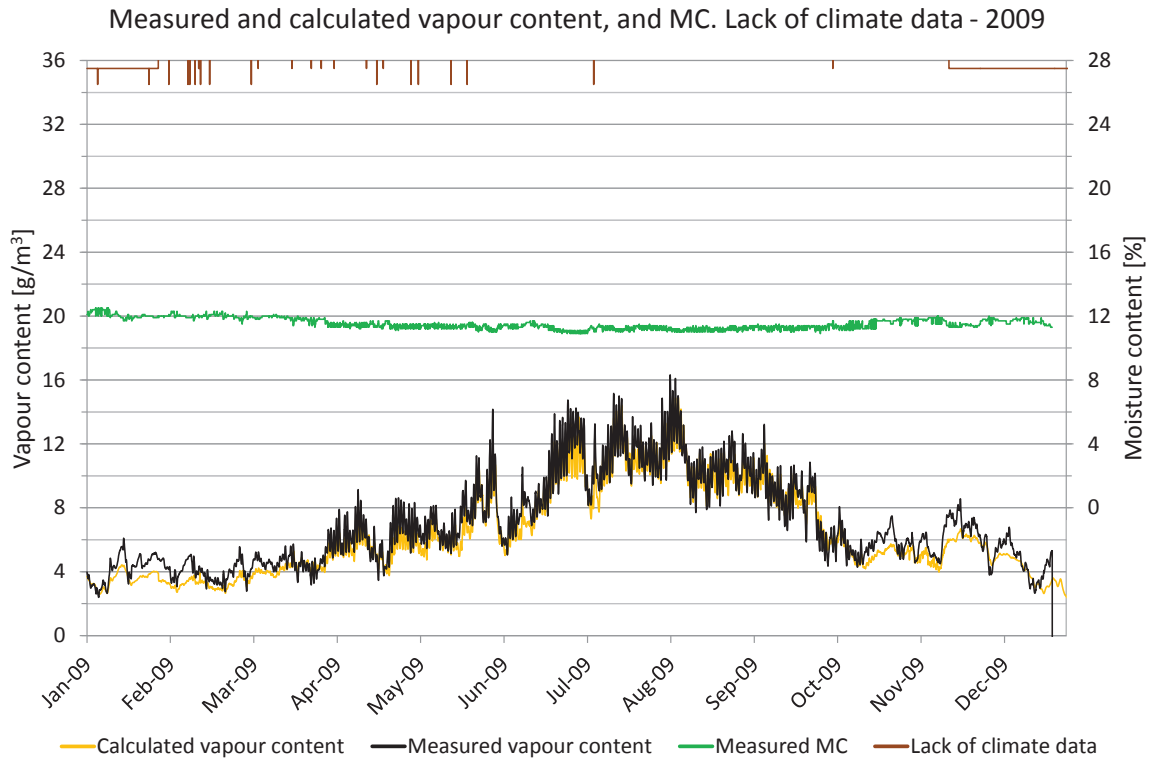


Figure 7.54.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

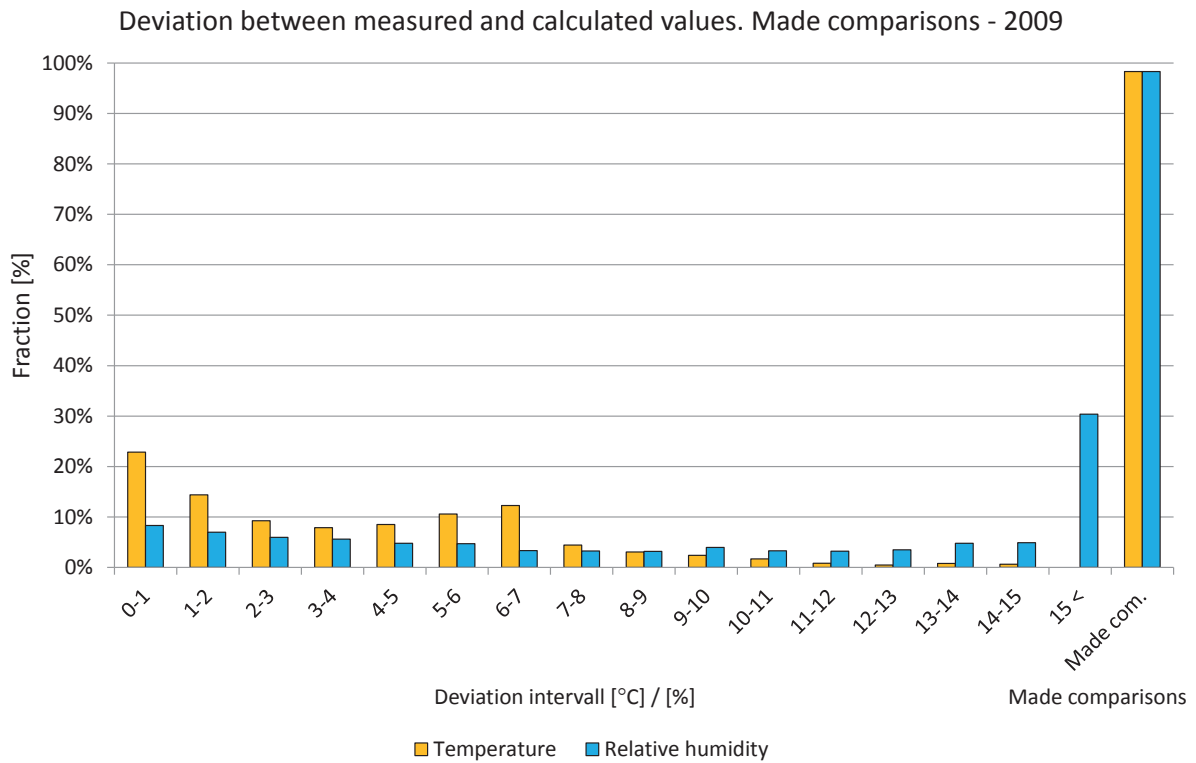


Figure 7.54.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

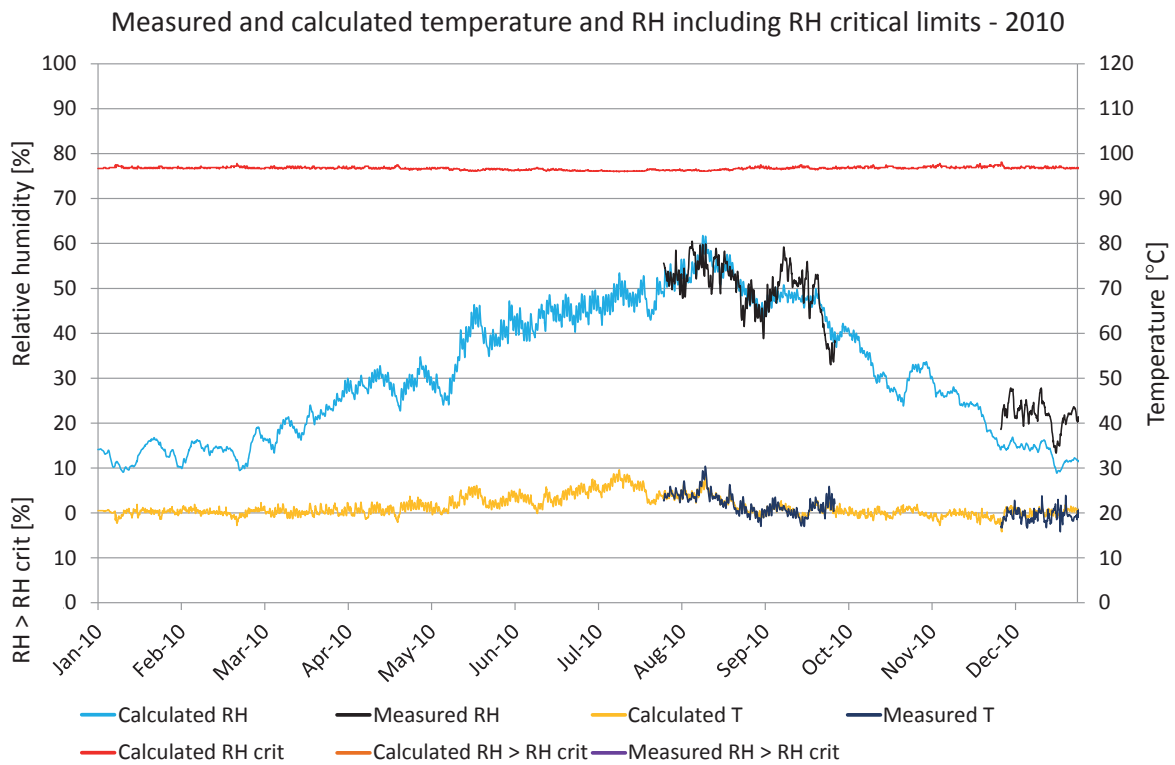


Figure 7.54.11. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

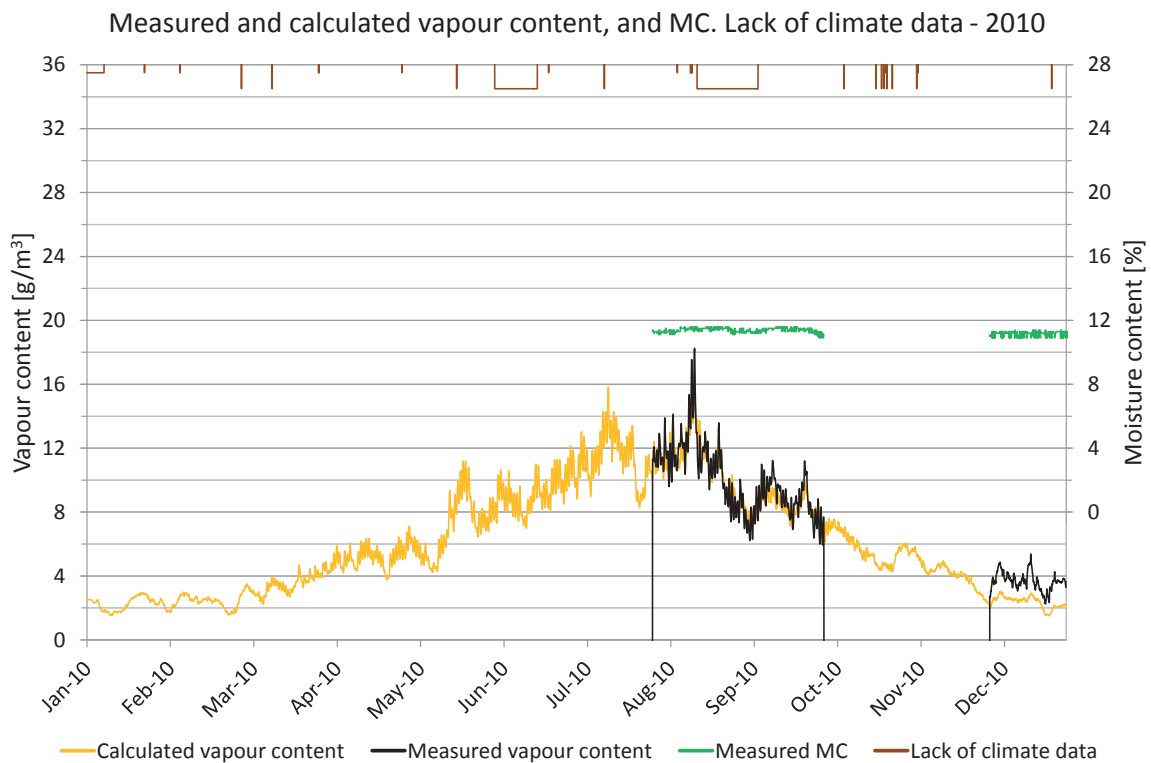


Figure 7.54.12. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

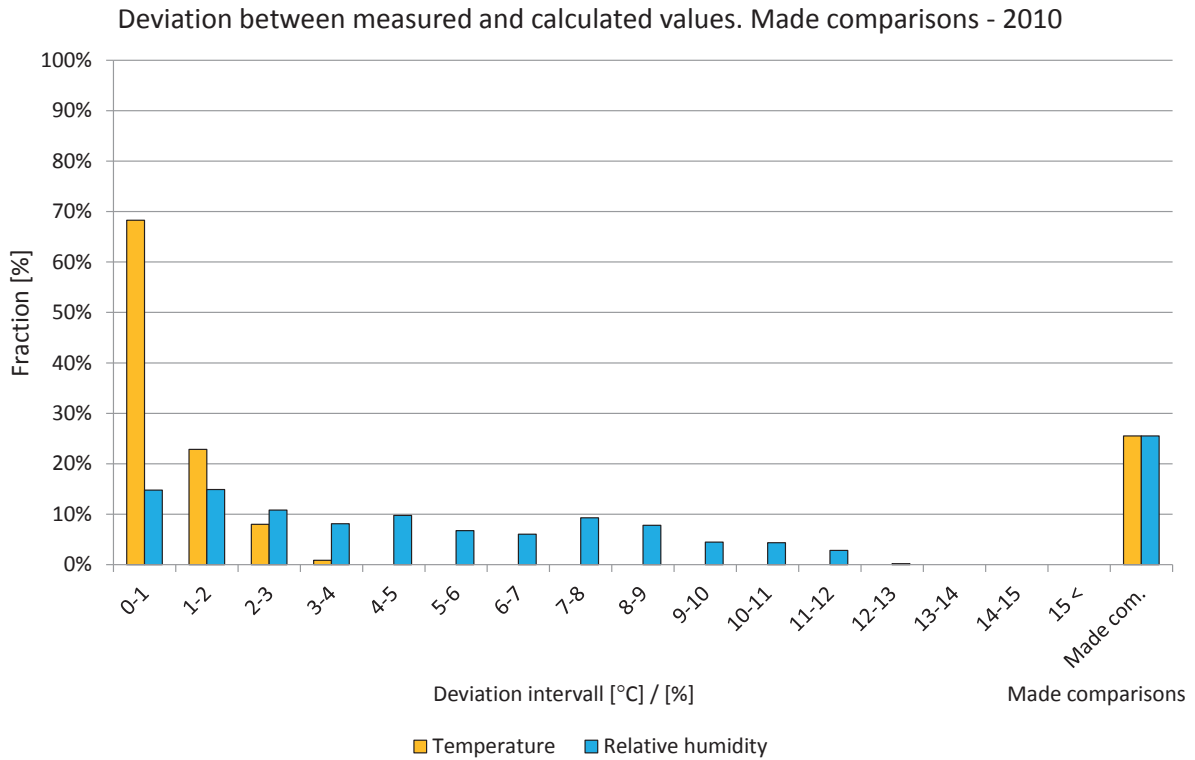


Figure 7.54.13. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

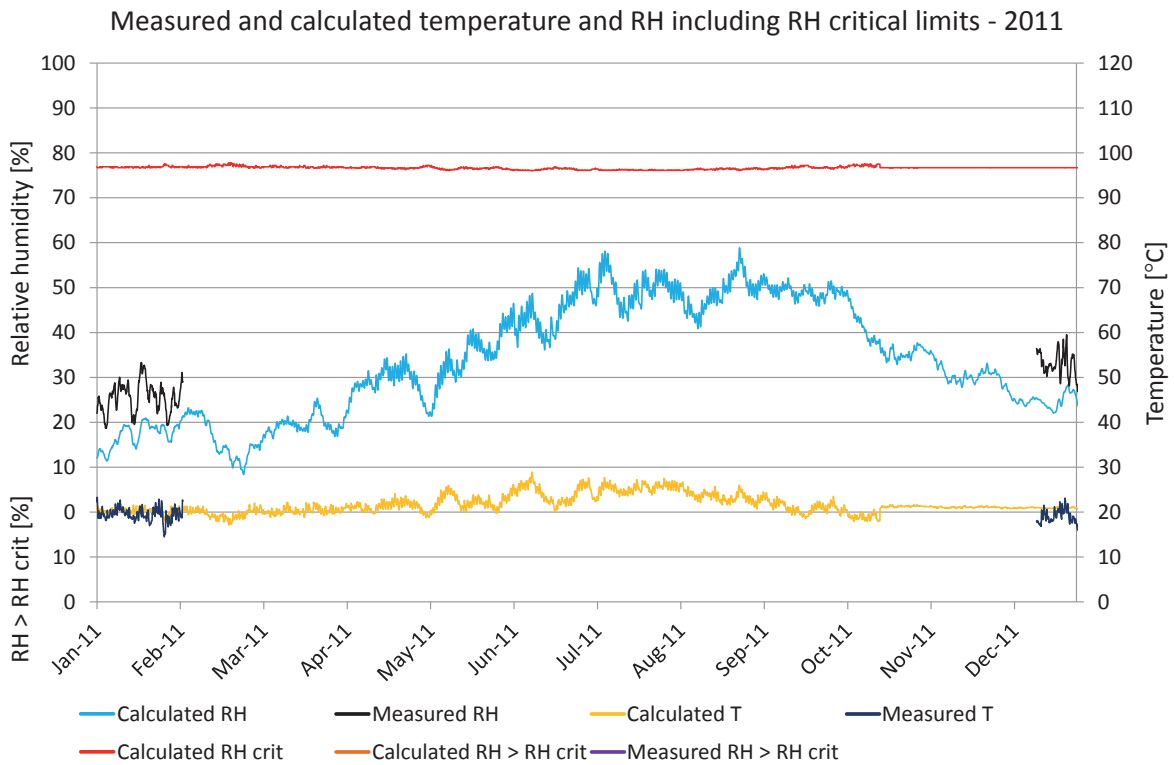


Figure 7.54.14. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated $RH > RH_{crit}$ (light brown), measured $RH > RH_{crit}$ (purple).

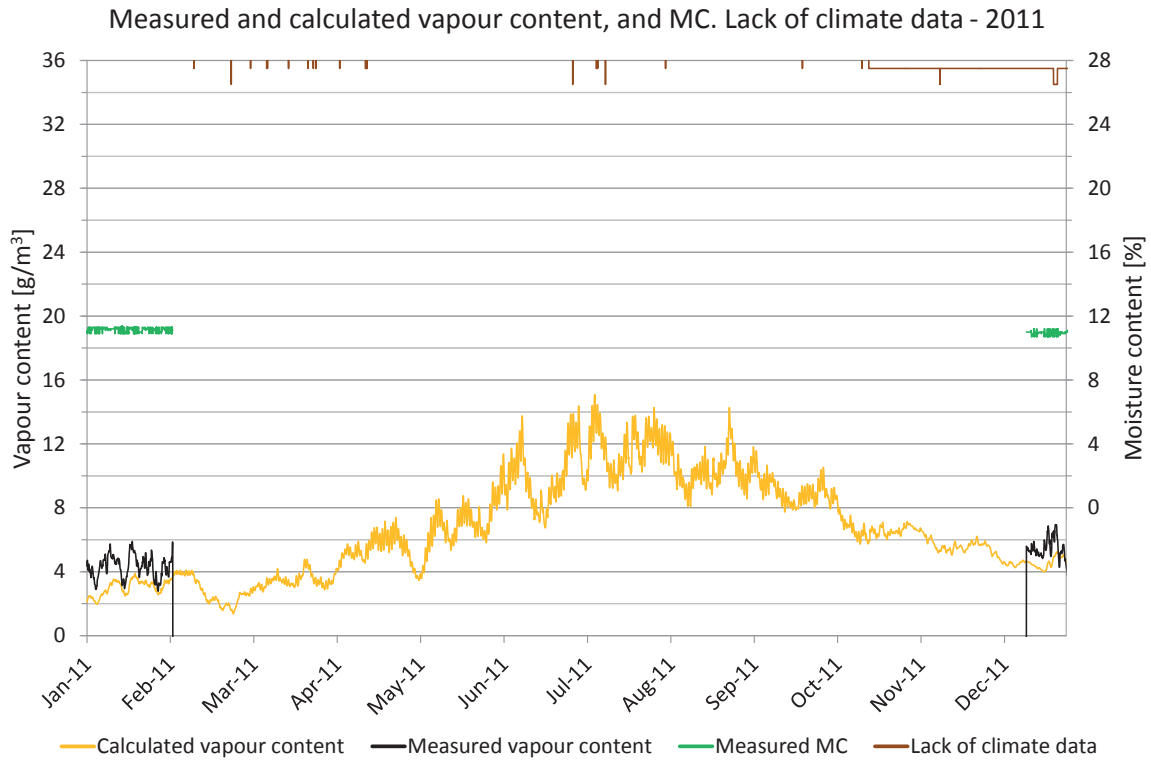


Figure 7.54.15. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

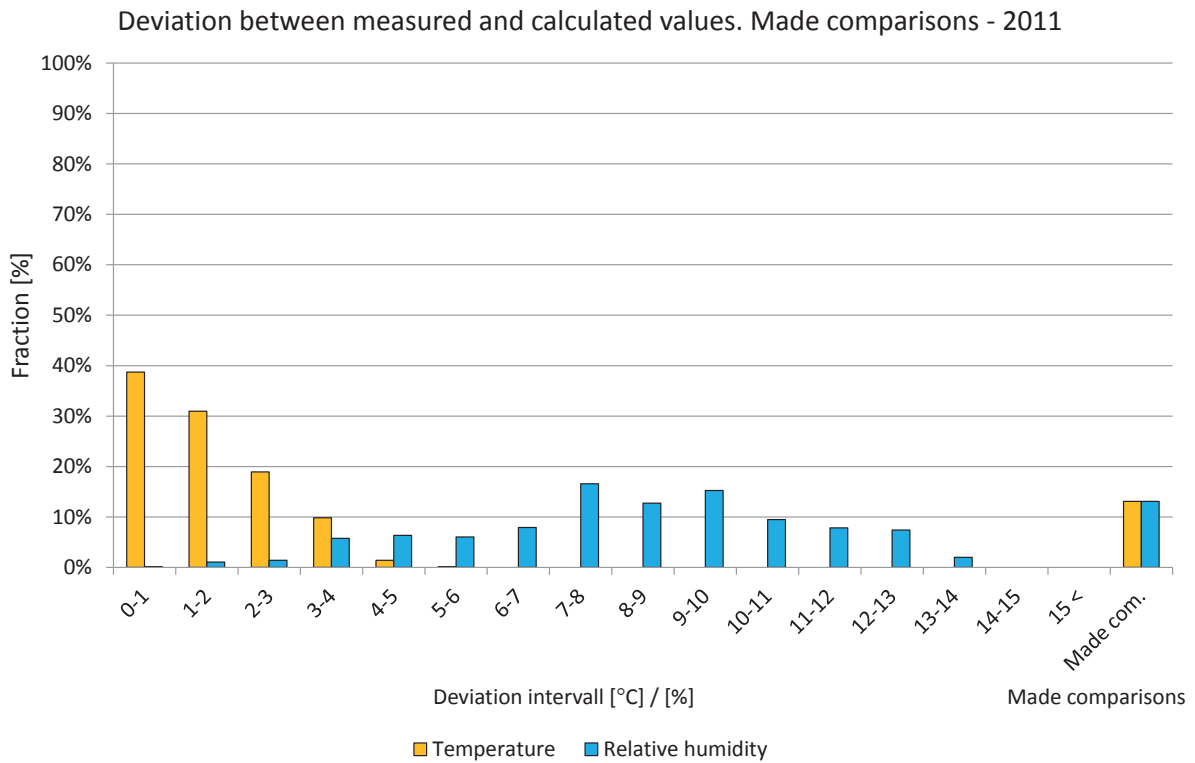


Figure 7.54.16. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

8 Discussion and analysis of the results

The general results from the comparisons of measured and calculated values in the studied positions are briefly summarized and discussed below.

8.1 Walls

In general, there was a clear correlation between the measured and blindly calculated values in most of the studied positions in the walls from March 2009 when the house had become occupied. In some of the studied positions the correlations were rather good. In other positions the measured values did not match the calculated values although they displayed similar behavior or similar daily amplitudes. Unfortunately there were two longer periods during 2010 and 2011 with a complete lack of measured data. However, there were significant differences between the measured and blindly calculated values in some positions. These differences are analyzed and discussed below. Possible factors influencing these differences are also discussed.

Measured relative humidity in the exterior part of the wall, on the whole, shows good correlations to calculated values. There were some deviations of approximately 5 to 10 percent lower measured relative humidity during the winter. The differences, between the measured and blindly calculated relative humidity, seem to depend on differences between the measured and blindly calculated temperatures. I.e. the vapor content was the same but different measured and blindly calculated temperatures indicate different vapor contents at saturation. Consequently this creates differences between the measured and blindly calculated relative humidity.

There were a poor correlation between the measured and calculated values close to the interior part of the wall, both in the installation layer inside the vapour barrier and in the inner part of the wall on the outside of the vapour barrier. Larger amplitudes in measured values compare to the calculated values could also be found in those comparisons. This may depend on that the interior room, inside the wall where measurements were carried out, was not in use during some parts of the year and the interior temperature therefore was lower.

Measurements located close to the horizontal wall bottom sill beams show significant lower measured relative humidity during the periods of the year when the floor heating system was switched on. This was a result of the high temperature that became created in the area close to the sill which affects the vapour content at saturation and consequently greatly reduces the relative humidity.

8.2 Attic

In general there was a clear correlation between the measured and blindly calculated values in most of the studied positions in the attic. Similarly to the results from the walls, some positions show better correlations and other positions show poorer correlations between the measured and blindly calculated values. The differences between the measured and blindly calculated values are analyzed and discussed below. Possible factors influencing the differences are also discussed.

All studied positions show good correlations between measured and calculated values during the warm periods or the year. During the cold periods there were deviations dependent on the temperature.

Similarly to the walls the daily variation in temperature and relative humidity in the cold attic space, on the inside of the tongued and grooved wood, and in air gap, were mainly the same when the measured and blindly calculated values were compared. However, in the insulation there were larger amplitudes in the measured temperature and relative humidity than in the blindly calculated values.

9 Conclusions

Although there are a number of differences between the measured and blindly calculated values most of the blind comparisons show significantly close correlations between the measured and blindly calculated temperature and relative humidity.

10 References

Falk, Jörgen, Sandin, Kenneth, 2013, Ventilated rainscreen cladding: Measurements of cavity air velocities, estimation of air change rates and evaluation of driving forces, Building and Environment 59 p167.

Framtidens Trähus, 2012, www.framtidenstrahus.se, 2012-01-23.

Hägerstedt, S. Olof, Harderup, Lars-Erik, 2010A, Importance of a proper applied airflow in the façade air gap when moisture and temperature are calculated in wood framed walls, Proceedings – 5th International BUILDAIR-Symposium “Building and Ductwork Air-tightness” Copenhagen, Denmark.

Hägerstedt, S. Olof, Arfvidsson, Jesper, 2010B, Comparison of field measurements and calculations of relative humidity and temperature in wood framed walls. Thermophysics 2010 – Conference proceedings, 15th International Meeting of Thermophysical Society, Valtice, Czech Republic.

Hägerstedt, S. Olof, Harderup, Lars-Erik, 2011, Comparison of measured and calculated temperature and relative humidity with varied and constant air flow in the façade air gap, Proceedings of the 9th Nordic Symposium on Building Physics – NSB 2011, Tampere, Finland.

IEA Annex 24, 1996, Heat air and moisture transfer through new and retrofitted insulated envelopes.

IBP, 2012, Fraunhofer Institute for Building Physics. www.ibp.fraunhofer.de, 2012-05-04.

Krus, Martin, 1996, Moisture Transport and Storage Coefficients of Porous Mineral Building Materials, Fraunhofer, IRB Verlag, Doctoral thesis, Fraunhofer Institute of Building Physics, Fraunhofer IRB Verlag, Stuttgart 1996, ISBN 3-8167-4535-0.

Mundt-Petersen, S. Olof, 2013, Licentiate thesis.

Mundt-Petersen, S. Olof, Wallentén, Petter, Toratti, Tomi, Heikkinen, Jorma, 2012, Thermophysics 2012 – Conference proceedings, 17th International Meeting of Thermophysical Society, Brno University of Technology, Faculty of Chemistry, 2012, ISBN 978-80-214-4599-4.

Nevander, Lars-Erik, Elmarsson Bengt, 1994, Fukthandbok, Praktik och teori, AB Svensk byggtjänst, Tredje utgåvan, Elanders Infologistics Väst AB, Mönlycke 2007, ISBN 978-91-7333-156-2.

Paroc, 2002, Produktinformation – byggboken.

Sandberg, Karin, Pousette, Anna, Dahlquist, Simon, 2011, Wireless in situ measurements of moisture content and temperature in timber constructions, 12th International conference on durability of building materials and components, XII DBMC, Porto – Portugal 2011.

