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Comparison of hygrothermal measurements and calculations in a single-family wooden house on the west coast of Sweden

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2013

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1

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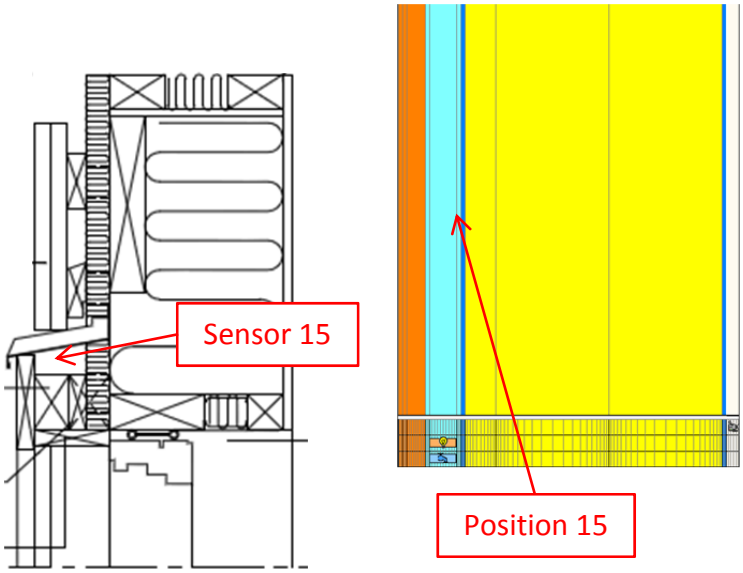
7.15 Position 15

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a wall facing northwest.



Wall, from the outside:
15/21 mm Facade panel - Spruce radial[1] including paint Sd = 1 m[2]
24 mm Air gap[1] with 30 ACH
1 mm Weather resistive barrier[1], Sd = 0,2 m
30 mm Mineral insulation board, λ = 0,037 W/mK[3 4]
220 mm Light studs/ Mineral insulation, λ = 0,037 W/mK[3 4]
1 mm Vapour retarder[1], Sd = 50 m
13 mm Gypsum board[5]

Figure 7.15.1. 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.

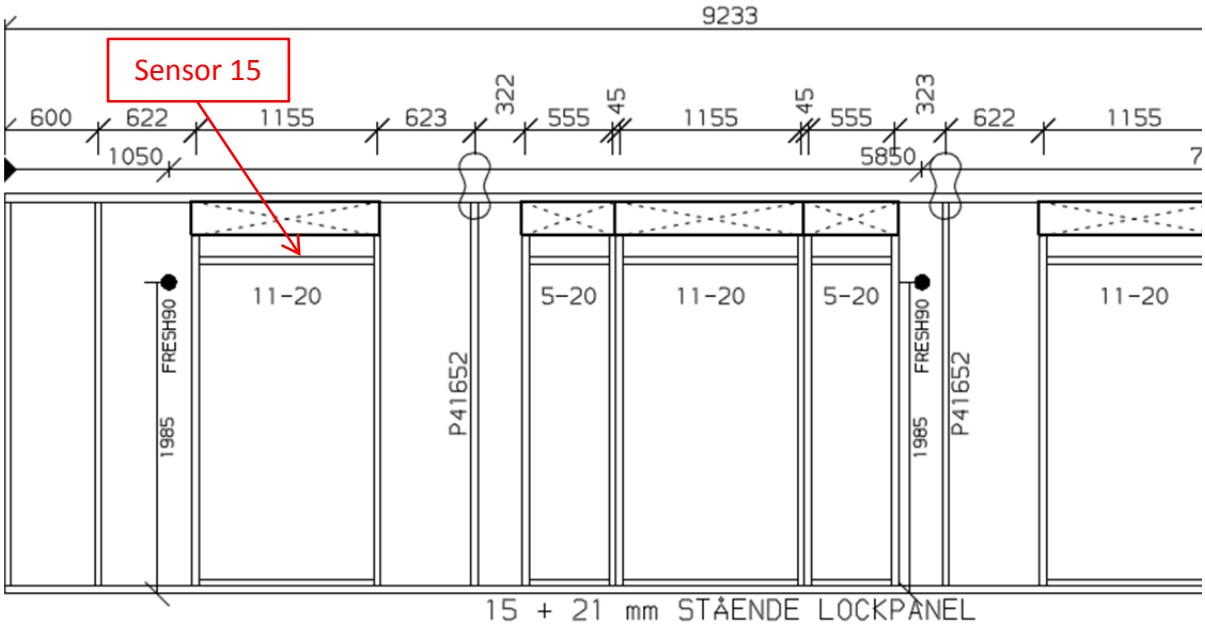


Figure 7.15.2. Location of the studied position.

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 2009

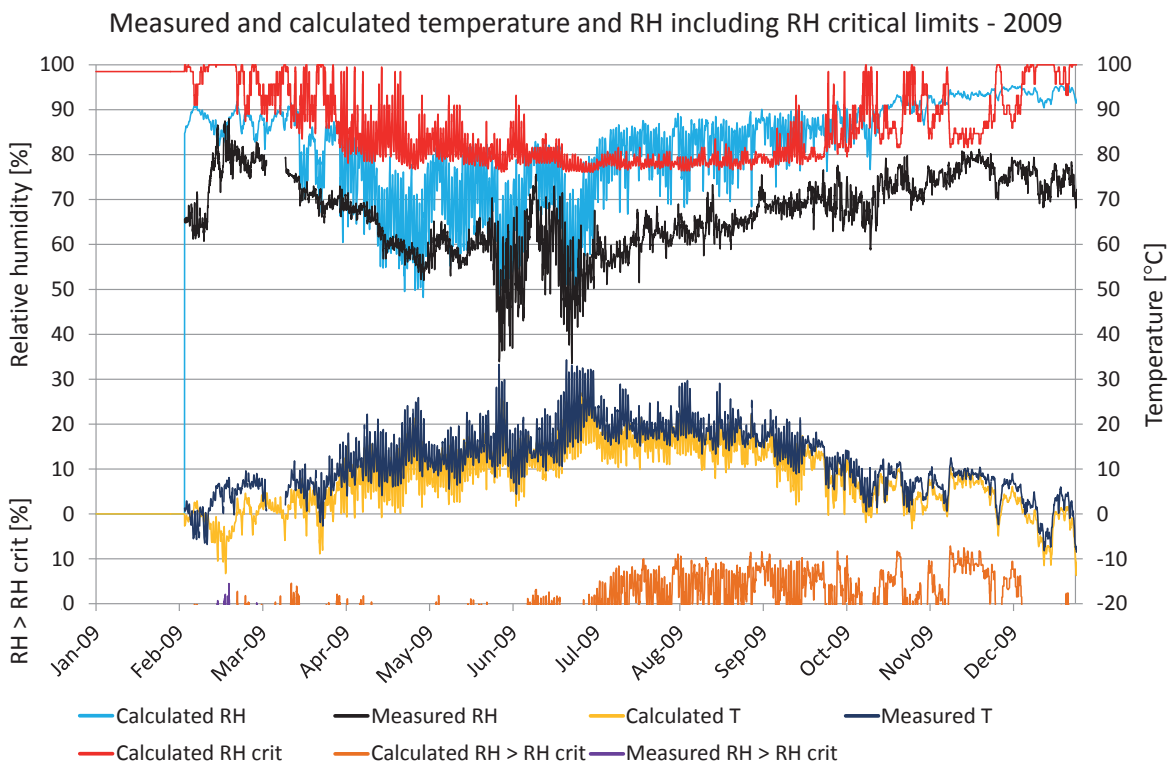


Figure 7.15.3. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

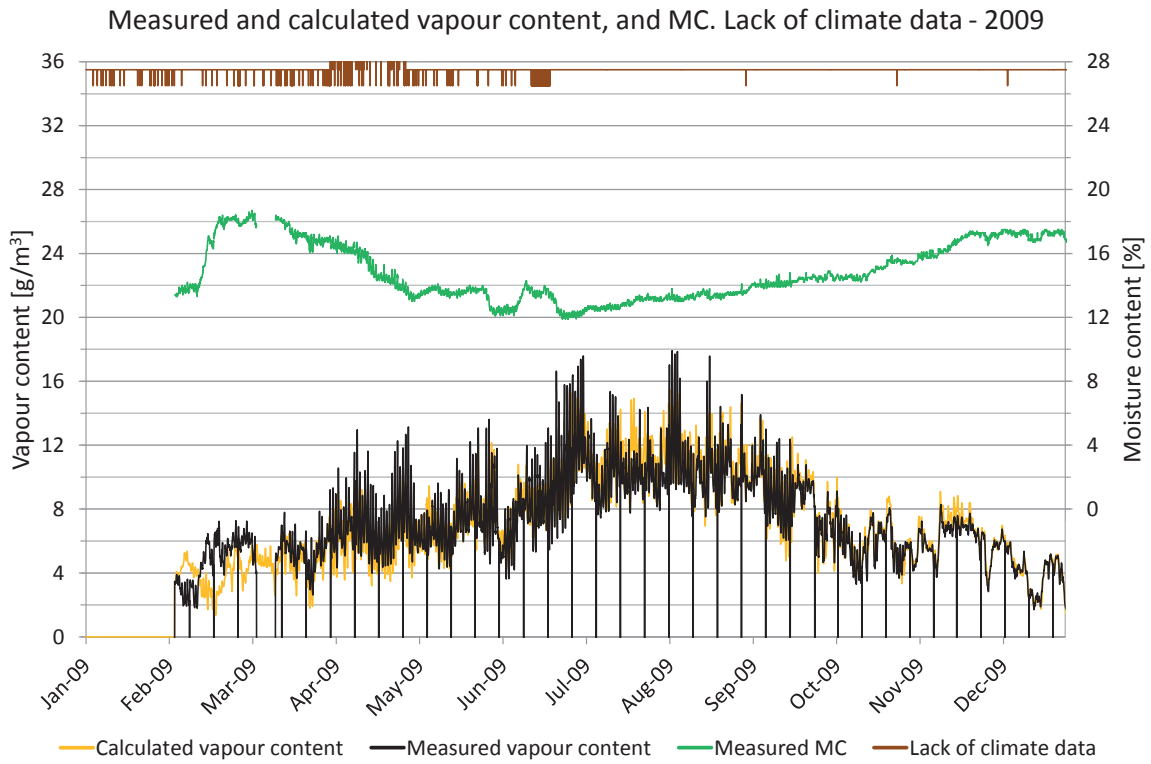


Figure 7.15.4. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

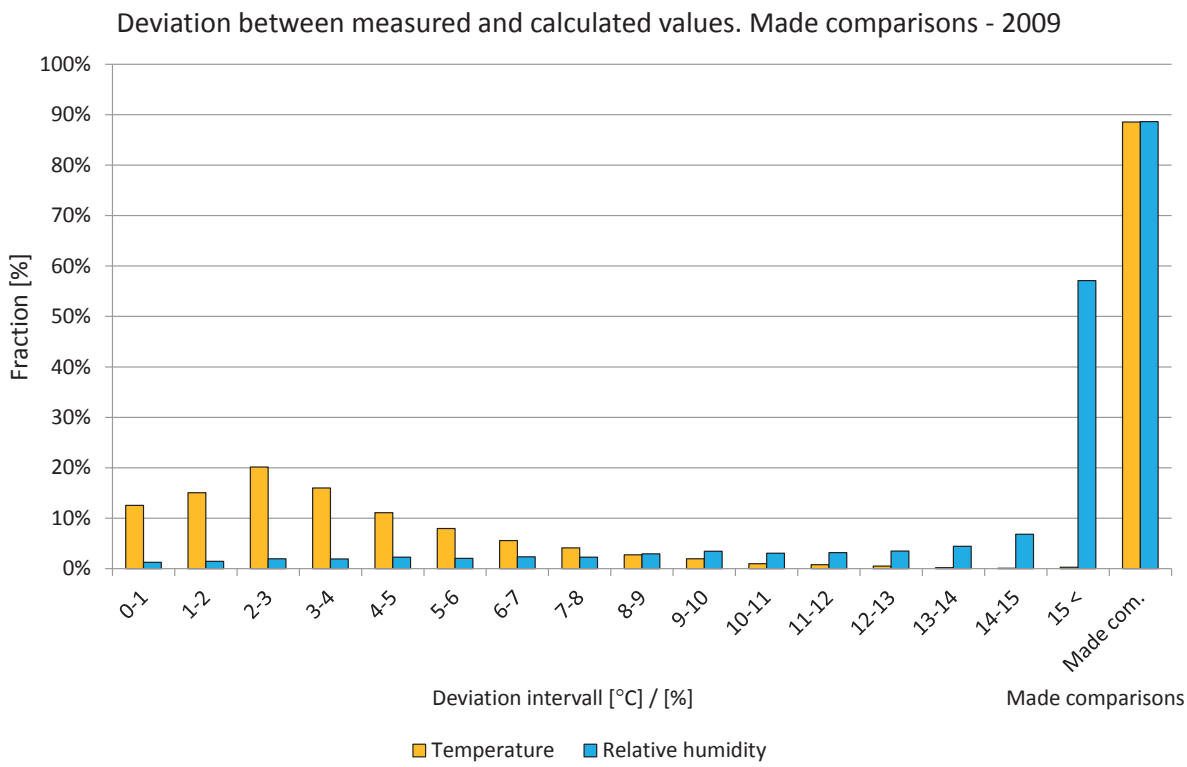


Figure 7.15.5. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

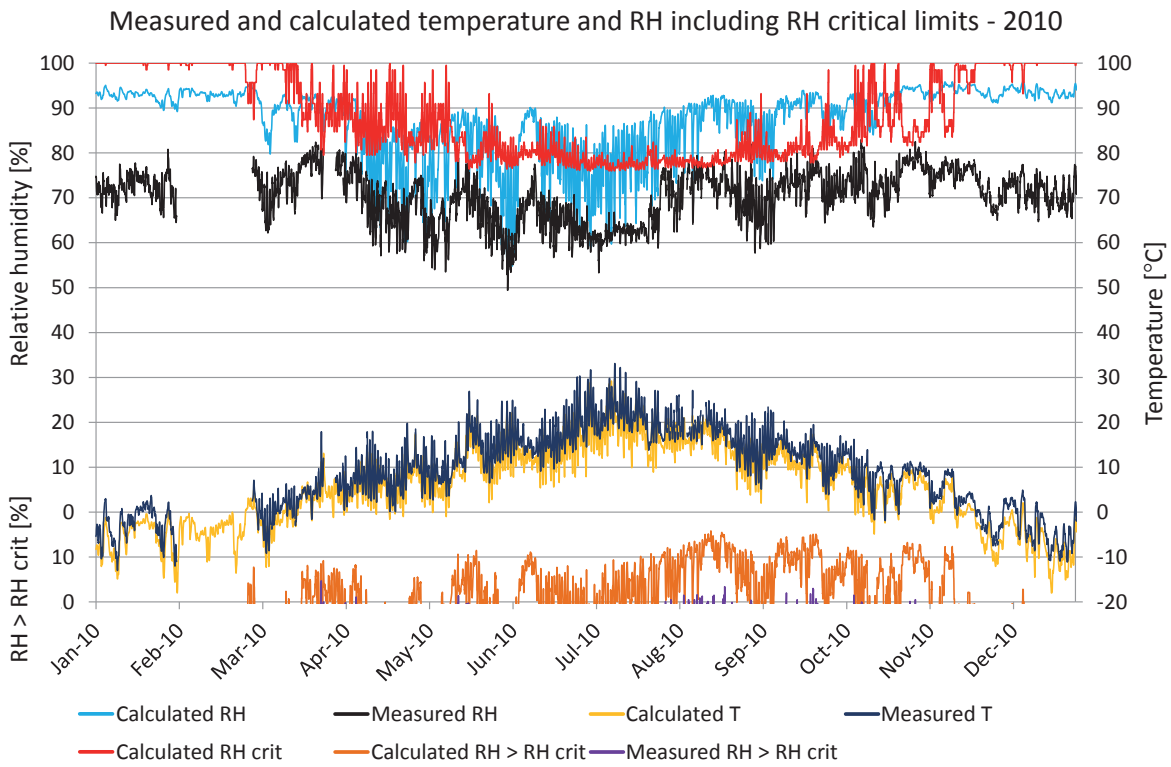


Figure 7.15.5. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

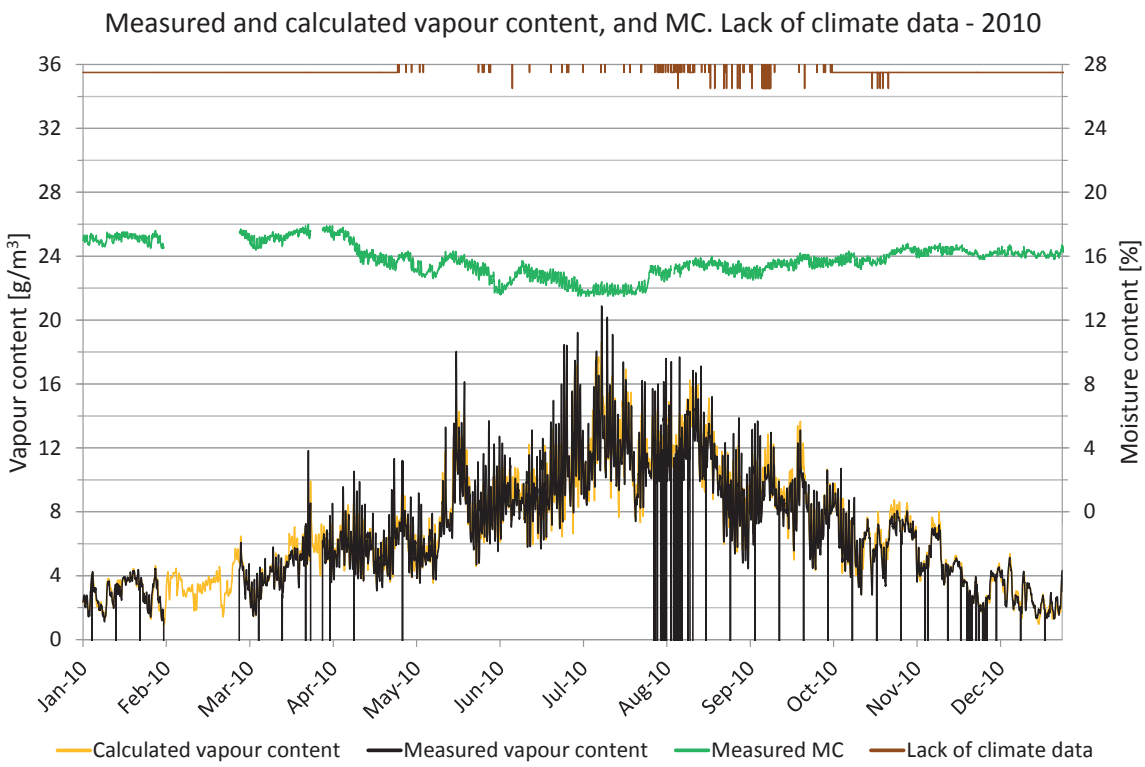


Figure 7.15.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

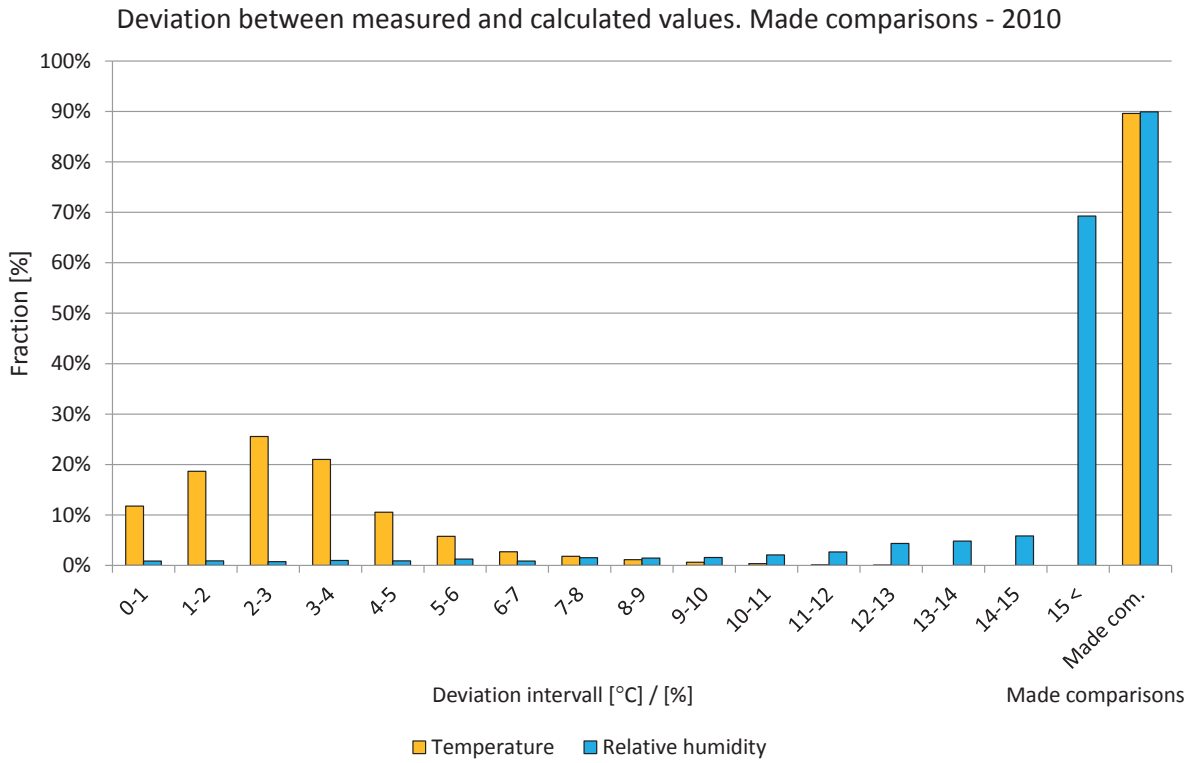


Figure 7.15.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

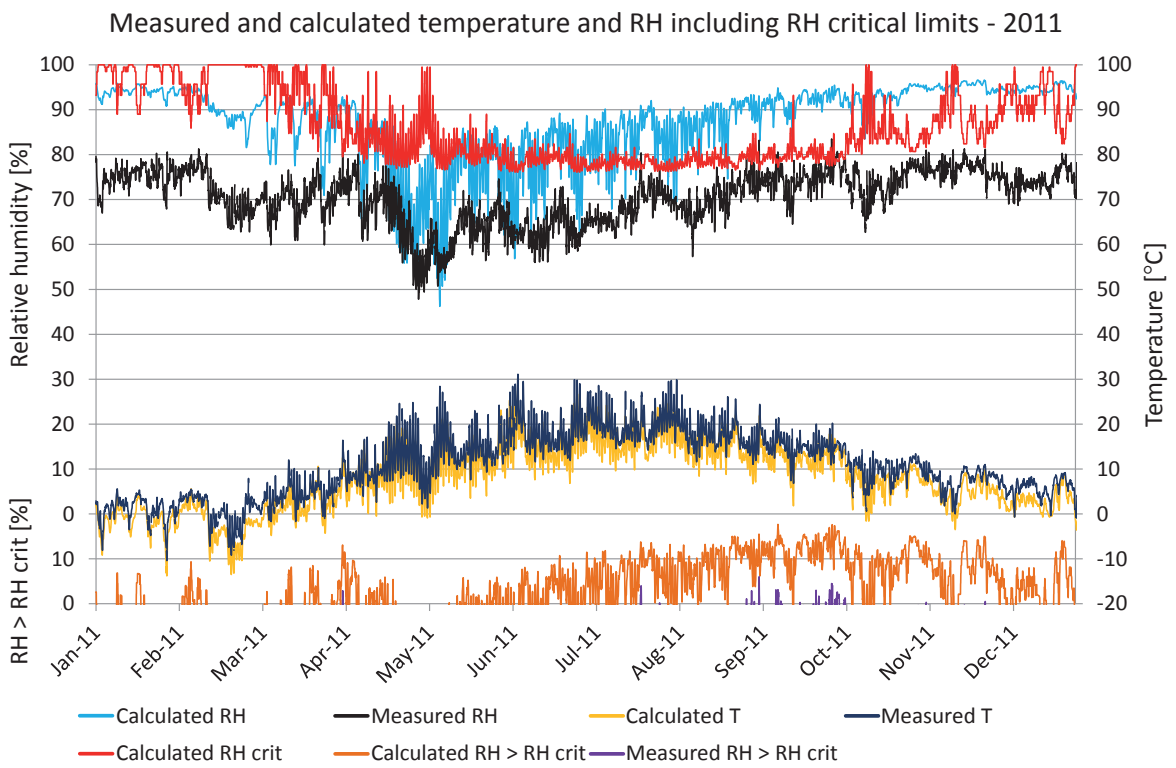


Figure 7.15.9. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

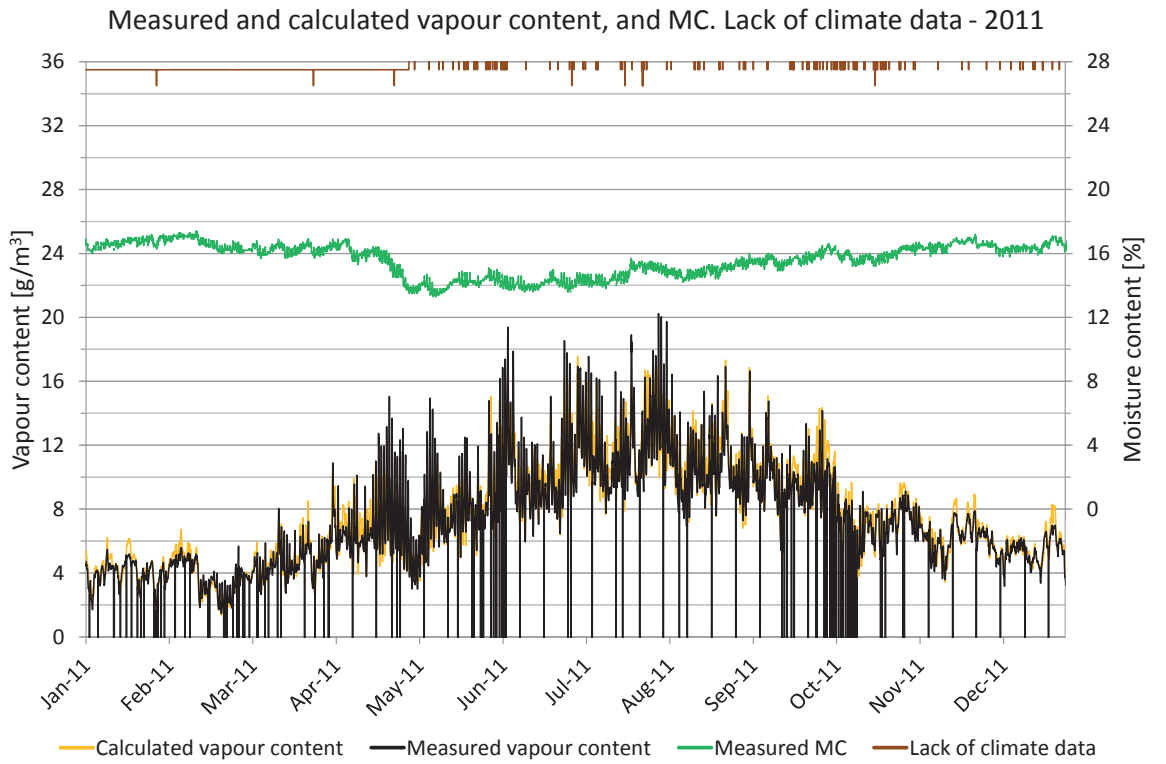


Figure 7.15.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

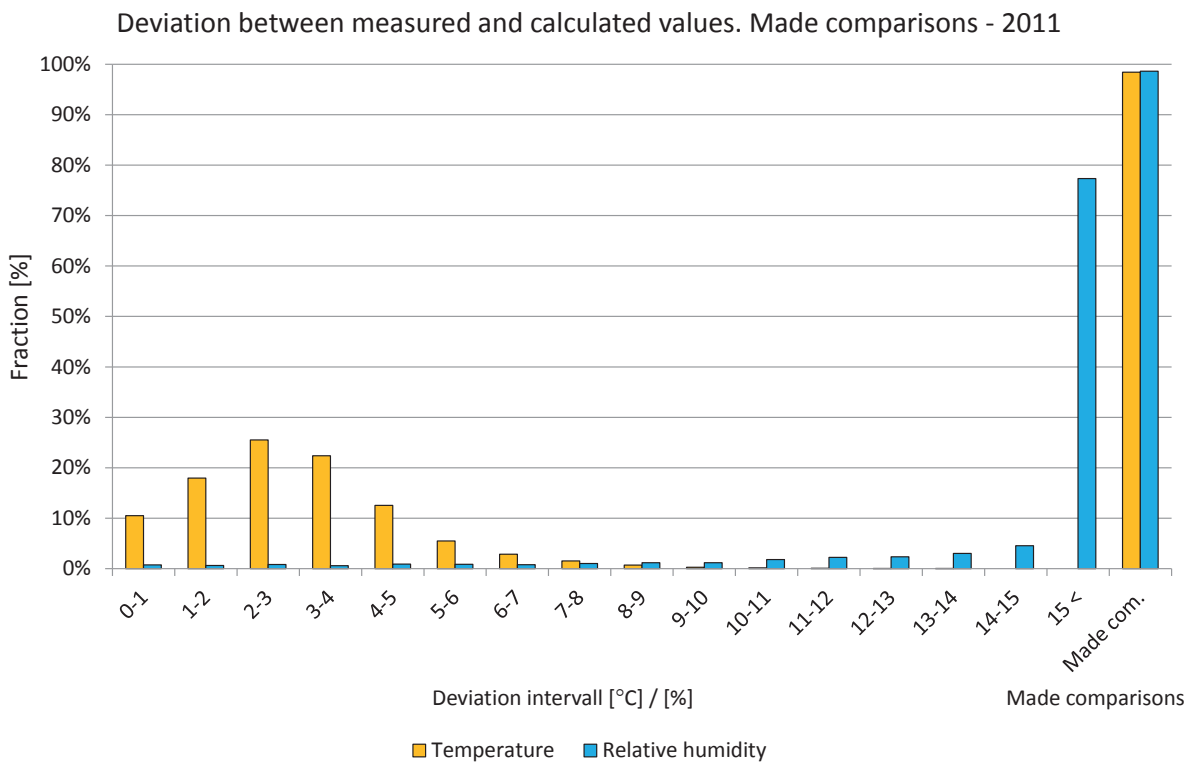
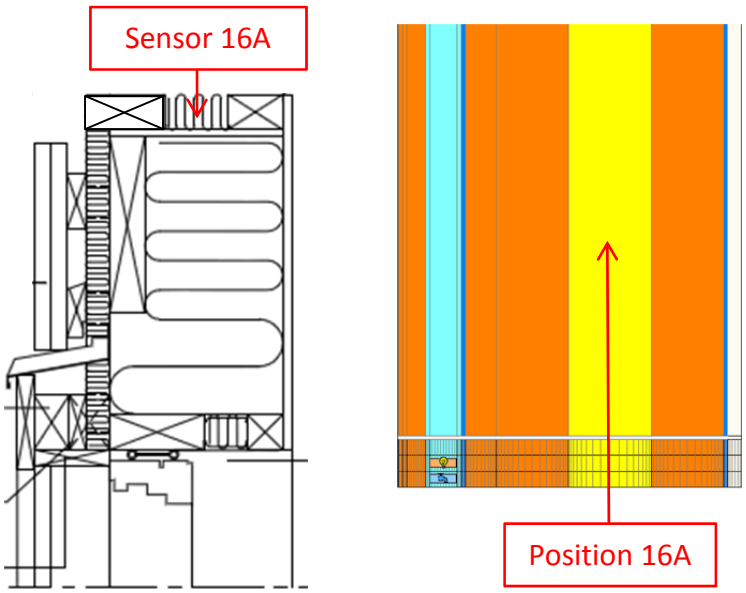


Figure 7.15.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.16 A Position 16A

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a wall facing northwest.



Wall, from the outside:
15/21 mm Facade panel - Spruce radial[1] including paint Sd = 1 m[2]
24 mm Air gap[1] with 30 ACH
1 mm Weather resistive barrier[1], Sd = 0,2 m
95 mm Horisontal stud - Spruce radial[1], initial MC 11,8%
85 mm Mineral insulation, λ = 0,037 W/mK[3 4]
70 mm Horisontal stud - Spruce radial[1], initial MC 11,8%
1 mm Vapour retarder[1], Sd = 50 m
13 mm Gypsum board[5]

Figure 7.16A.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.*

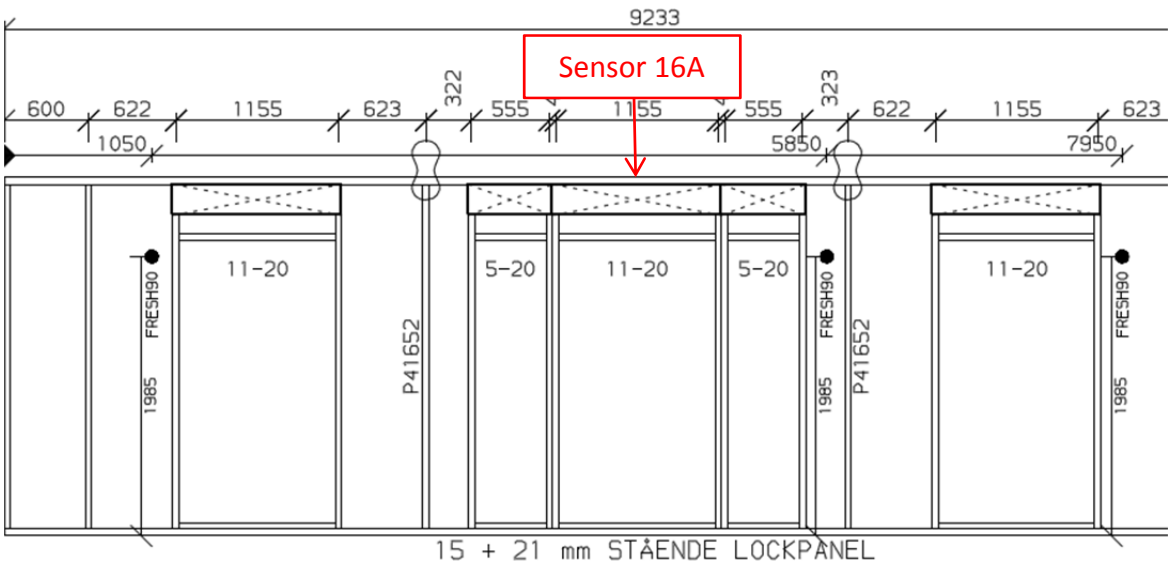


Figure 7.16A.2. Location of the studied position.

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 2009

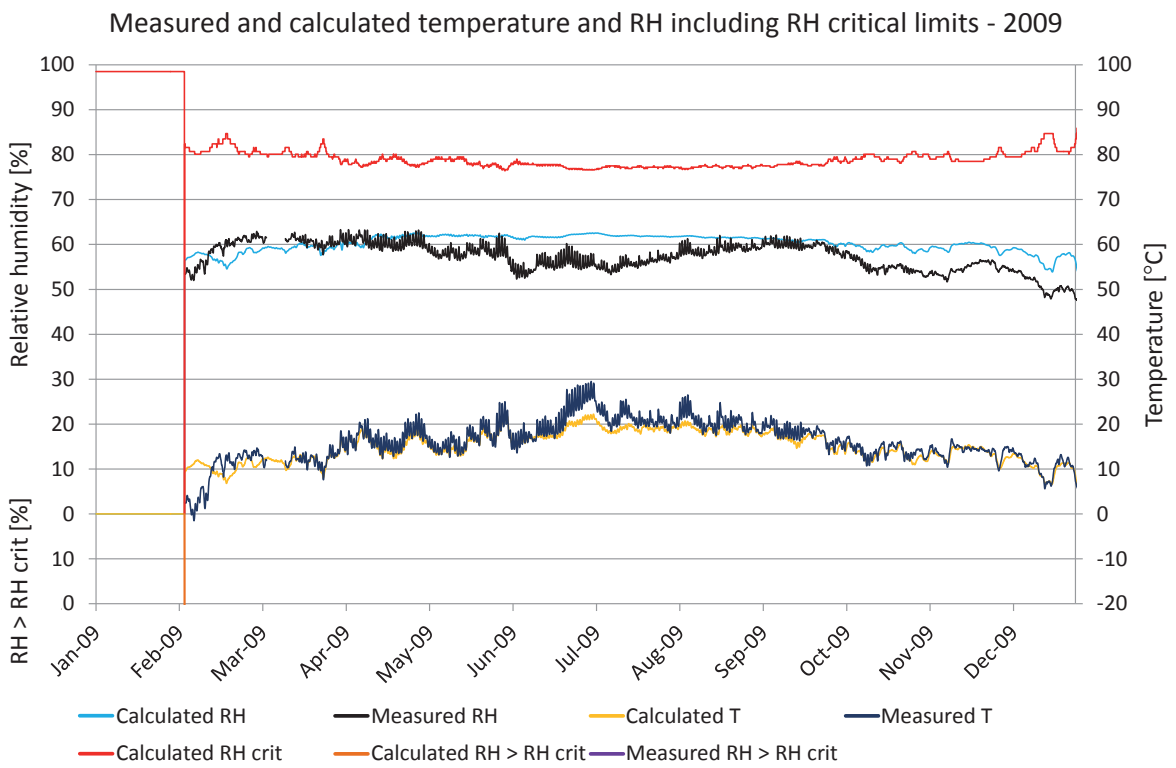


Figure 7.16A.3. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

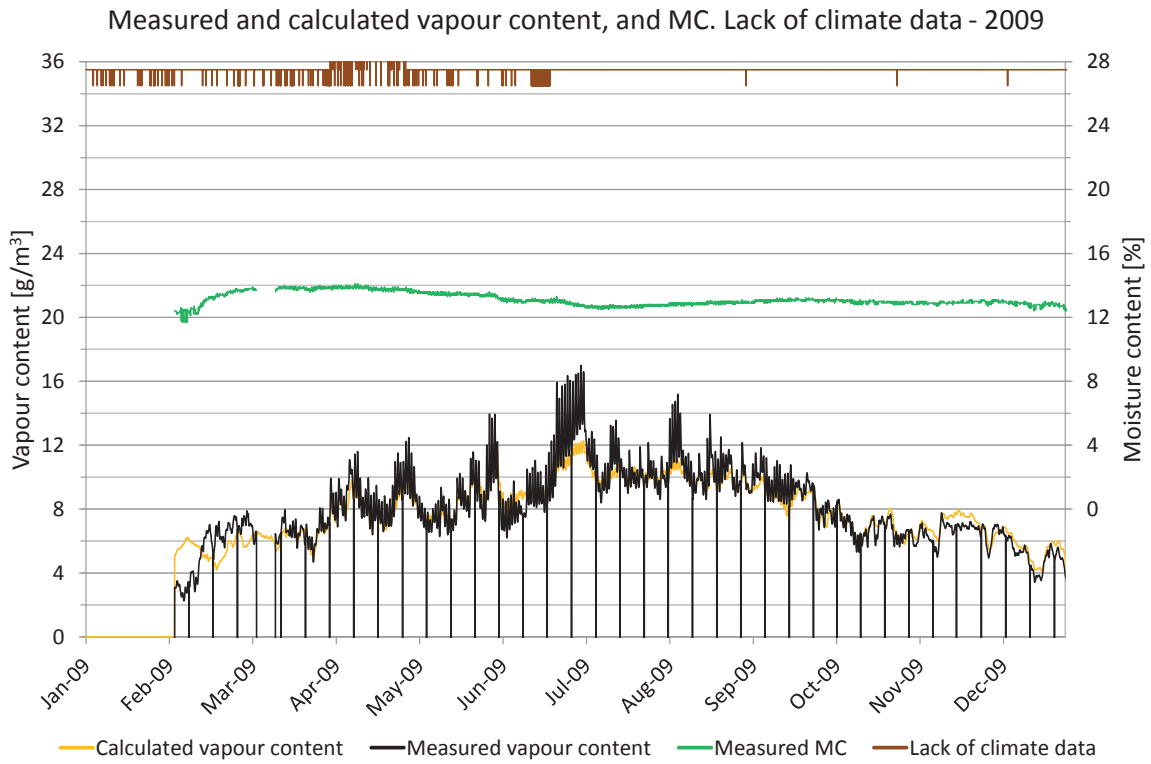


Figure 7.16A.4. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

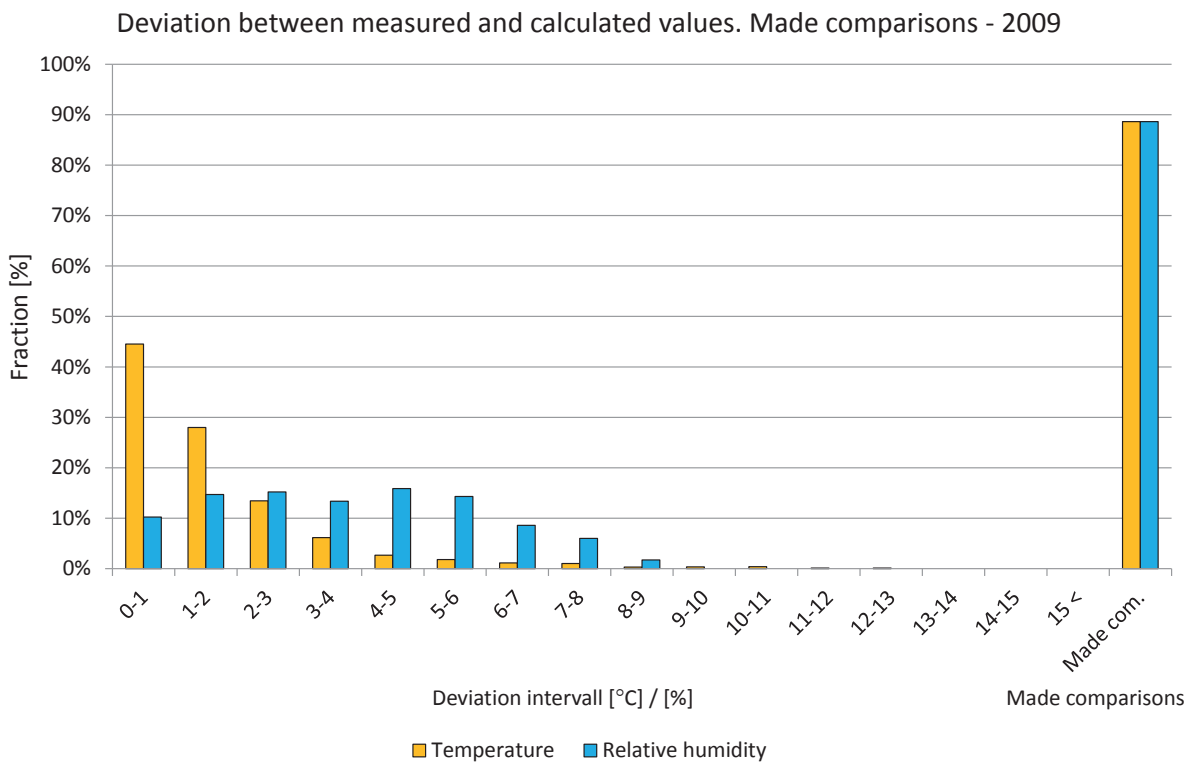


Figure 7.16A.5. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

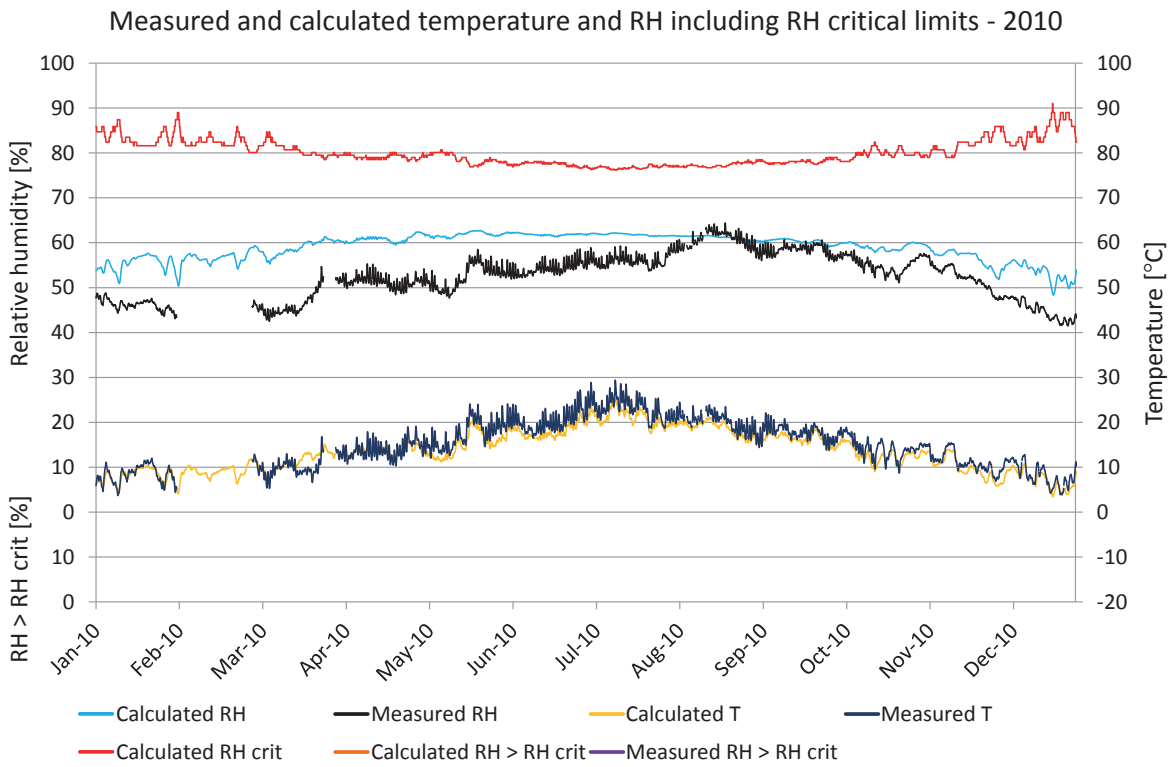


Figure 7.16A.6. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

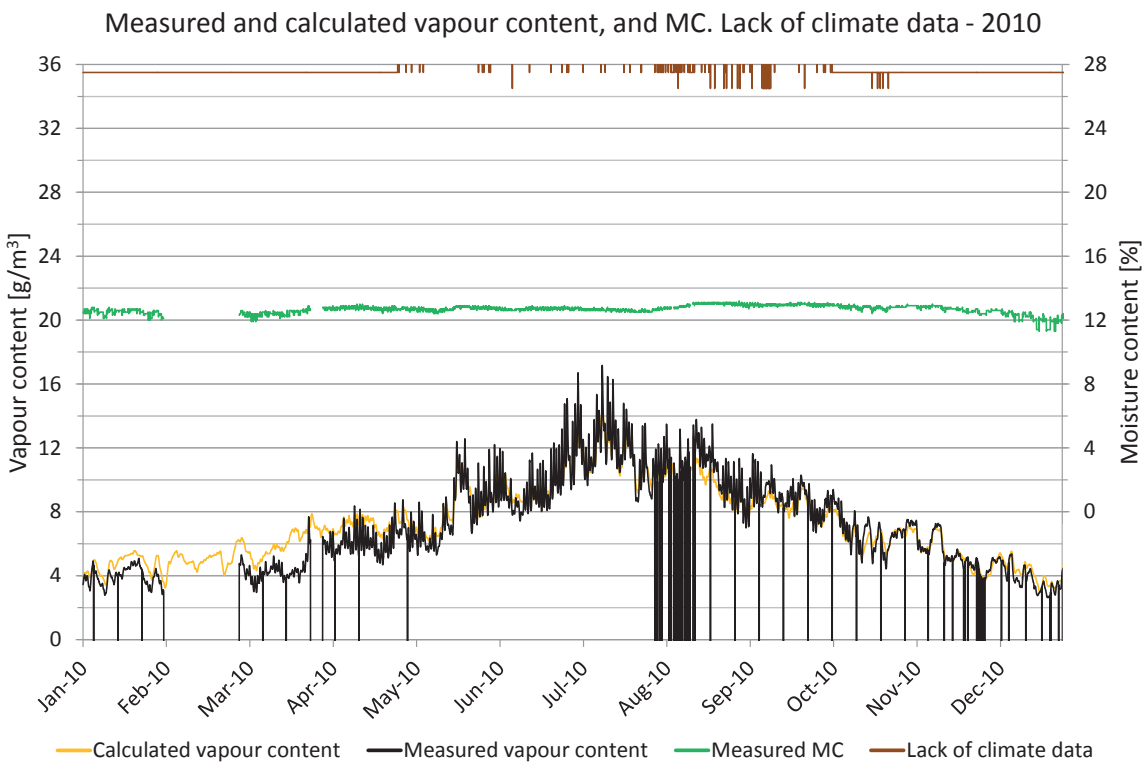


Figure 7.16A.7. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

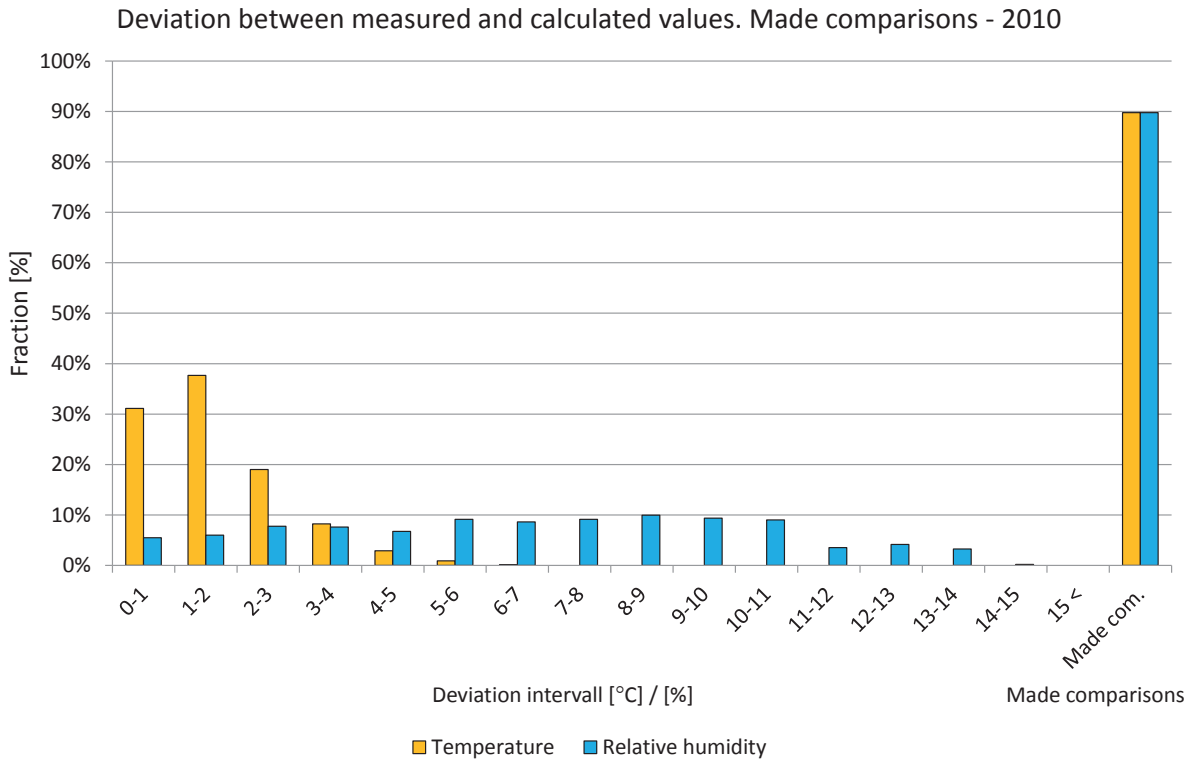


Figure 7.16A.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

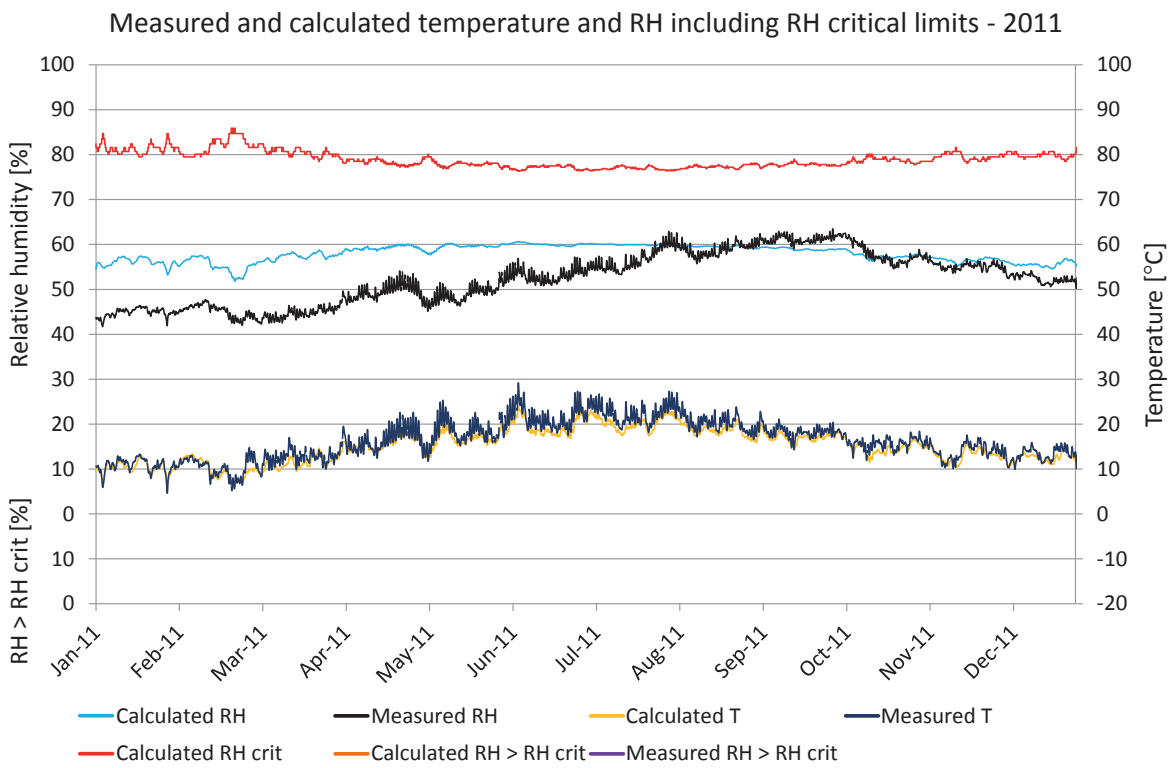


Figure 7.16A.9. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

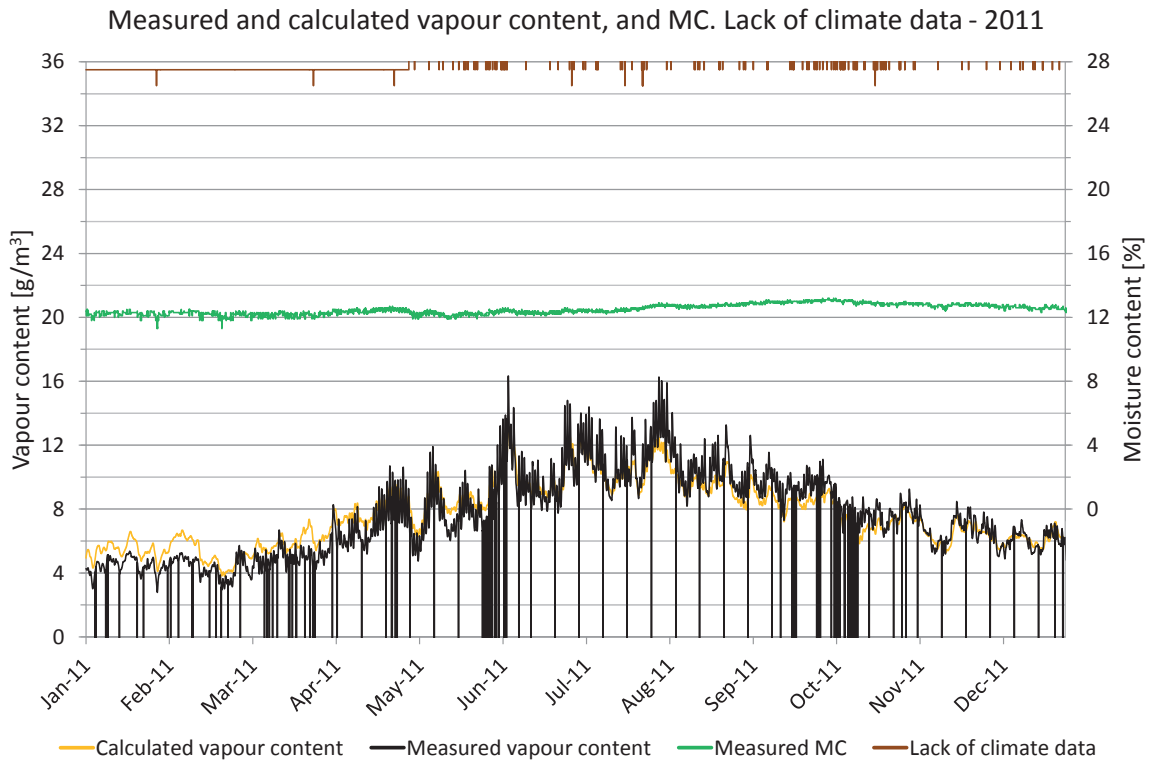


Figure 7.16A.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

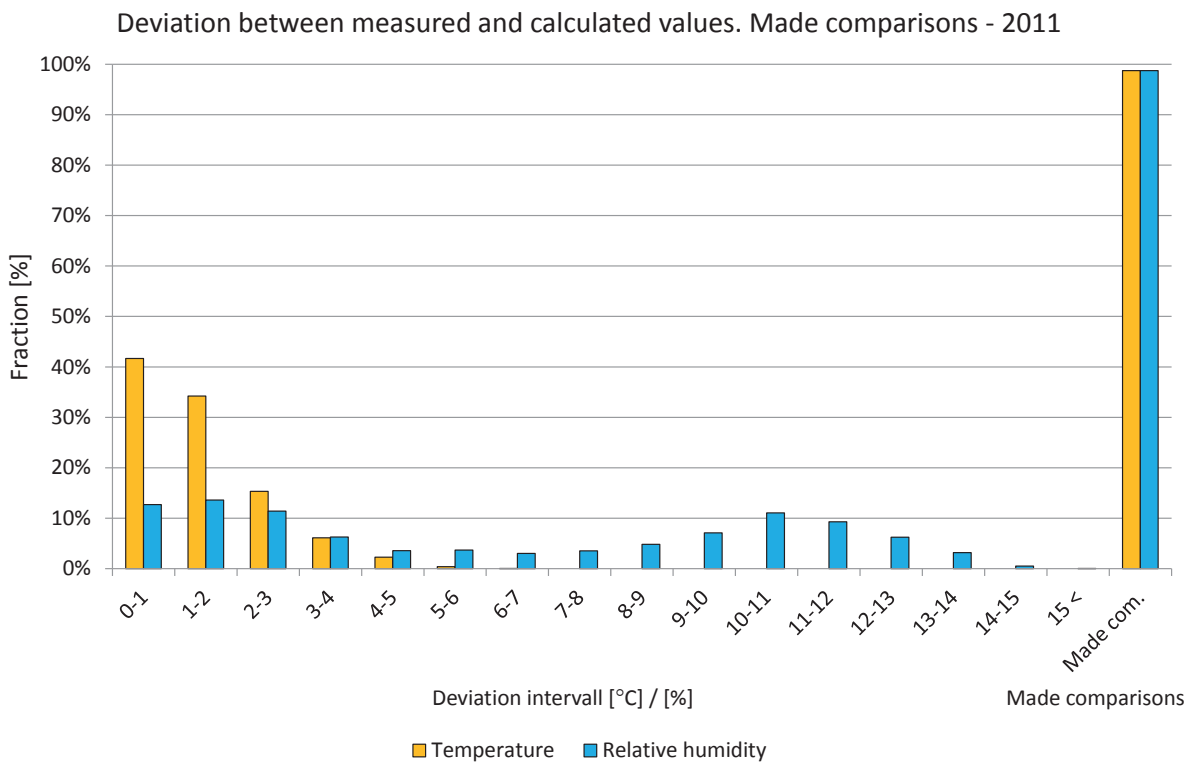
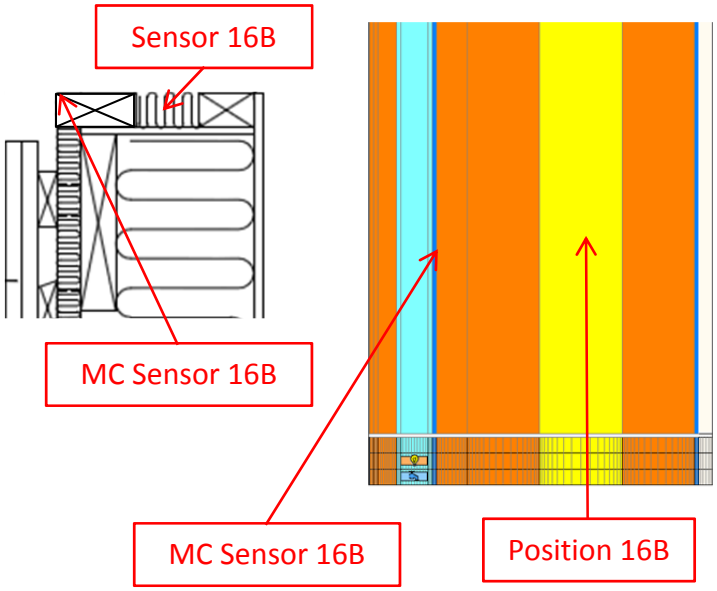


Figure 7.16A.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.16 B Position 16B

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a wall facing northwest.



Wall, from the outside:
15/21 mm Facade panel - Spruce radial[1] including paint Sd = 1 m[2]
24 mm Air gap[1] with 30 ACH
1 mm Weather resistive barrier[1], Sd = 0,2 m
95 mm Horisontal stud - Spruce radial[1], initial MC 11,8%
85 mm Mineral insulation, λ = 0,037 W/mK[3 4]
70 mm Horisontal stud - Spruce radial[1], initial MC 11,8%
1 mm Vapour retarder[1], Sd = 50 m
13 mm Gypsum board[5]

Figure 7.16B.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.

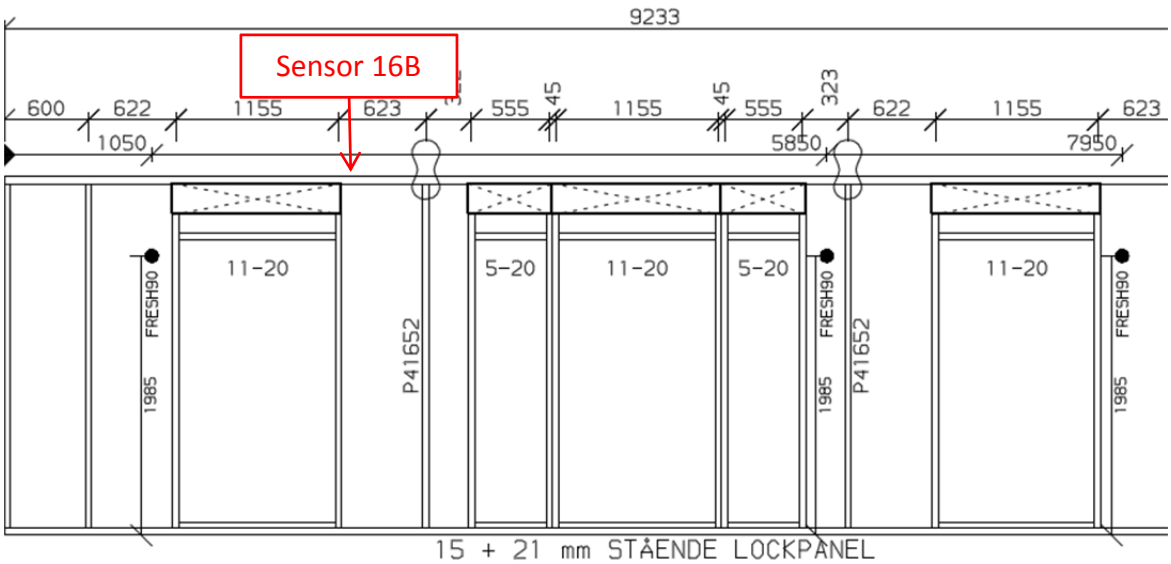


Figure 7.16B.2. Location of the studied position.

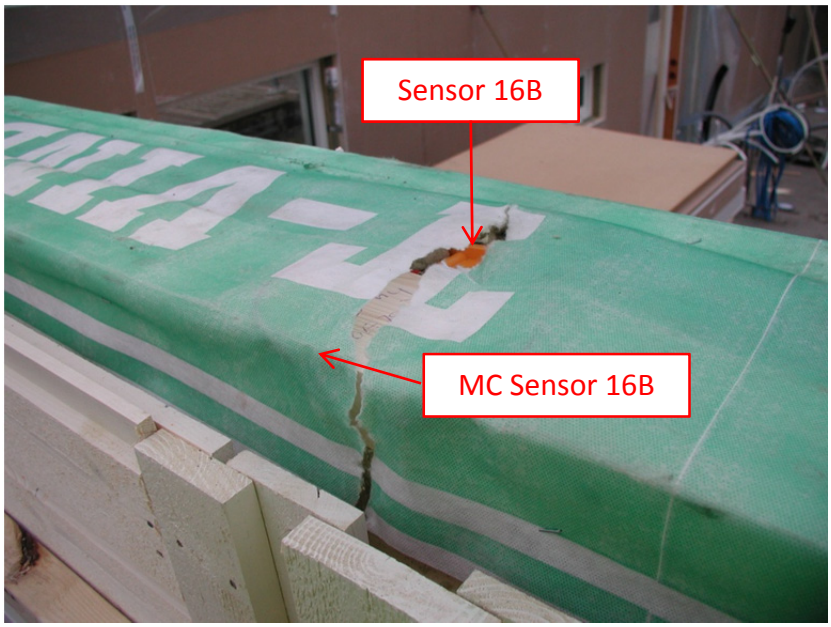


Figure 7.16B.3. Location of the studied position.

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 2009

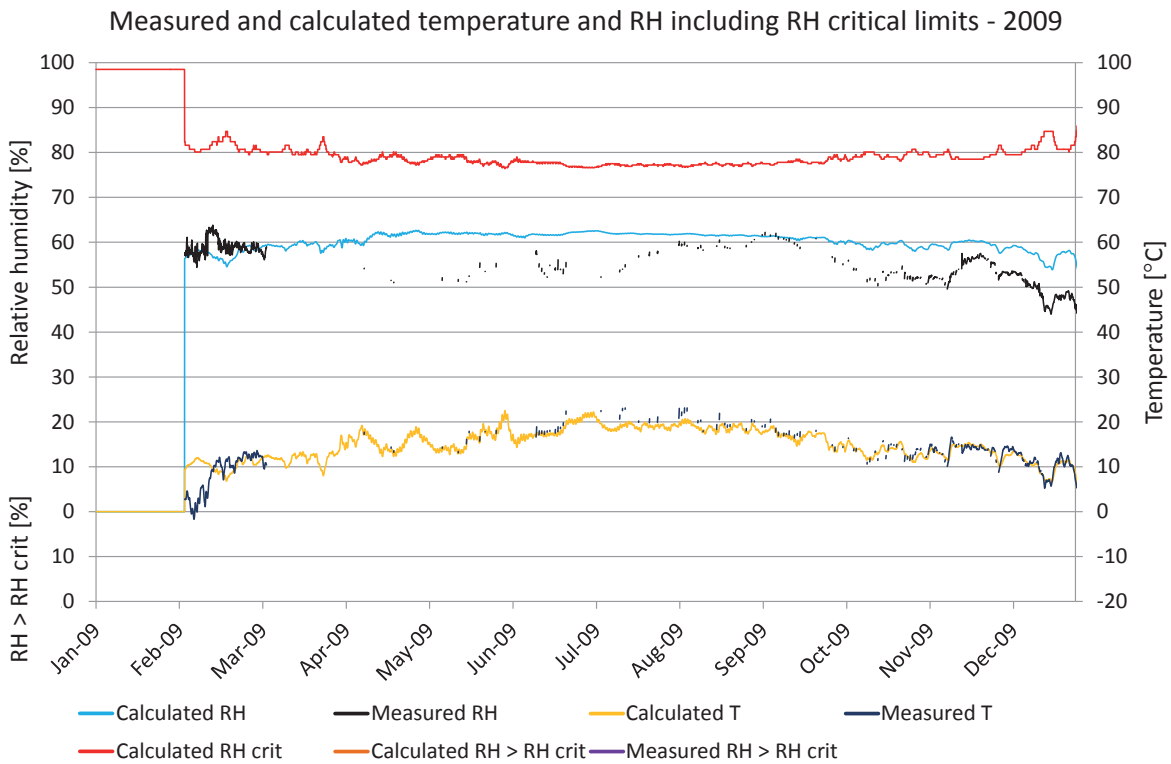


Figure 7.16B.4. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

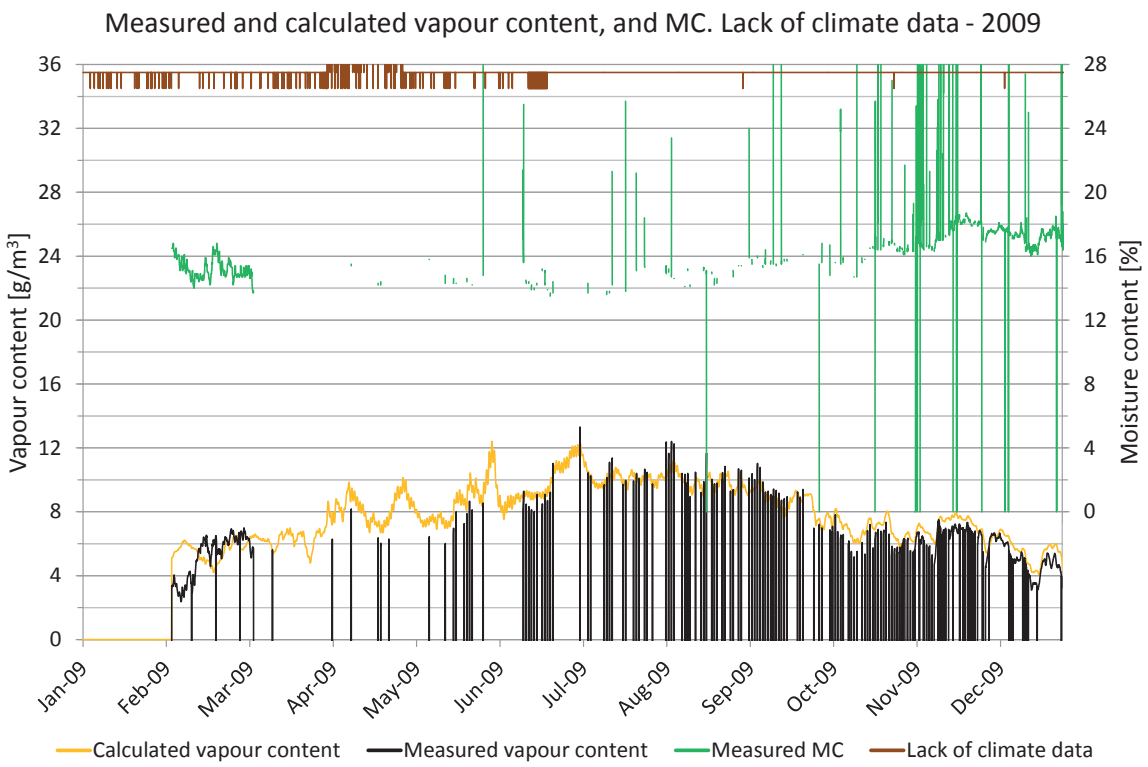


Figure 7.16B.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

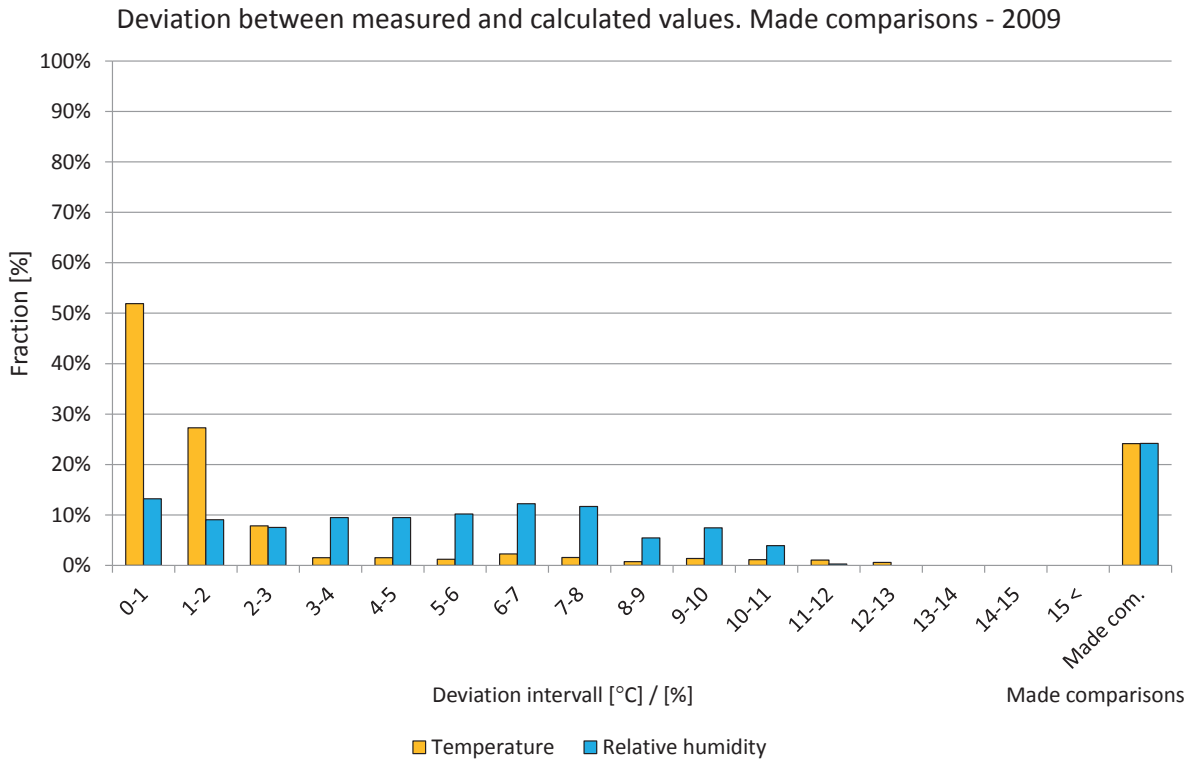


Figure 7.16B.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

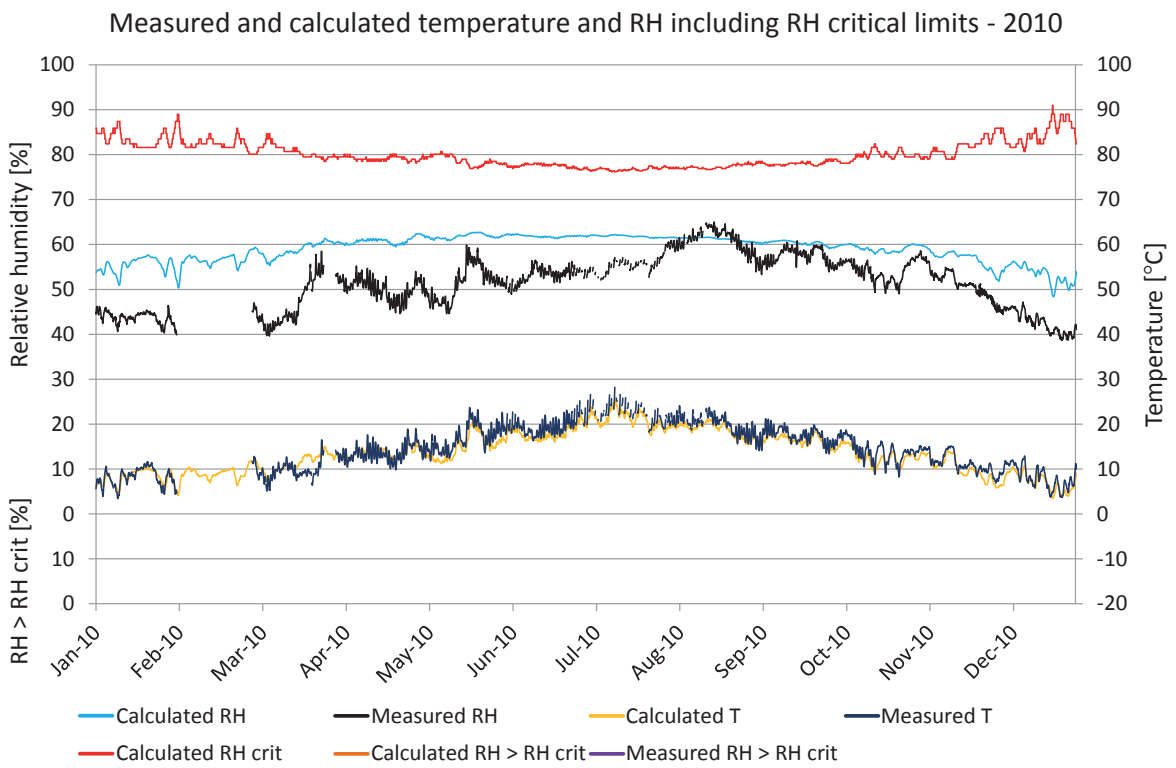


Figure 7.16B.7. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

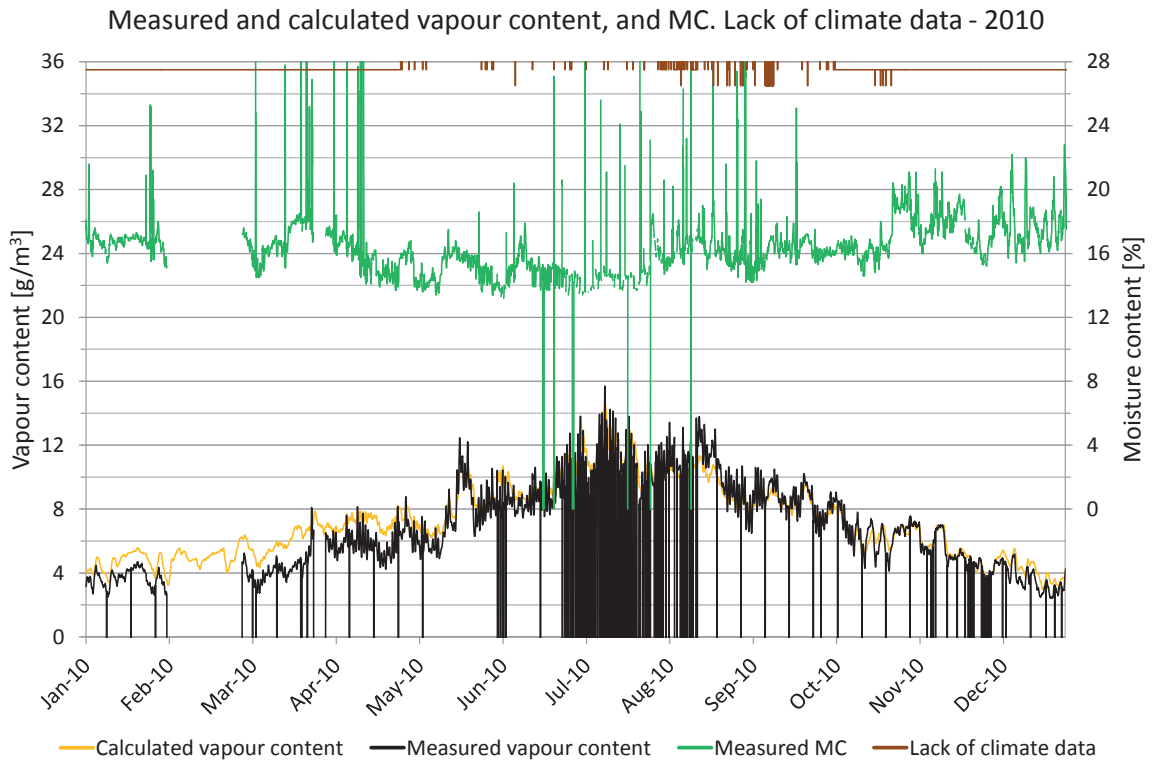


Figure 7.16B.8. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

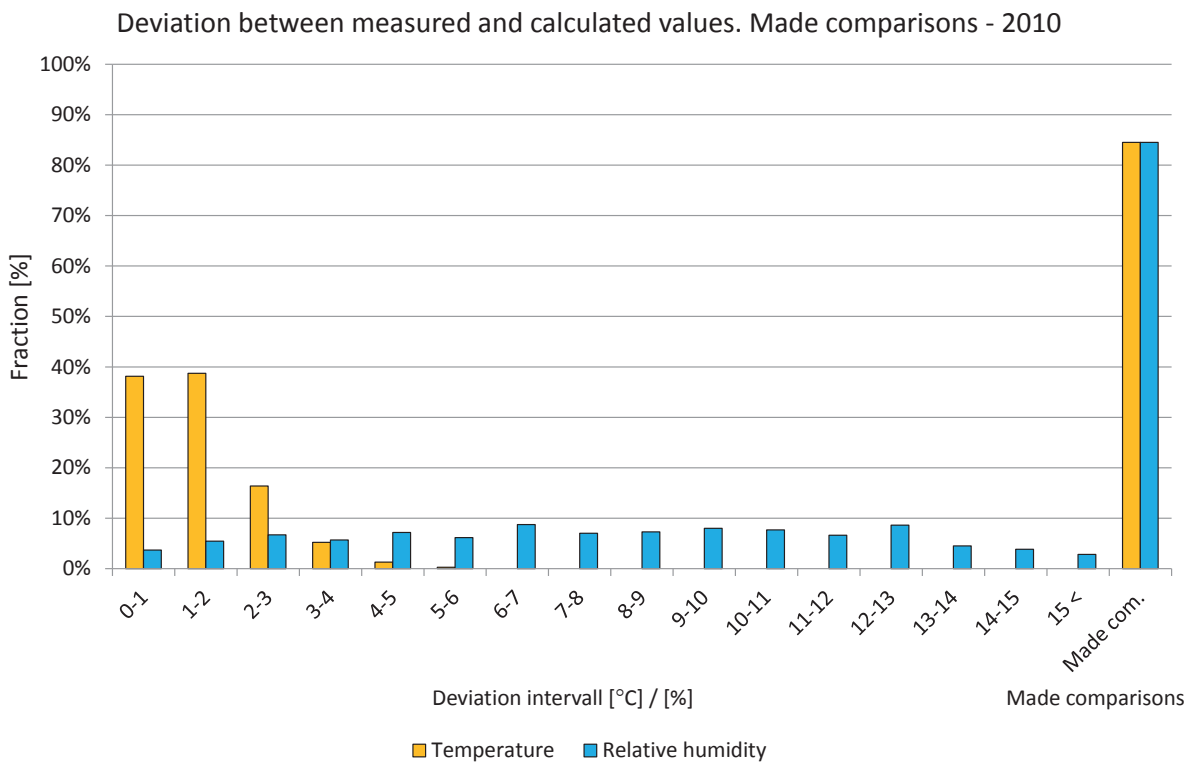


Figure 7.16B.9. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

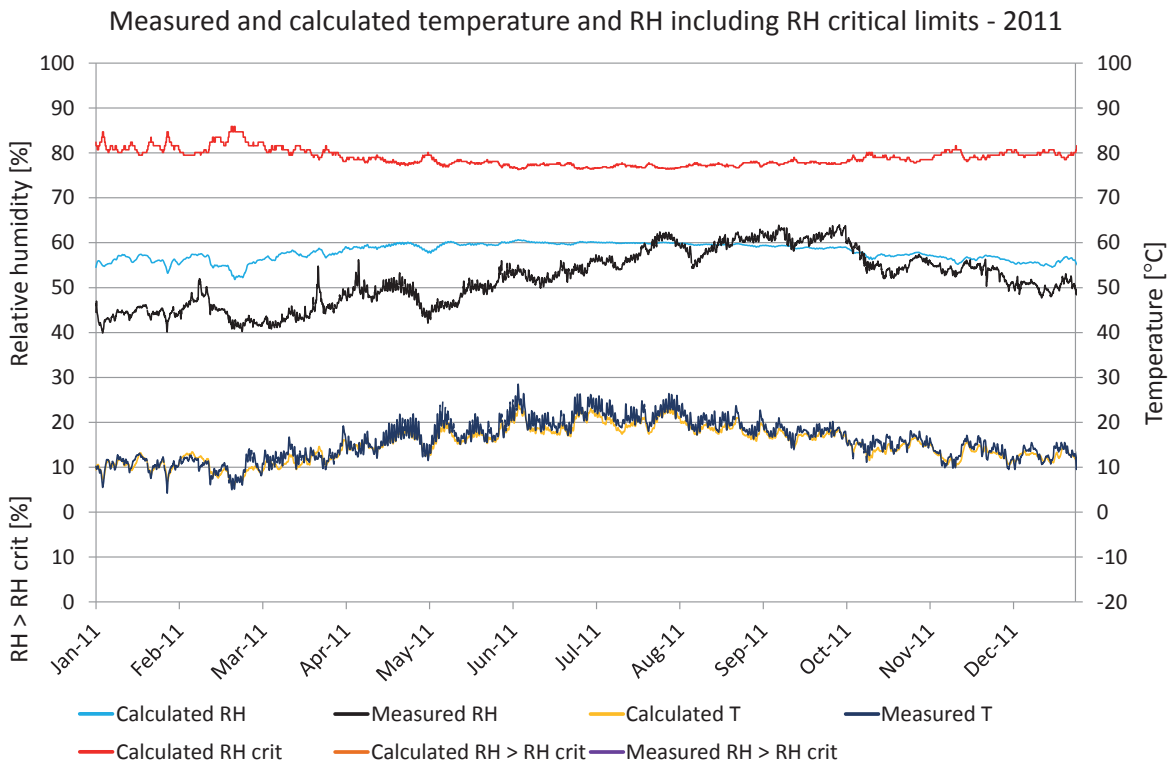


Figure 7.16B.10. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

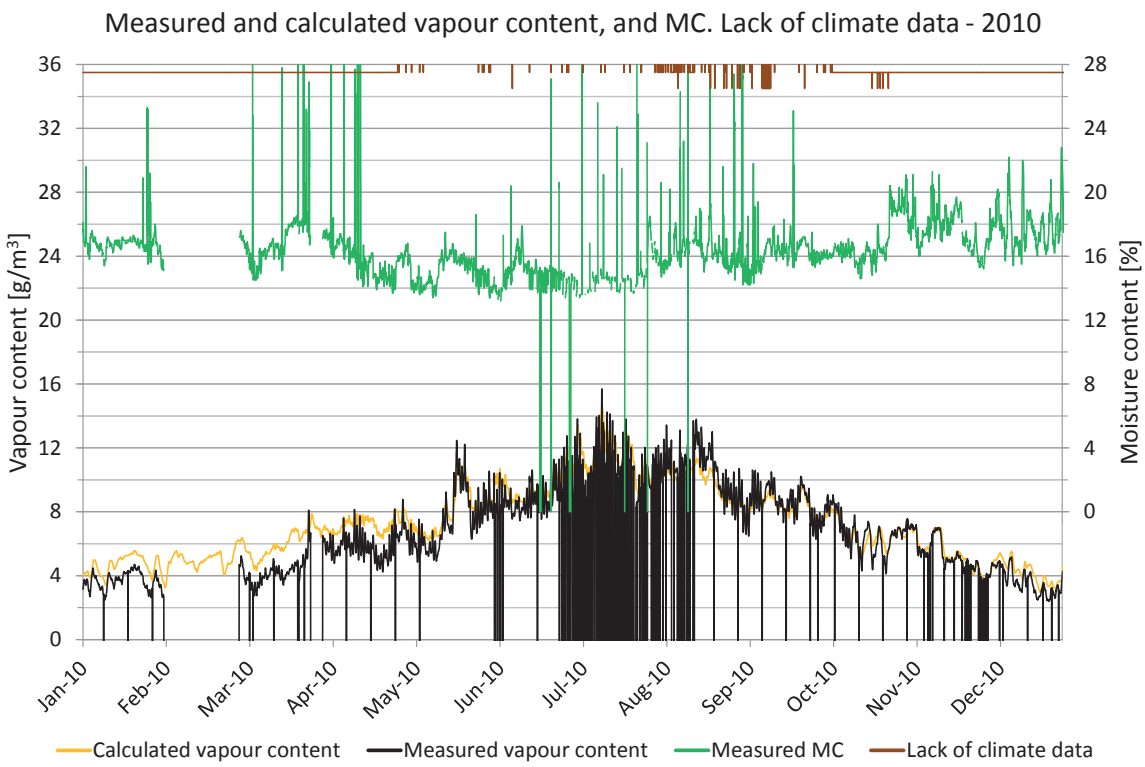


Figure 7.16B.11. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

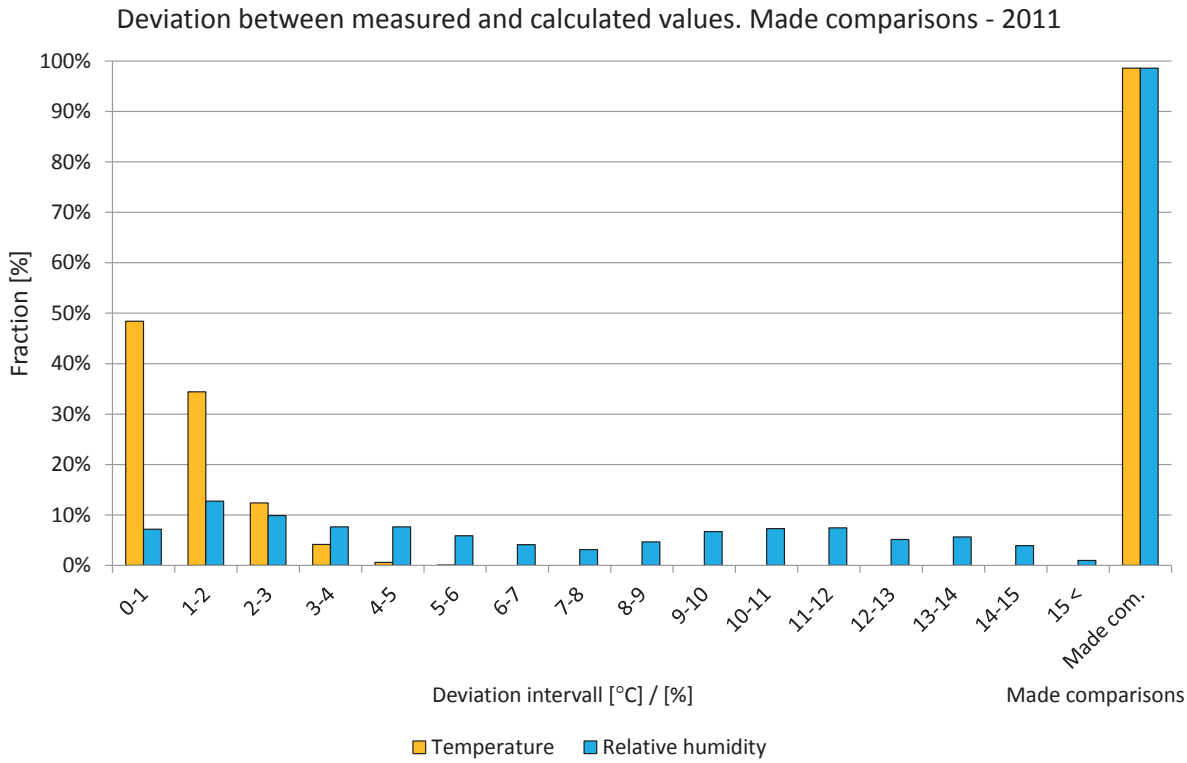
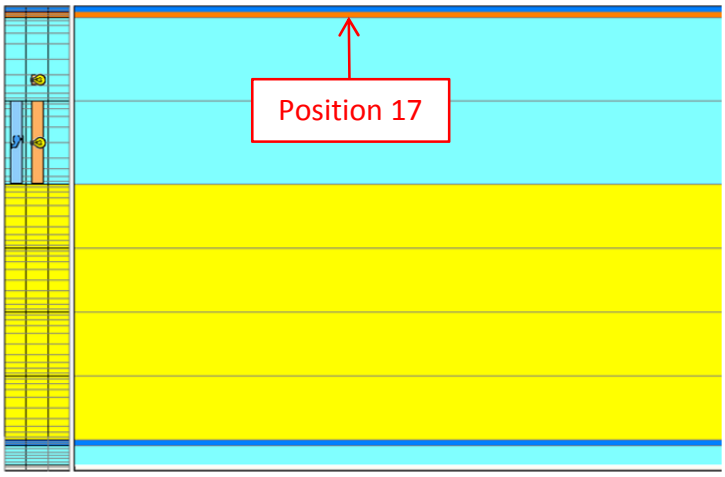


Figure 7.16B.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.17 Position 17

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing southwest.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.17.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

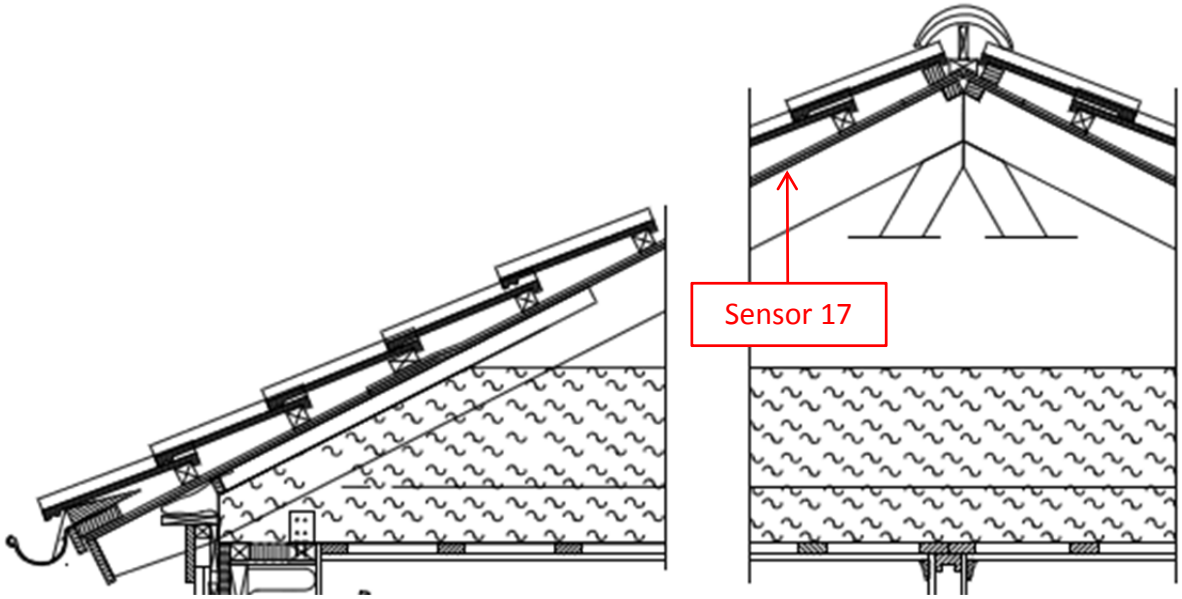


Figure 7.17.2. Location of the studied position.

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 plywood roofing boards which do not have the same properties as tongued and grooved wood.

Year 2009

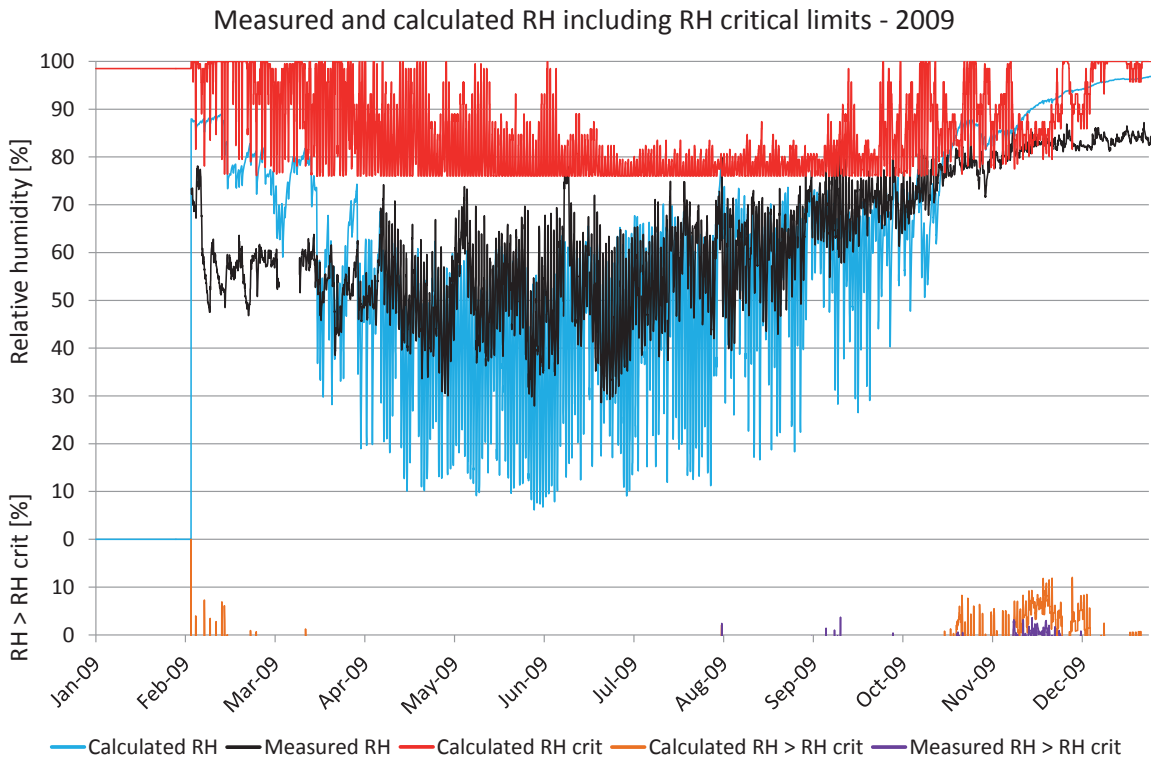


Figure 7.17.3. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

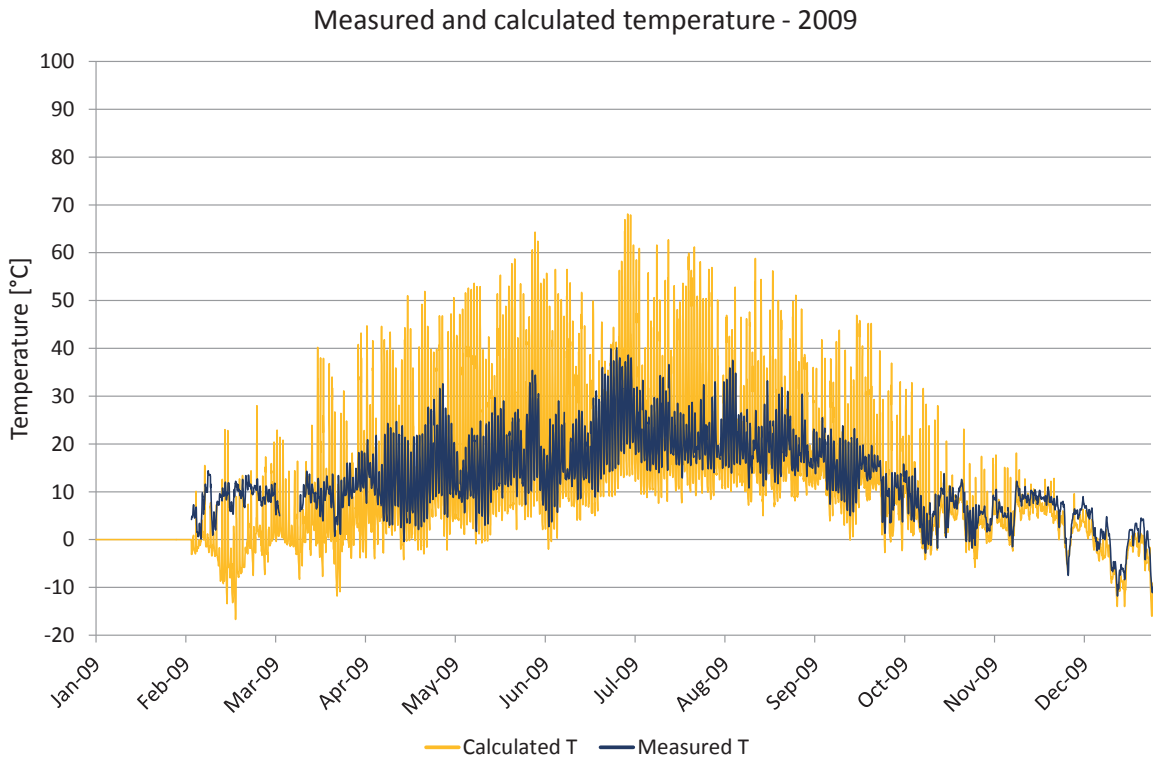


Figure 7.17.4. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

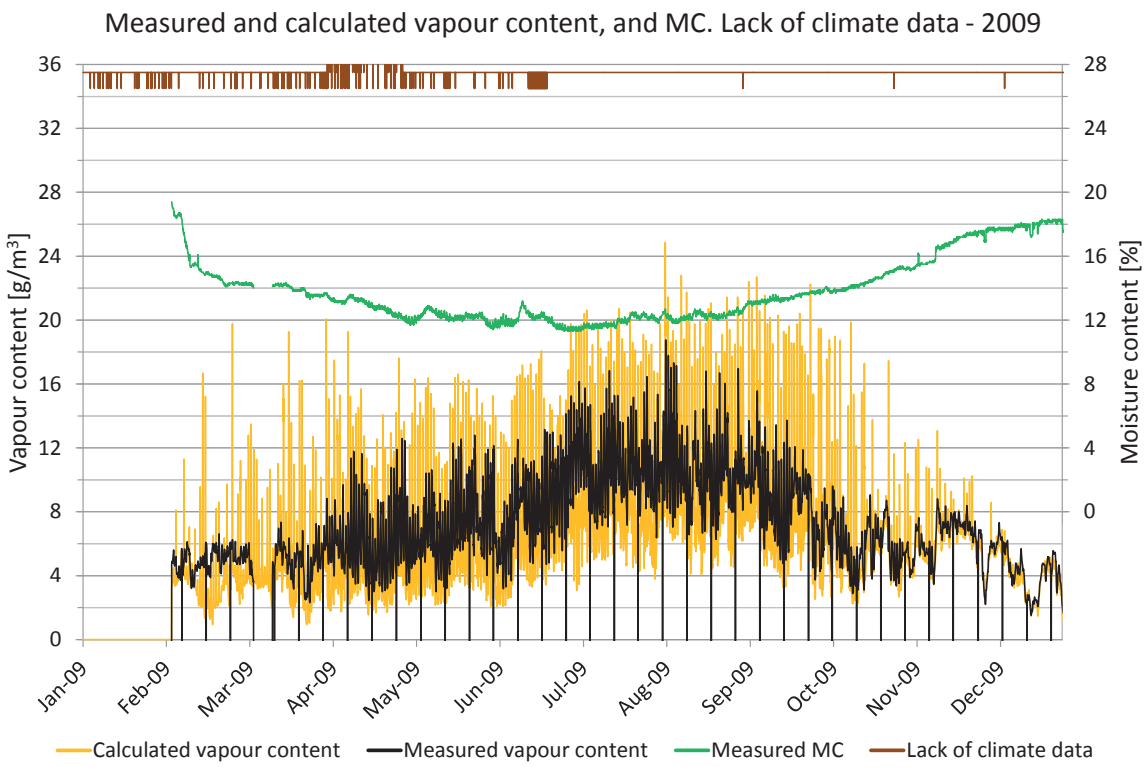


Figure 7.17.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

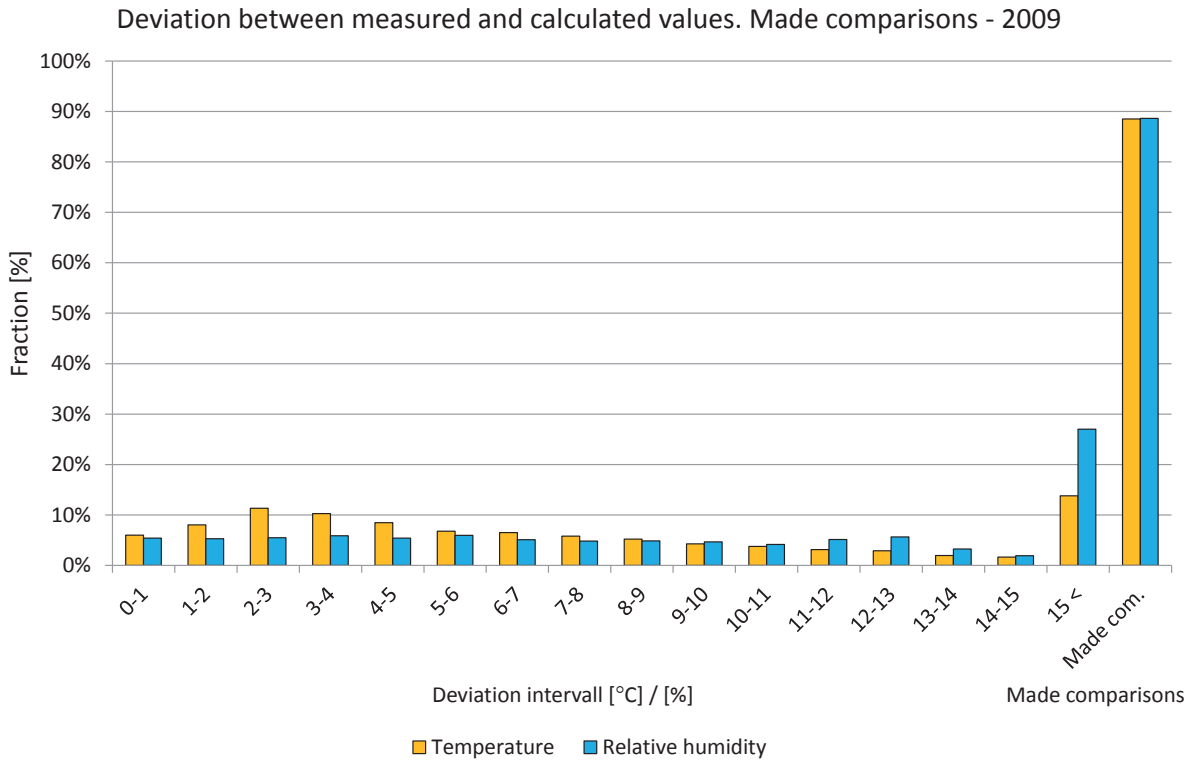


Figure 7.17.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

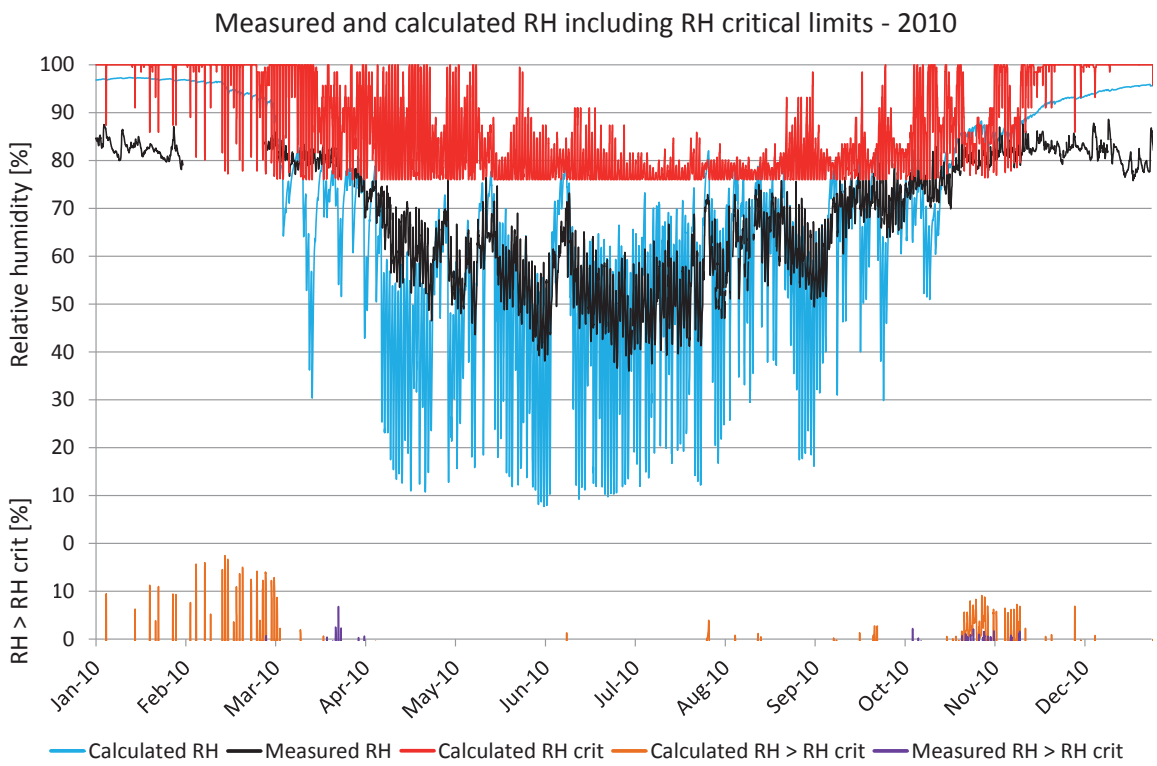


Figure 7.17.7. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

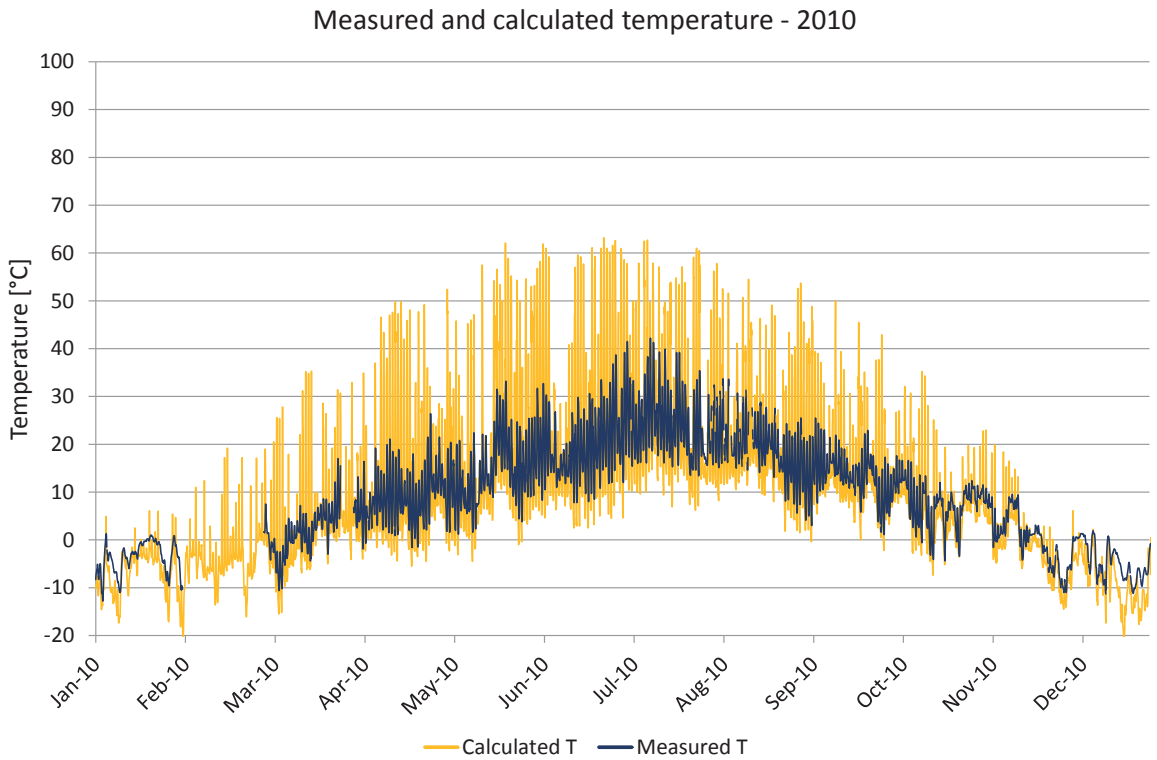


Figure 7.17.8. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

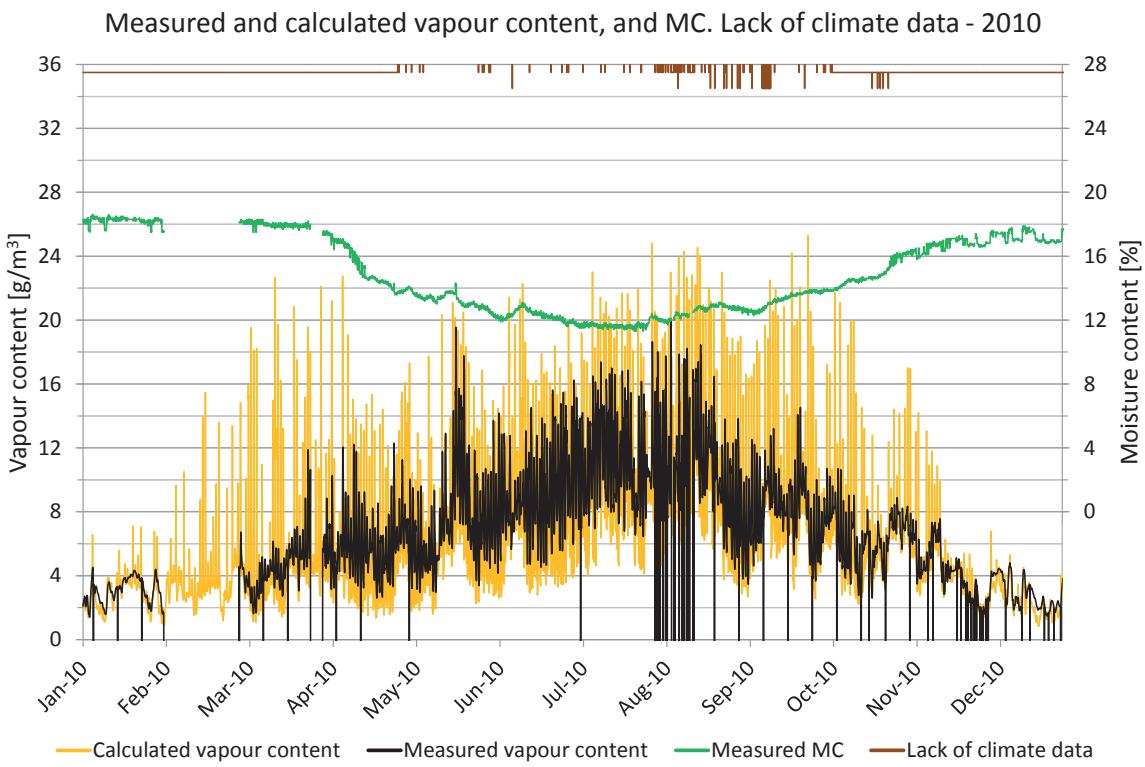


Figure 7.17.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

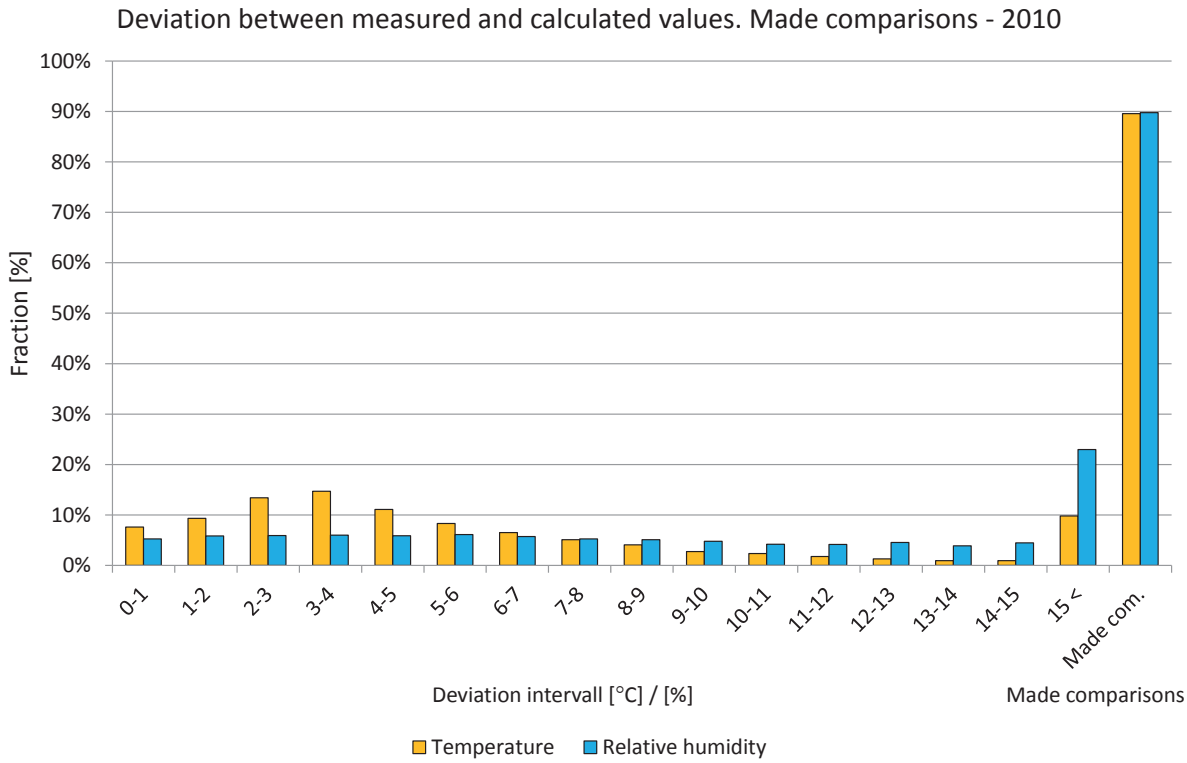


Figure 7.17.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

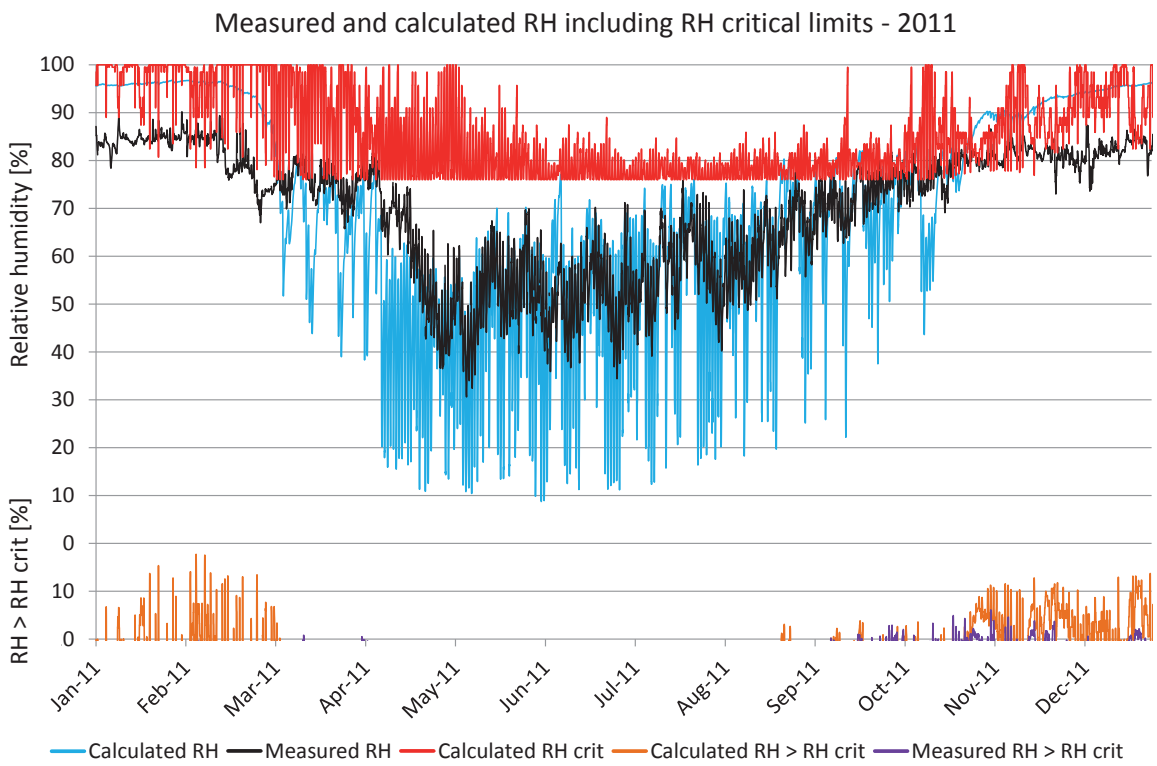


Figure 7.17.11. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

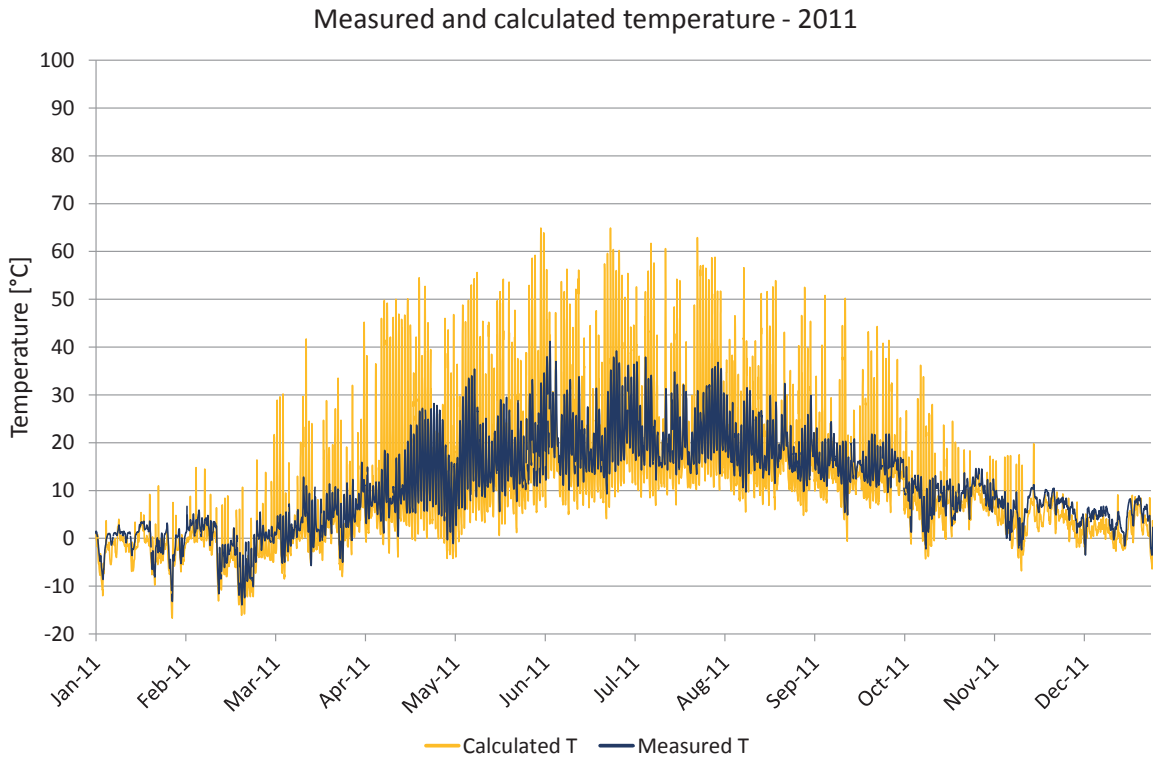


Figure 7.17.12. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

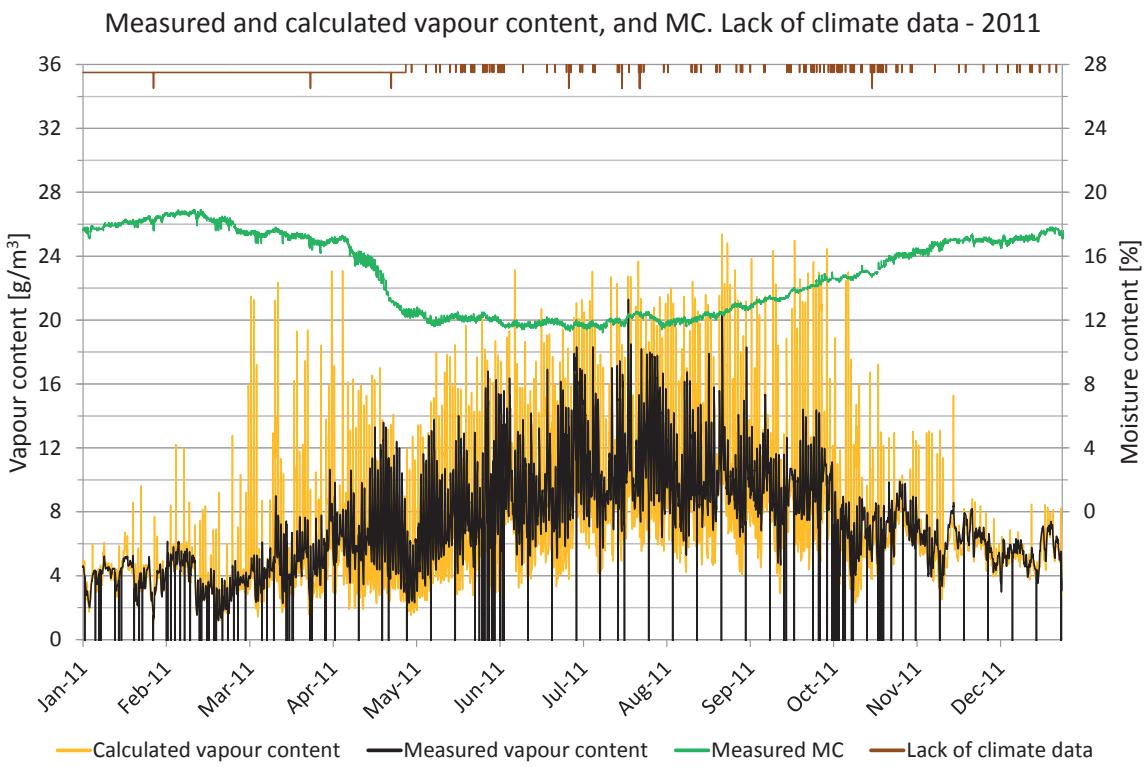


Figure 7.17.13. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

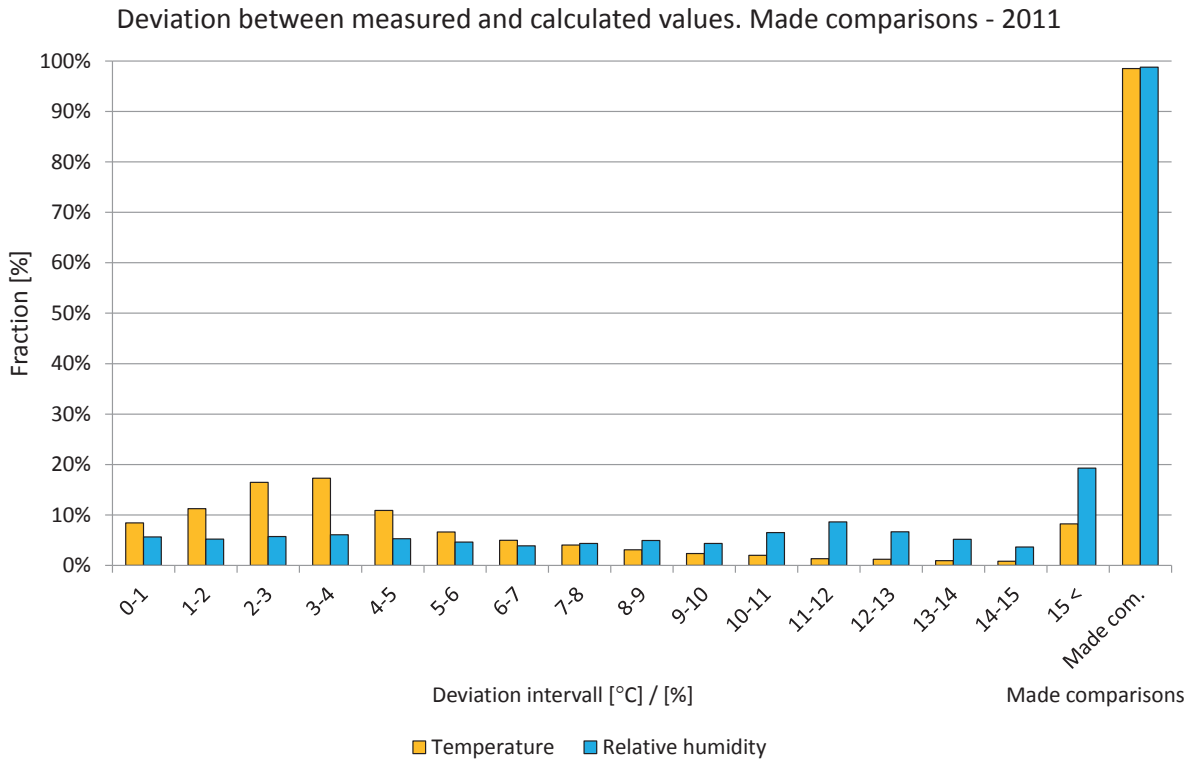
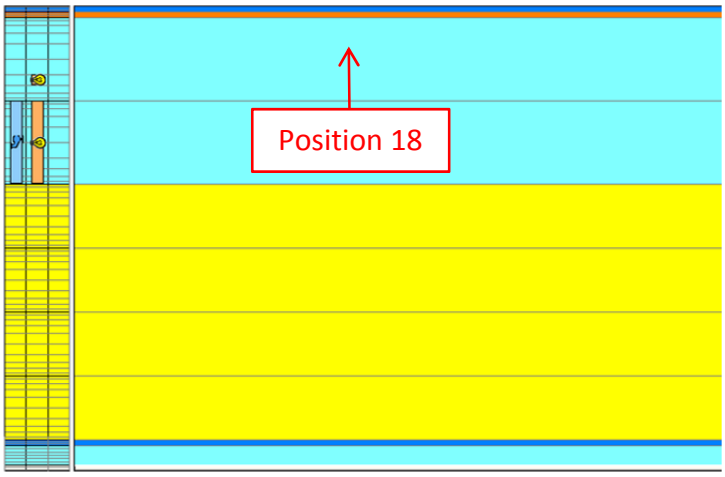


Figure 7.17.14. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.18 Position 18

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing northeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.18.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

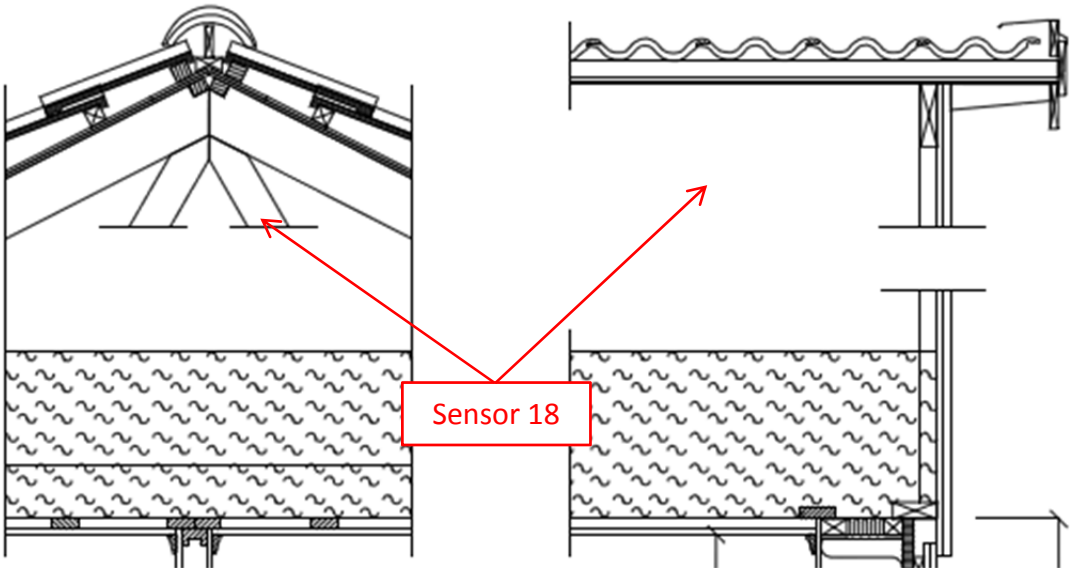


Figure 7.18.2. Location of the studied position.

Figure 7.18.3. Location of the studied position.

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 2009

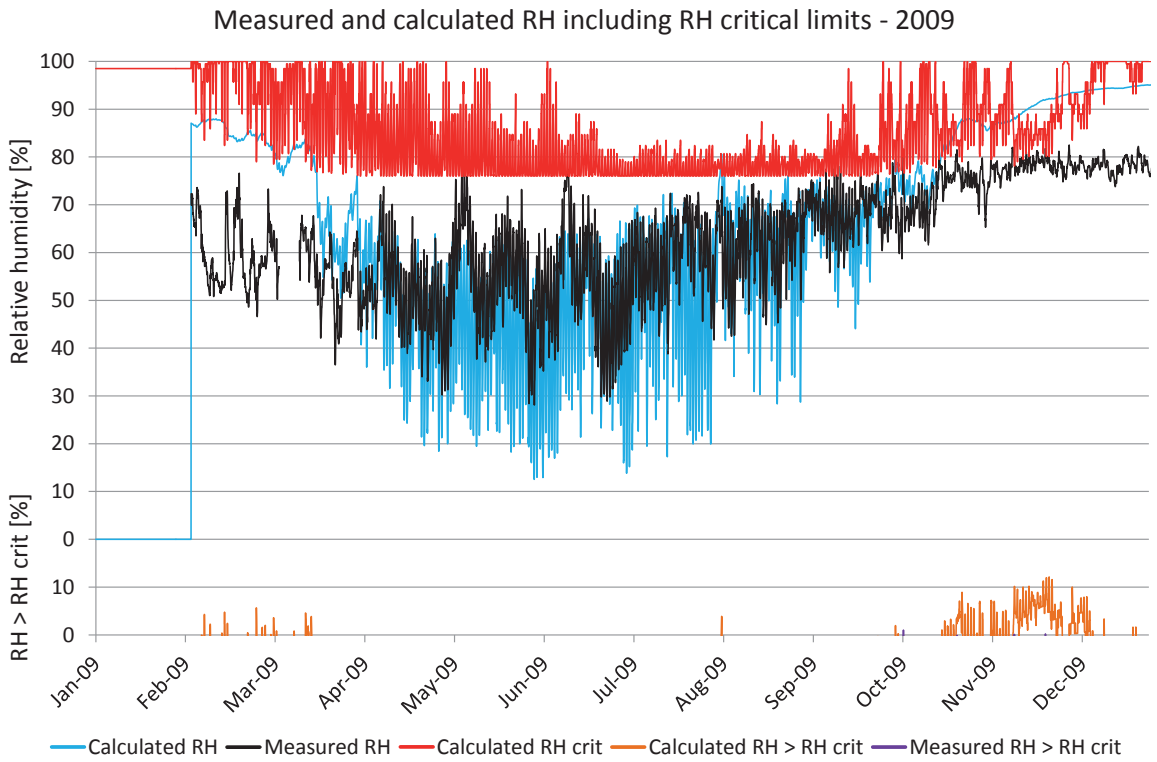


Figure 7.18.4. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

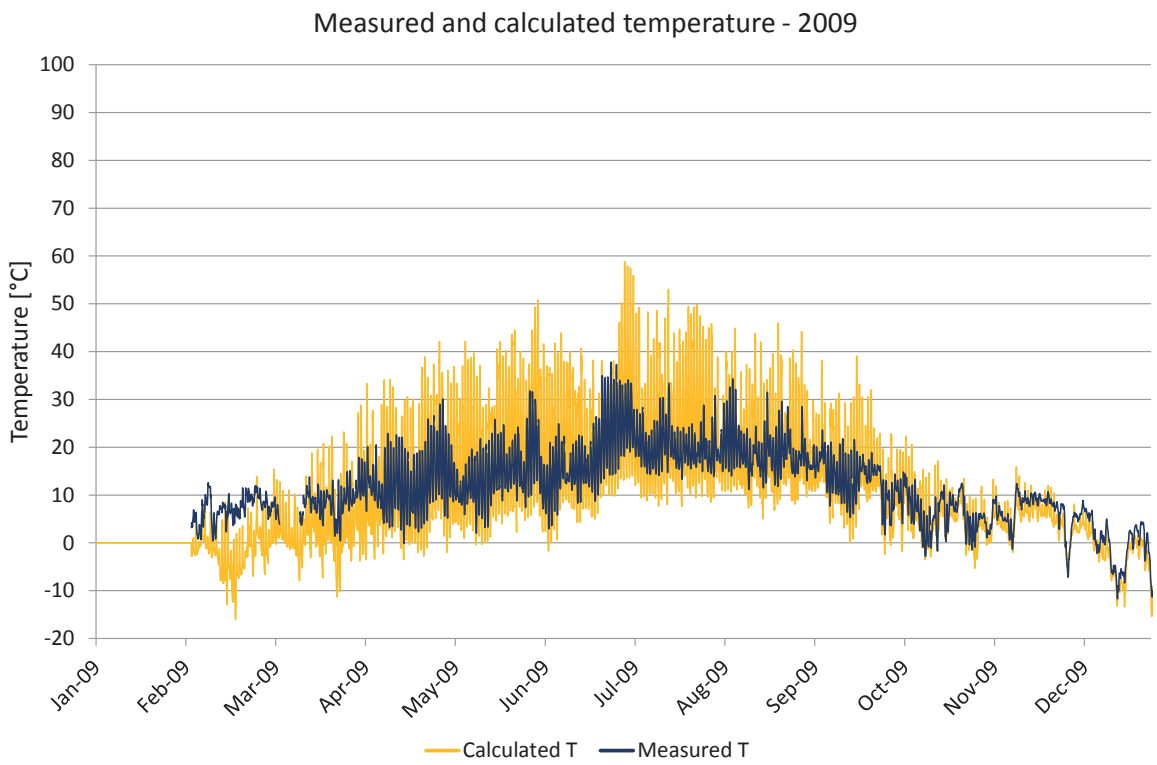


Figure 7.18.5. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

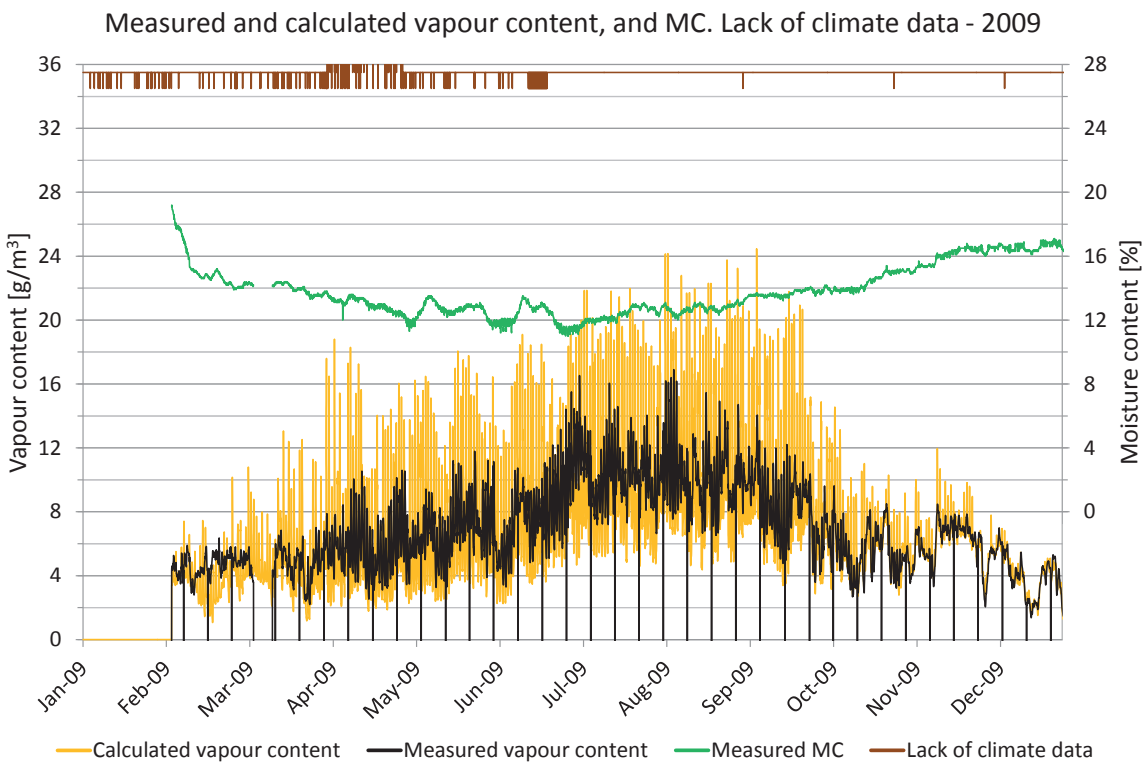


Figure 7.18.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

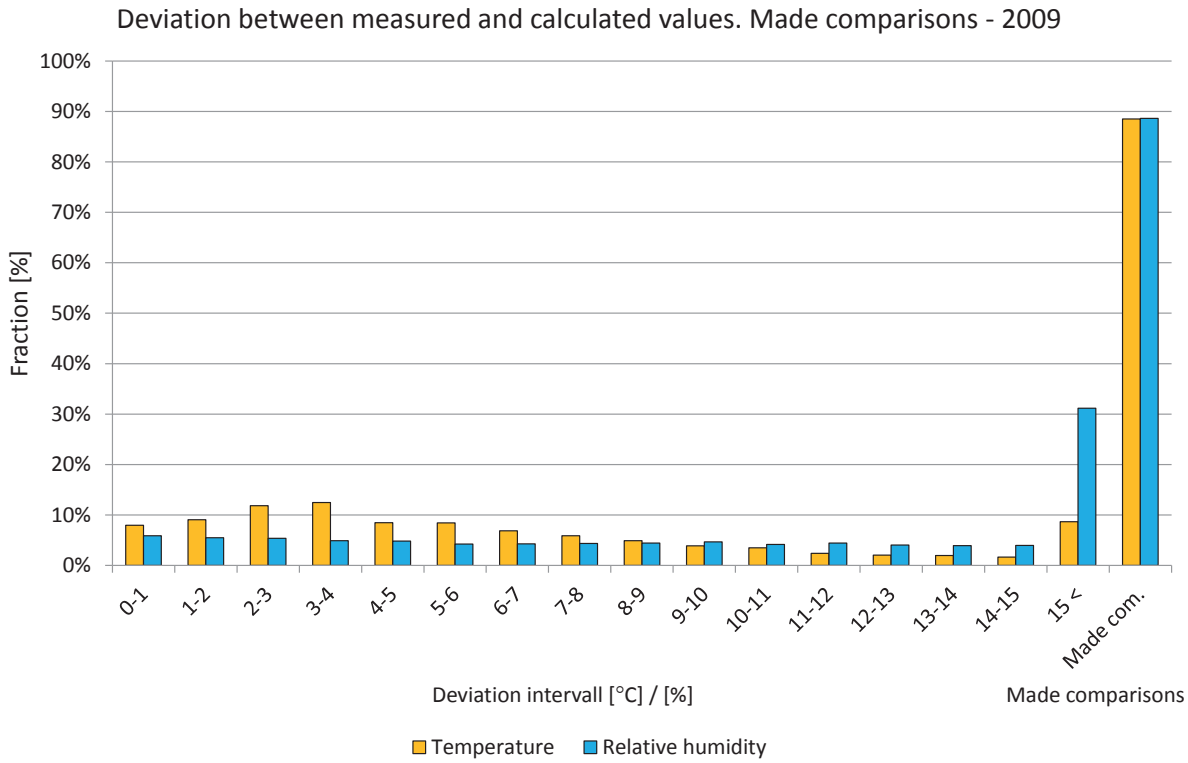


Figure 7.18.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

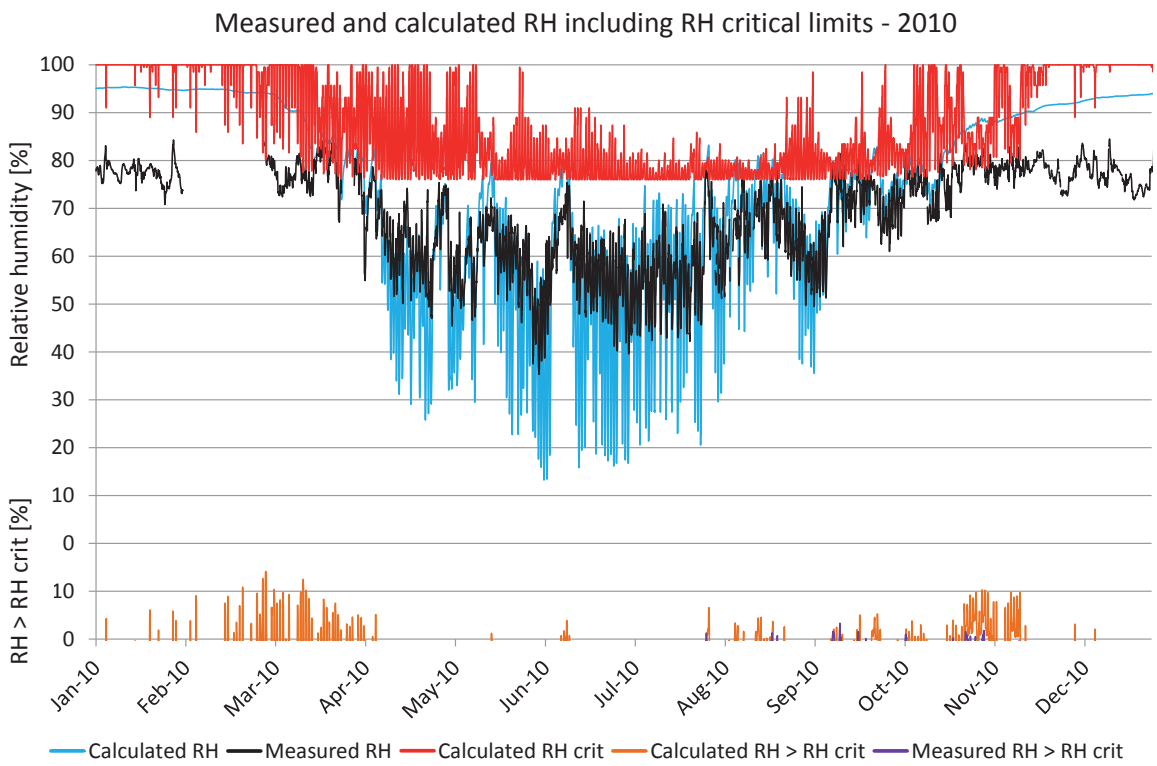


Figure 7.18.8. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

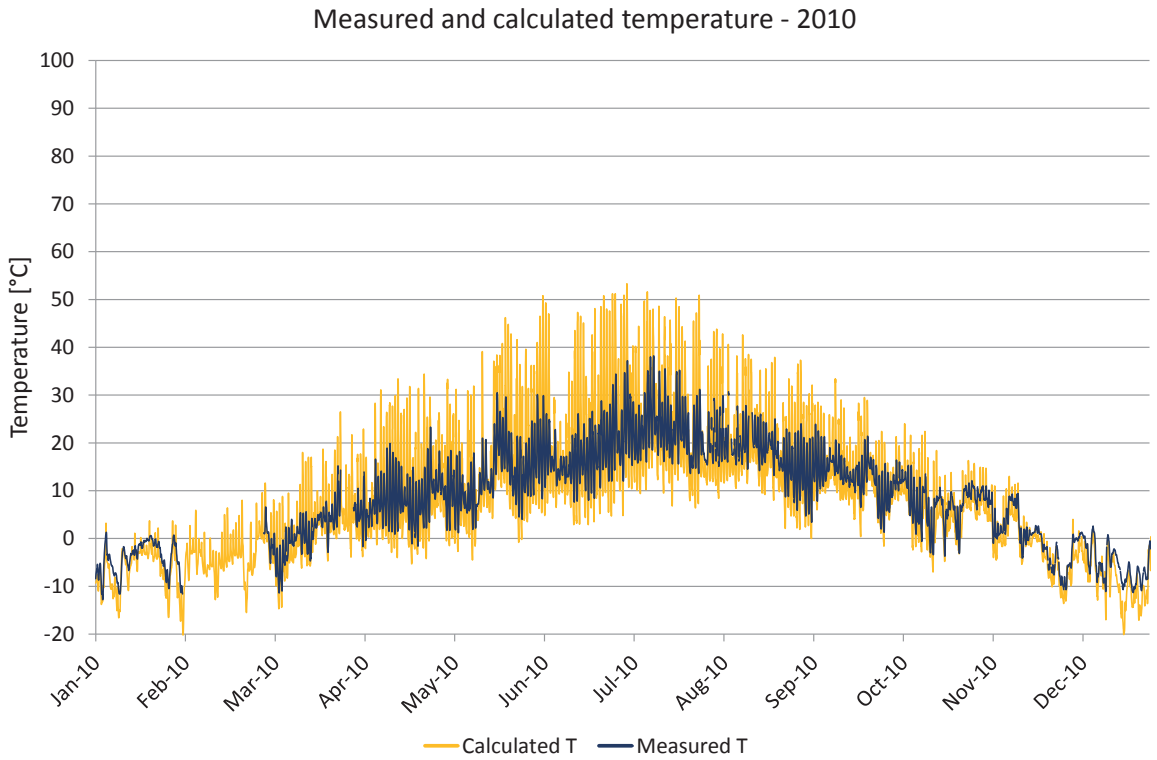


Figure 7.18.9. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

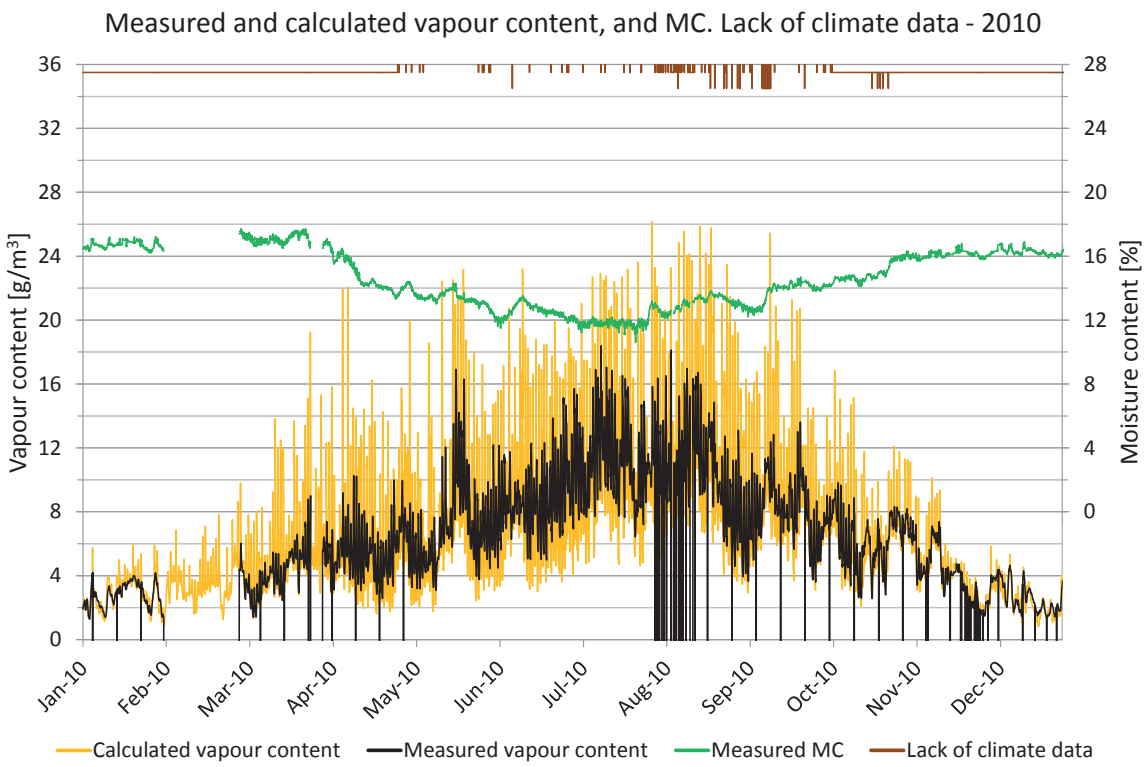


Figure 7.18.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

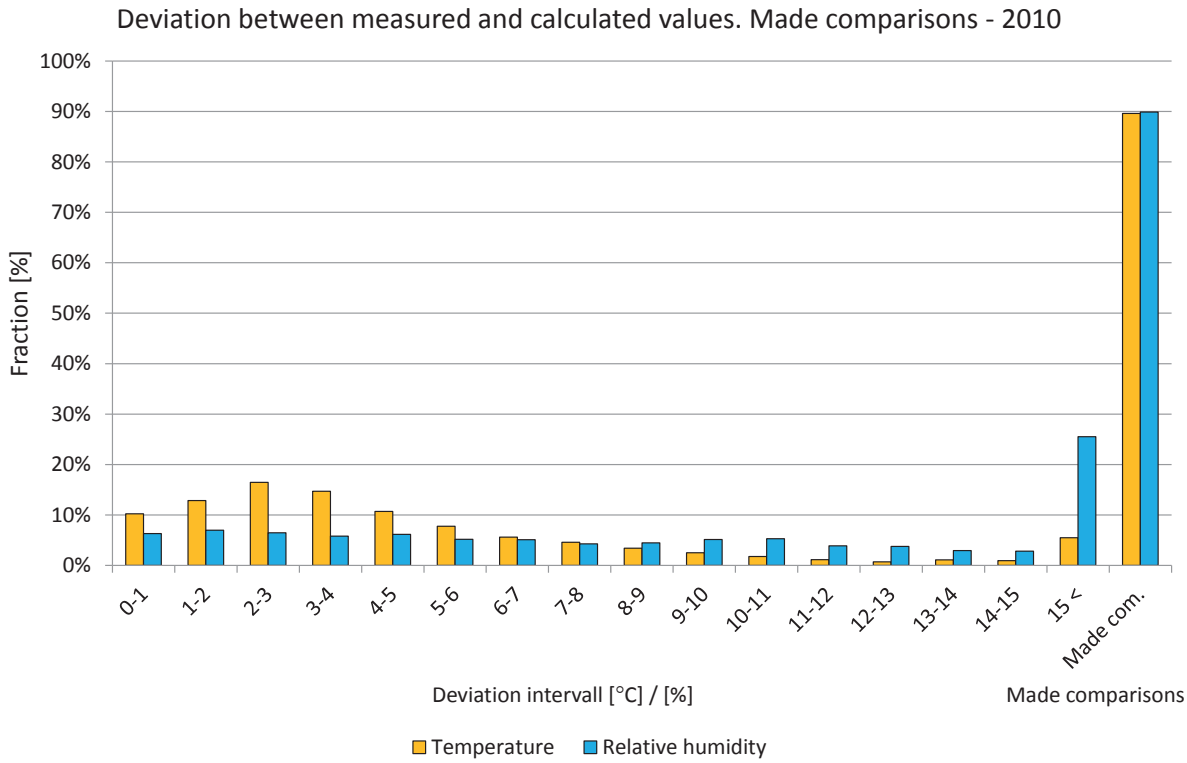


Figure 7.18.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

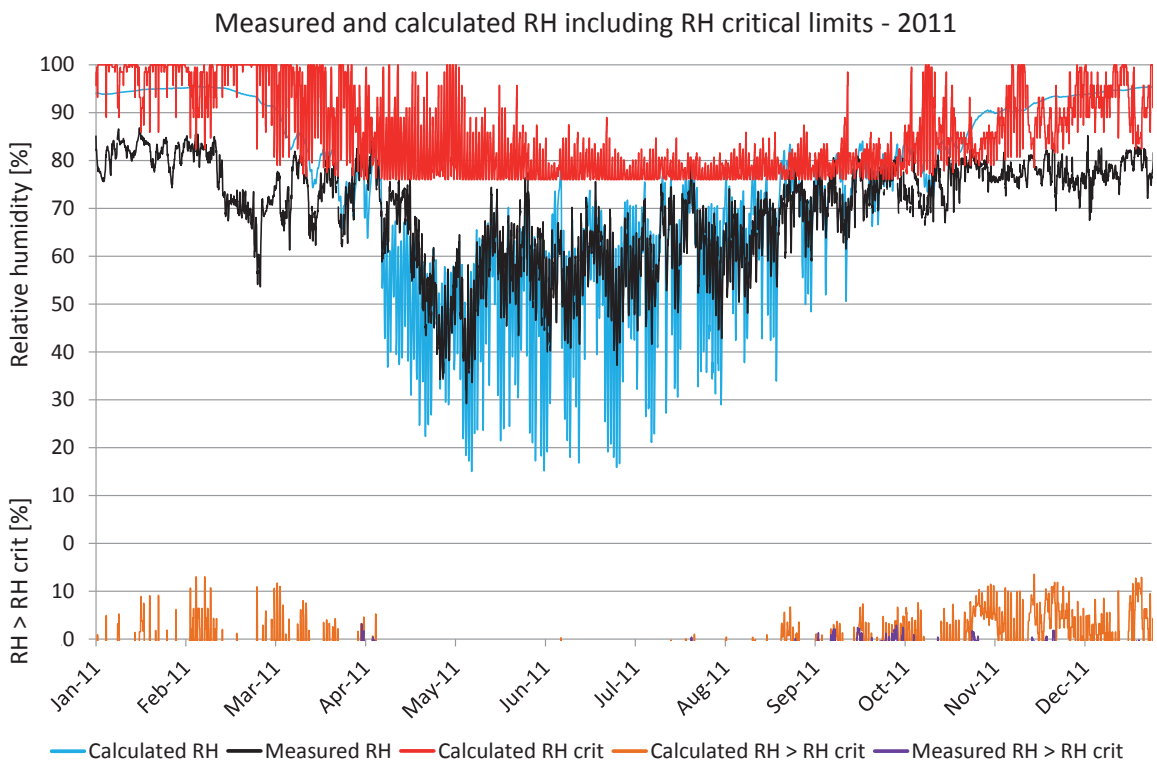


Figure 7.18.12. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

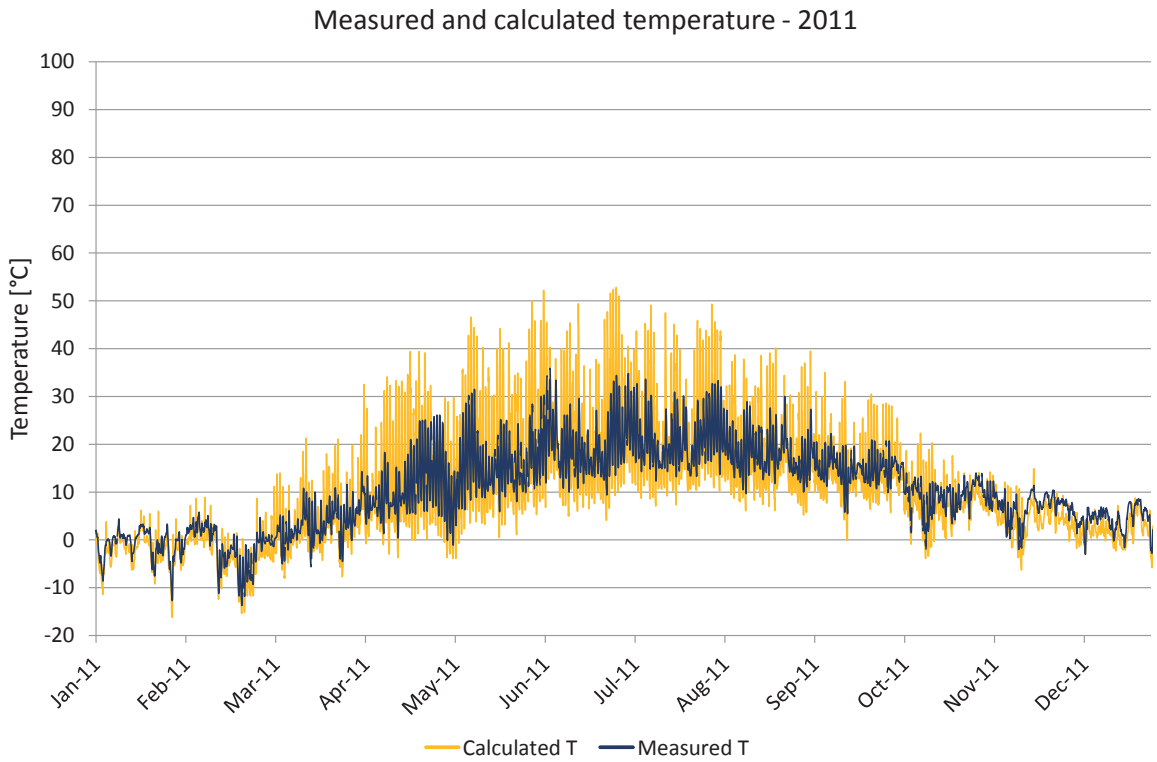


Figure 7.18.13. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

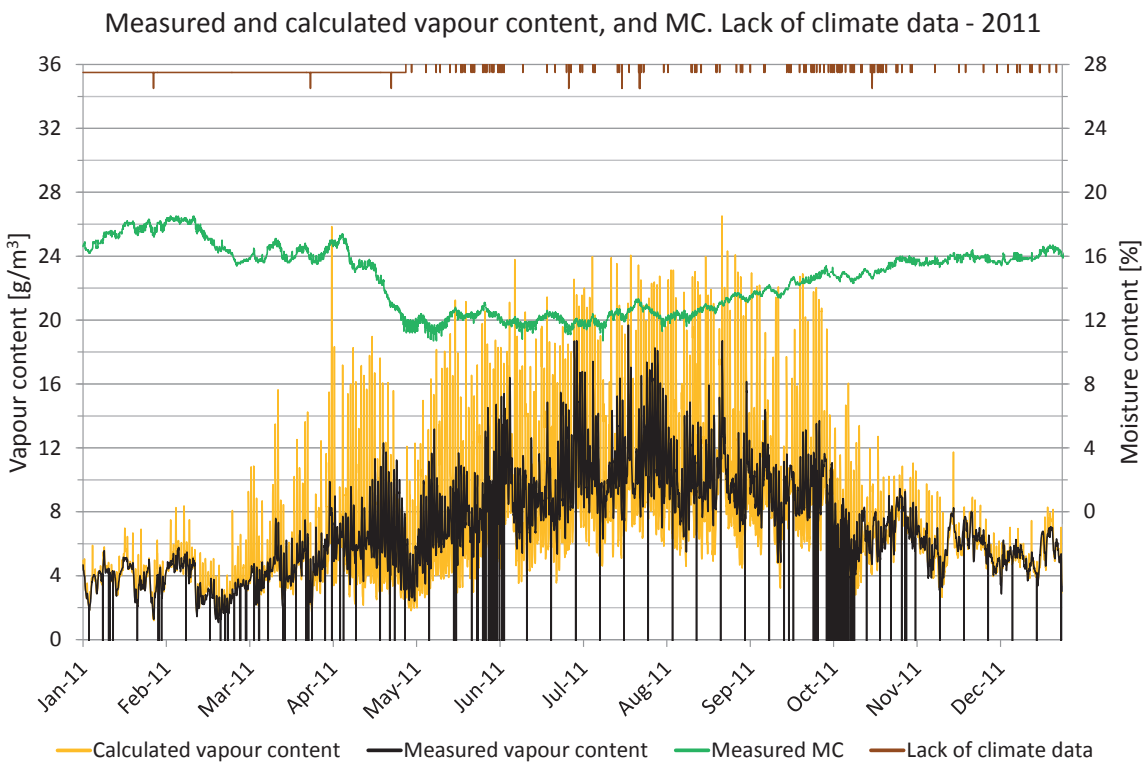


Figure 7.18.14 Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

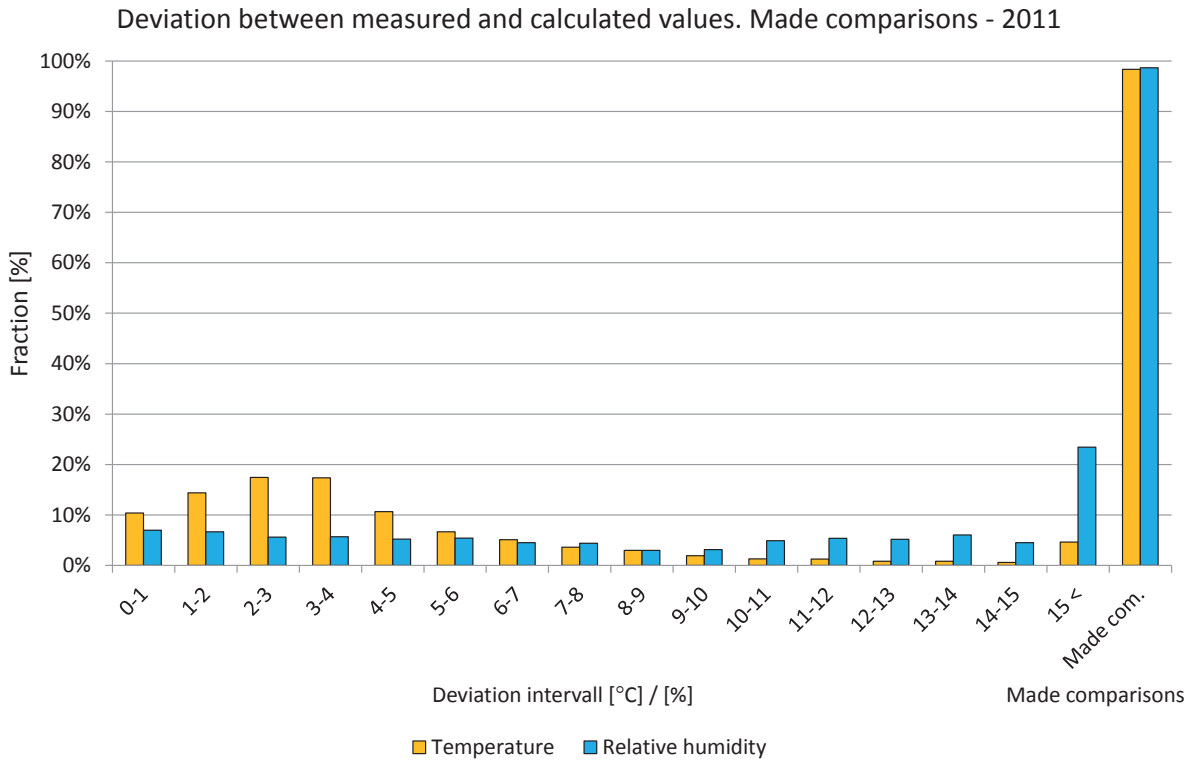
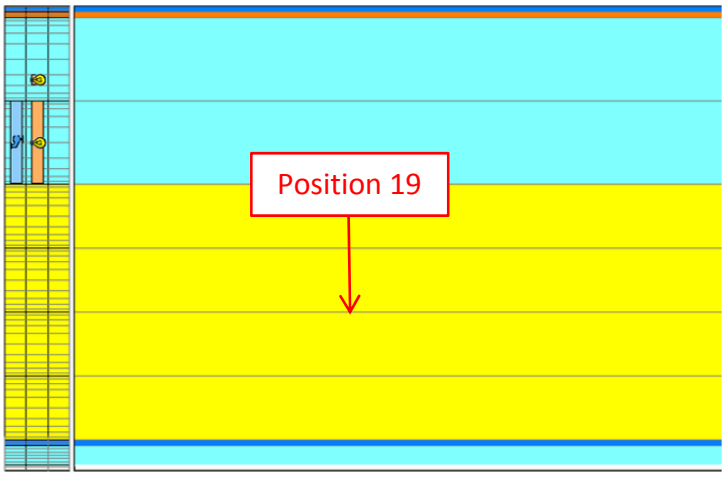


Figure 7.18.15. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

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 in a roof with 27 degrees roof angle facing northeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.19.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

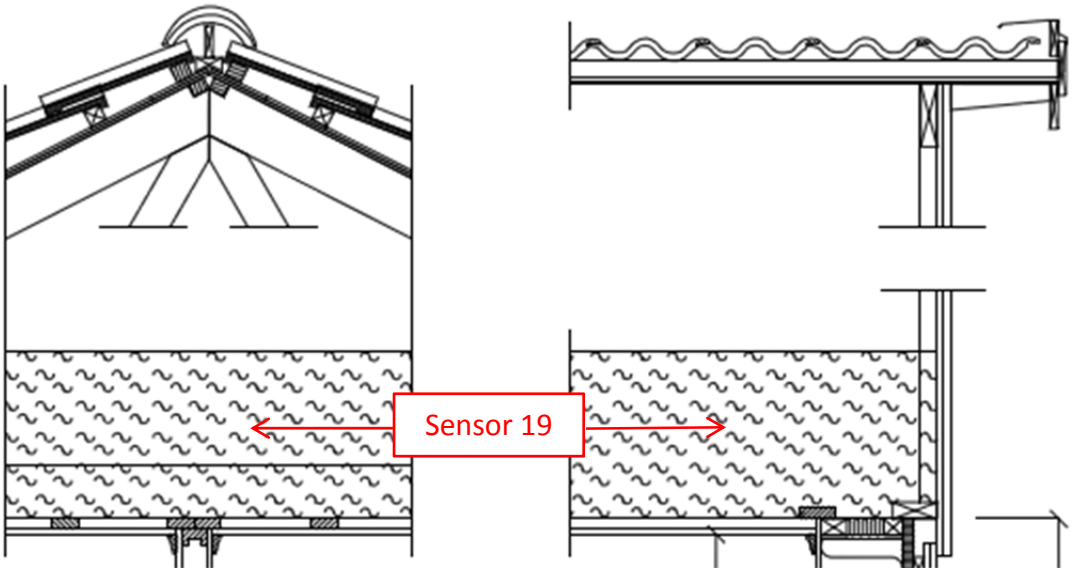


Figure 7.19.2. Location of the studied position.

Figure 7.19.3. Location of the studied position.

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 2009

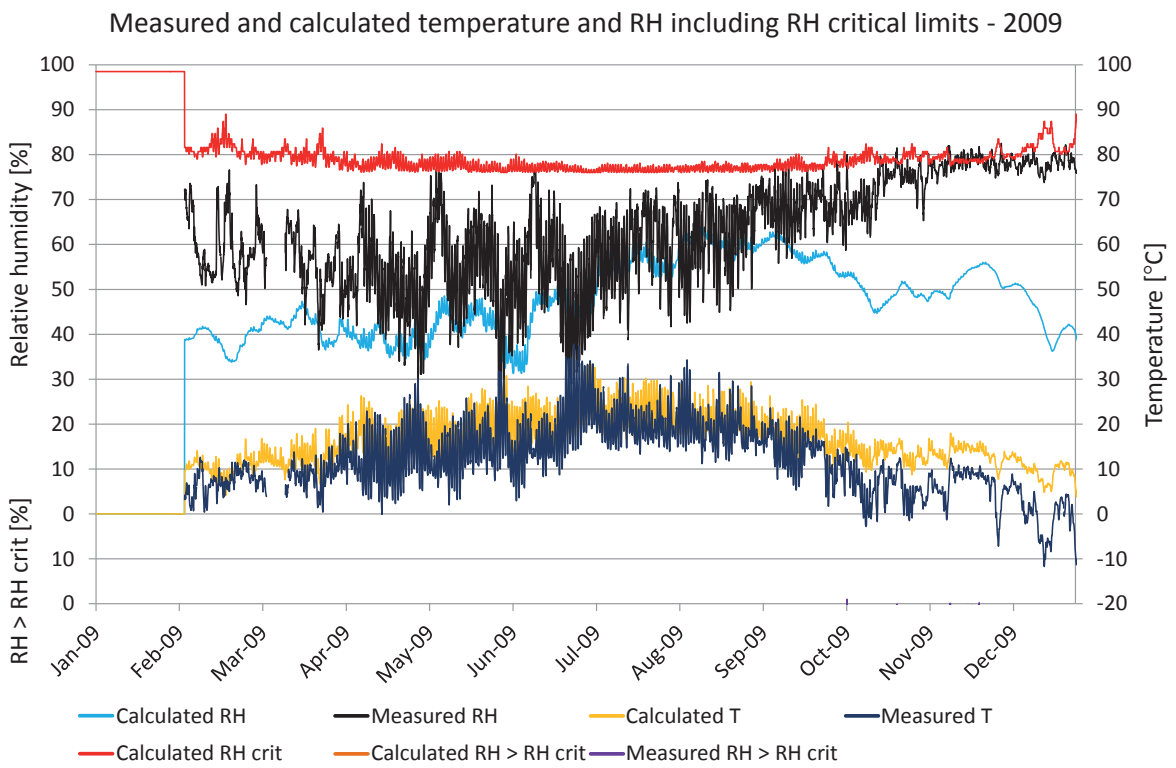


Figure 7.19.4. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

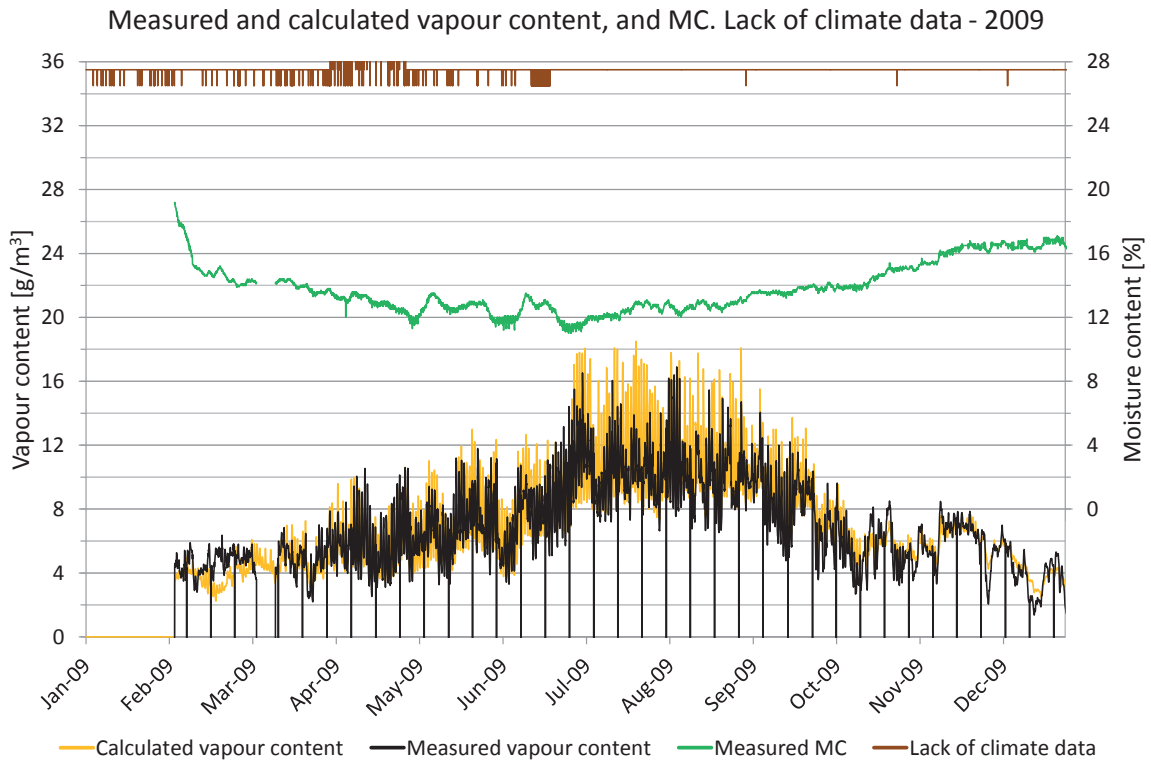


Figure 7.19.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

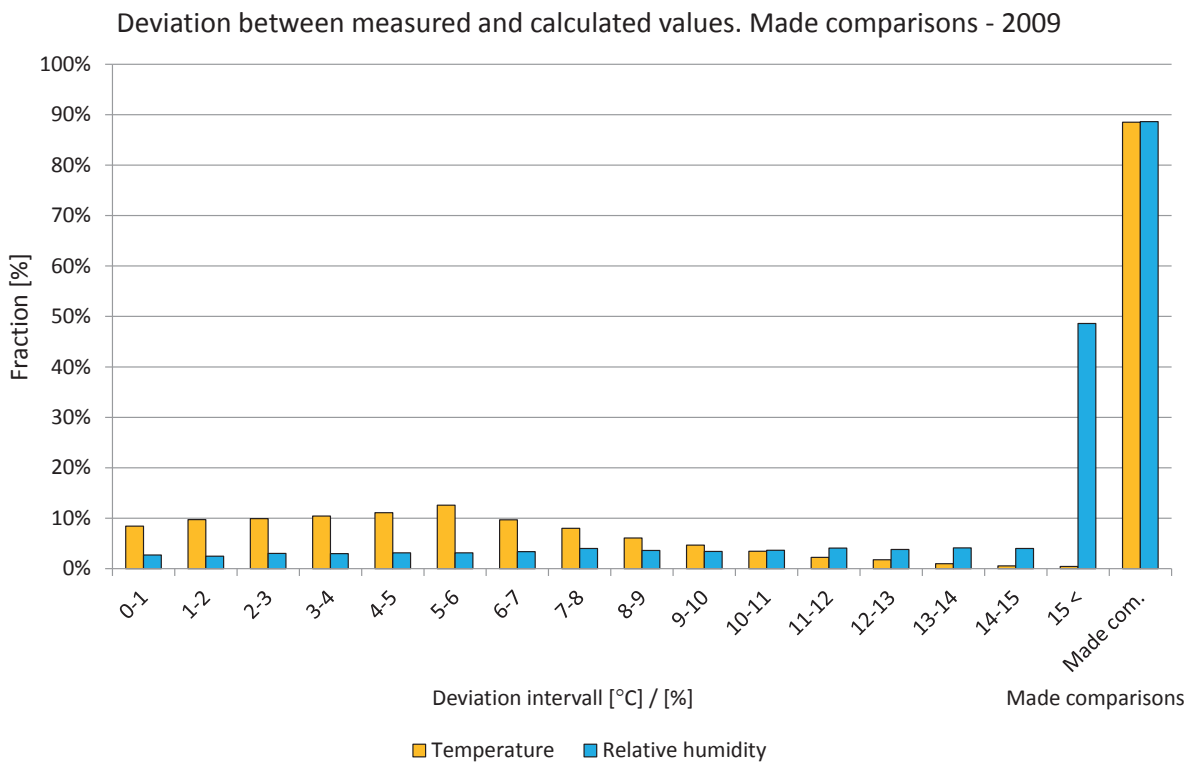


Figure 7.19.6 Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

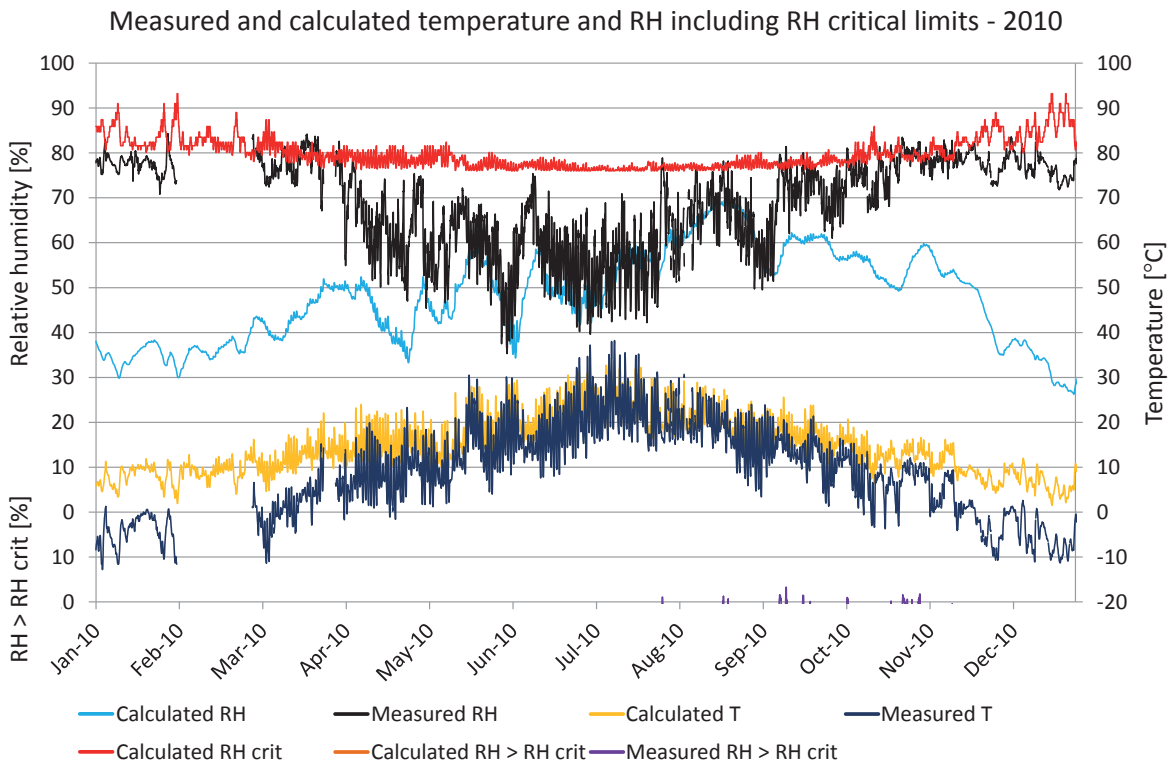


Figure 7.19.7. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

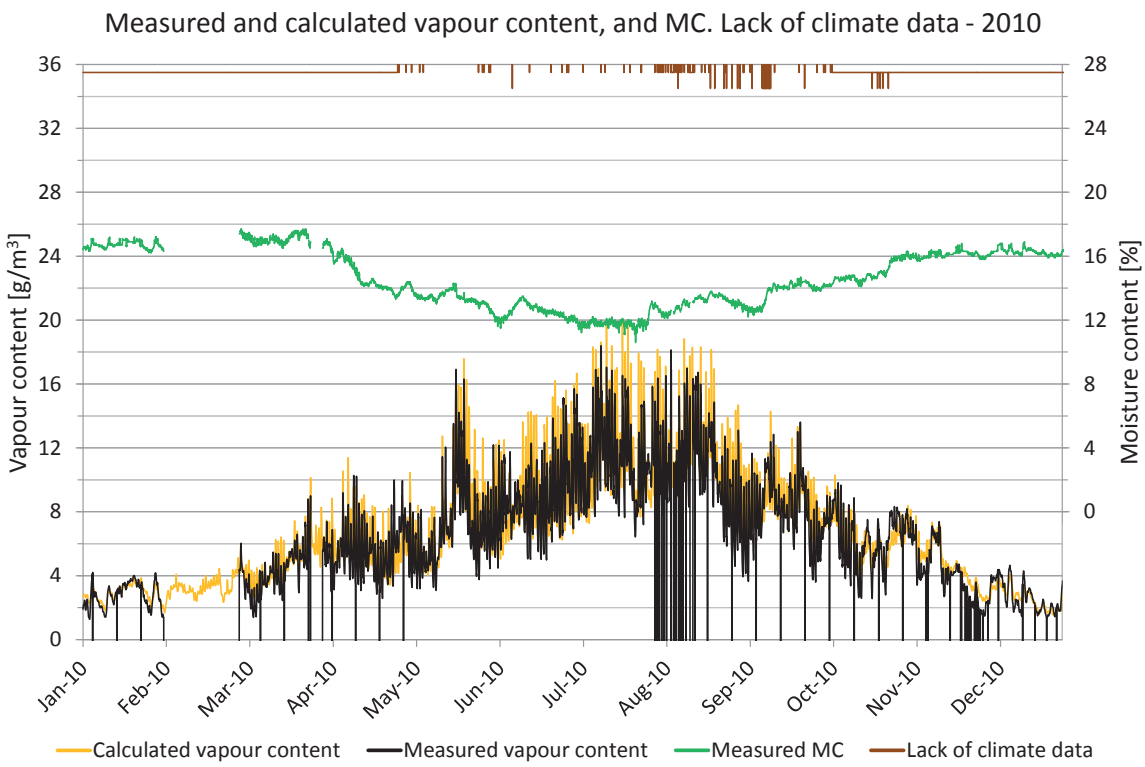


Figure 7.19.8. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

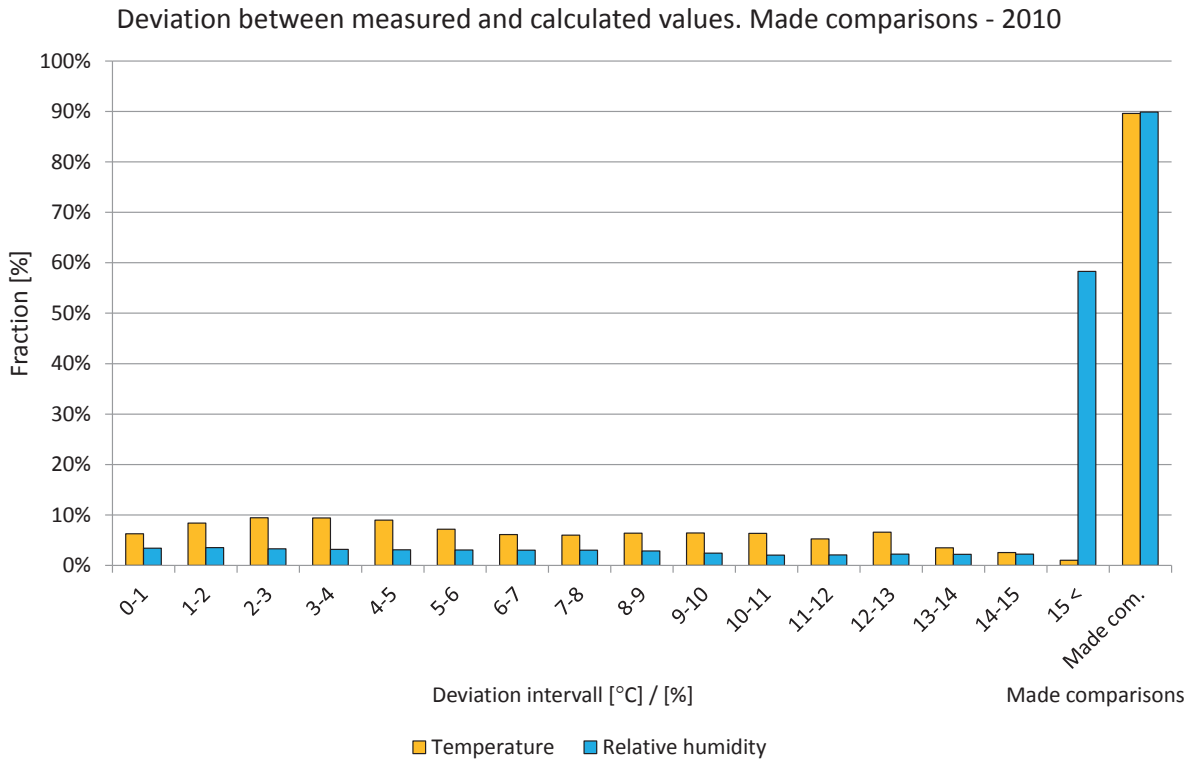


Figure 7.19.9. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

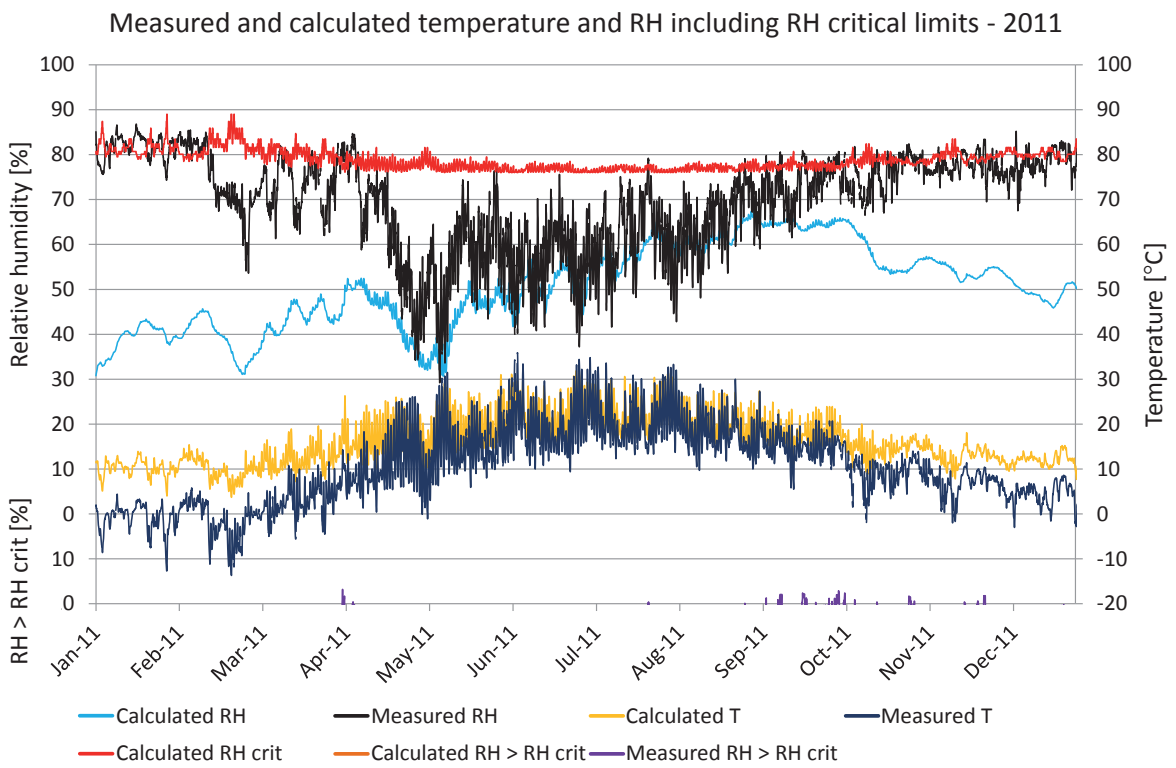


Figure 7.19.10. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

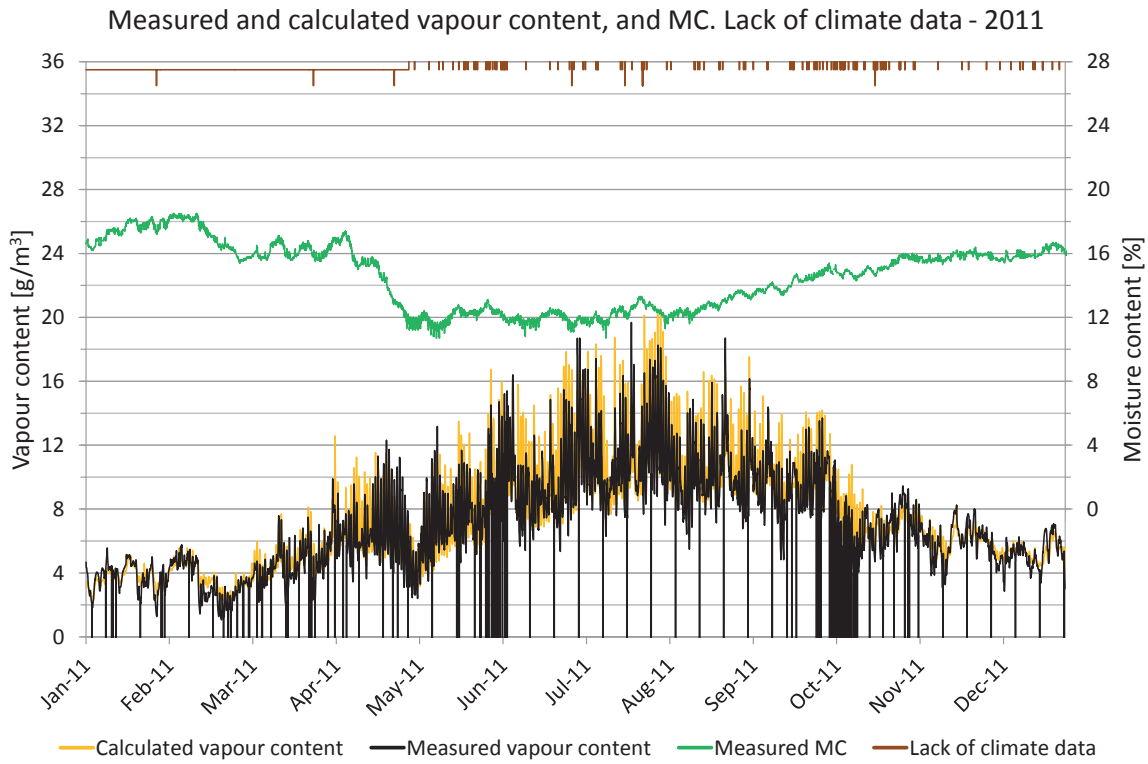


Figure 7.19.11 Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

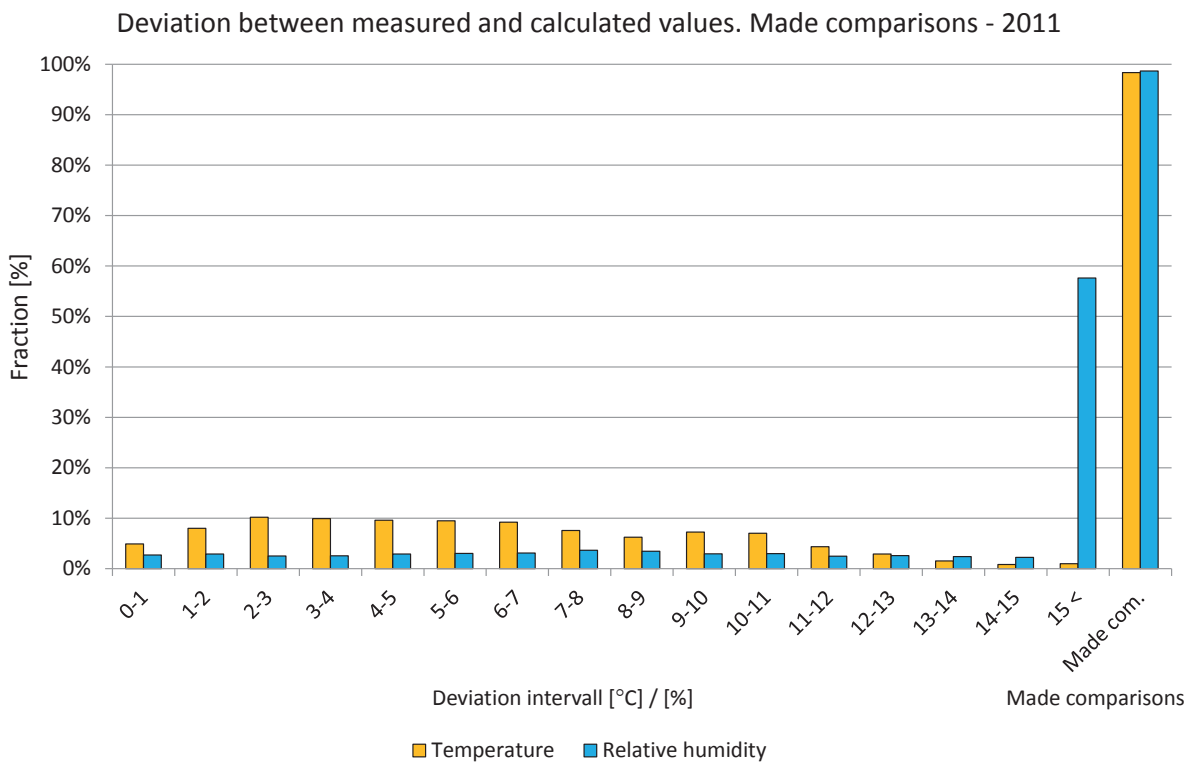
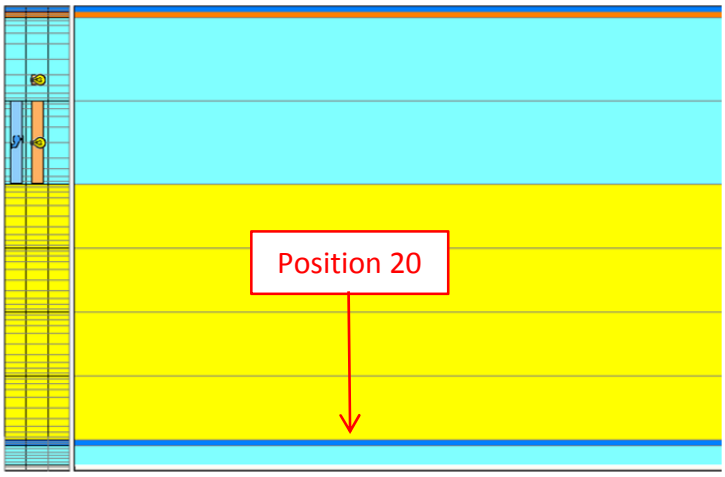


Figure 7.19.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.20 Position 20

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing northeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.20.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

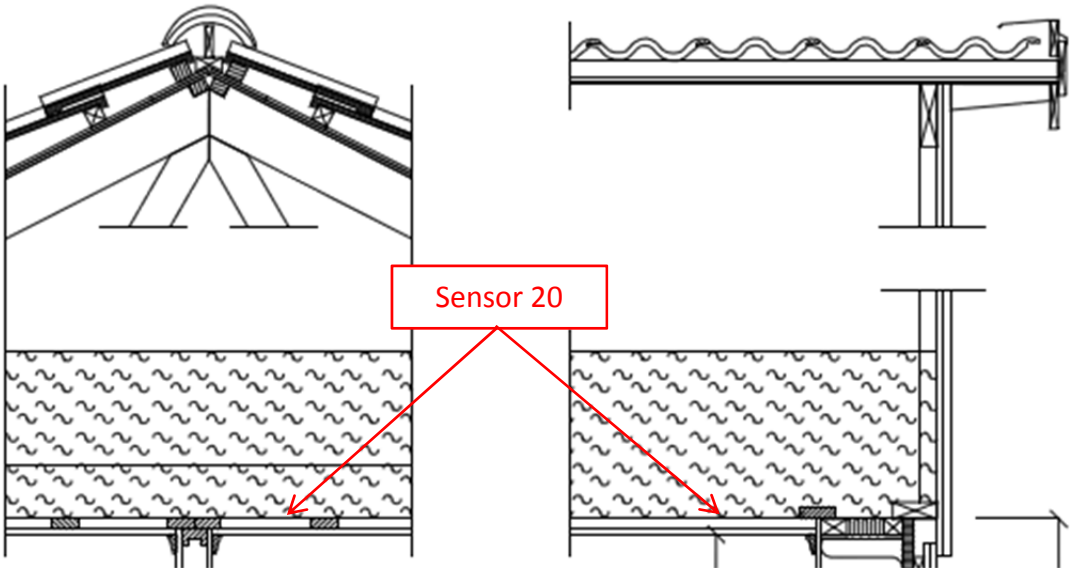


Figure 7.20.2. Location of the studied position.

Figure 7.20.3. Location of the studied position.

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 2009

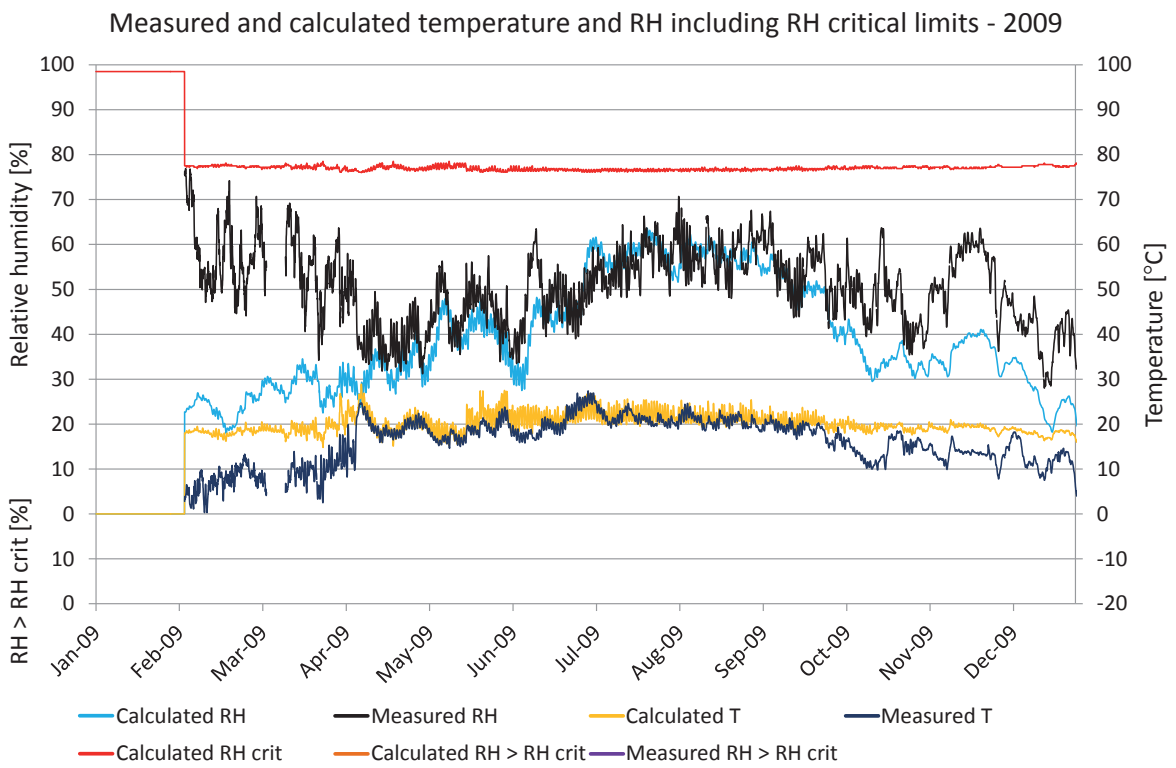


Figure 7.20.4. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

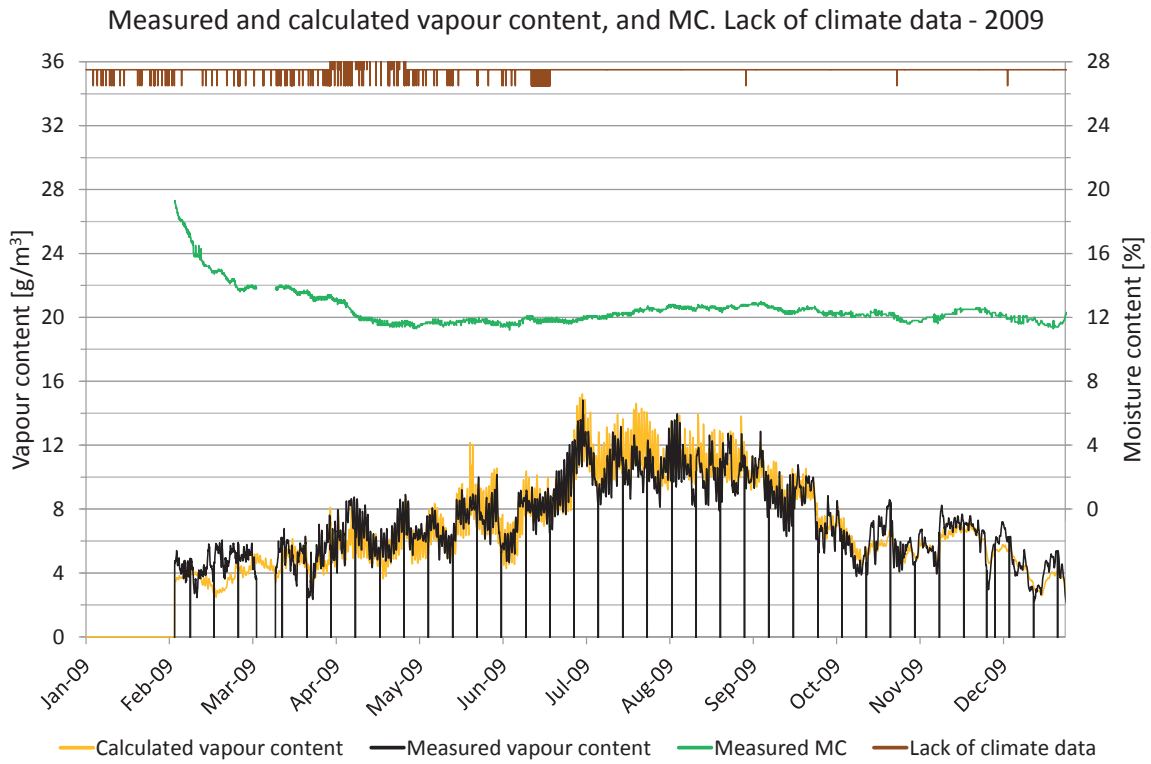


Figure 7.20.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

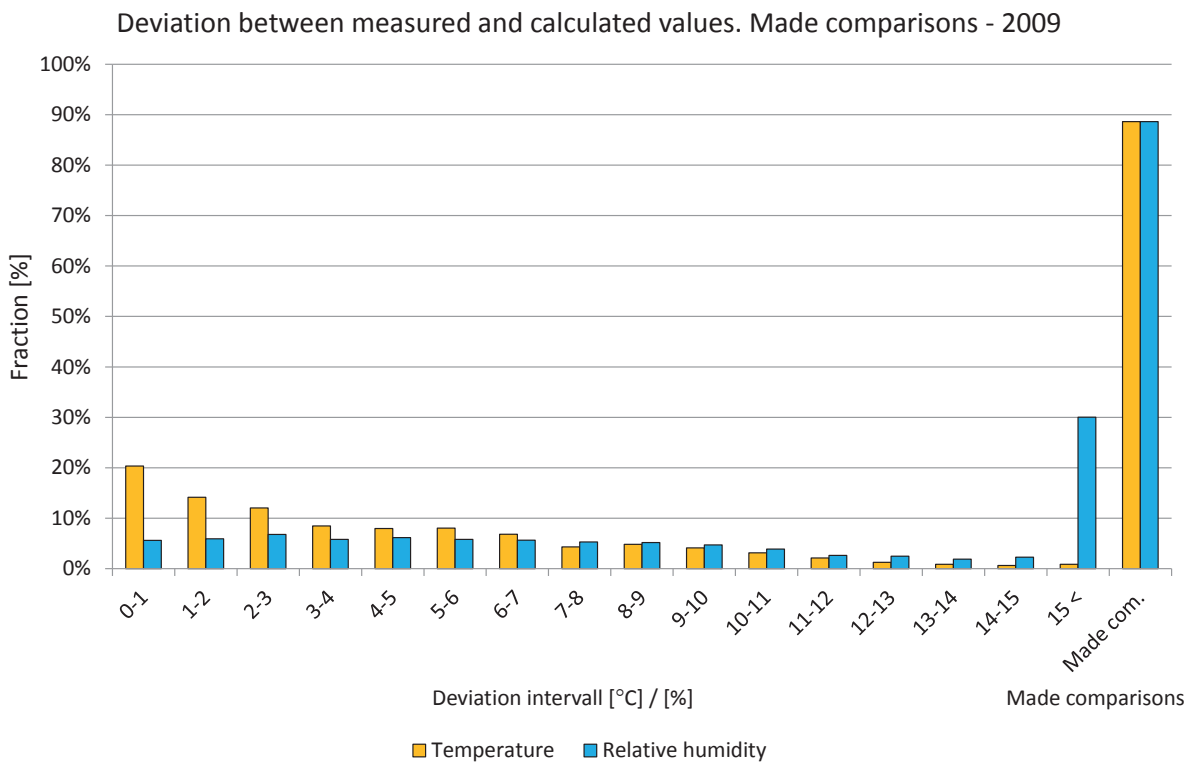


Figure 7.20.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

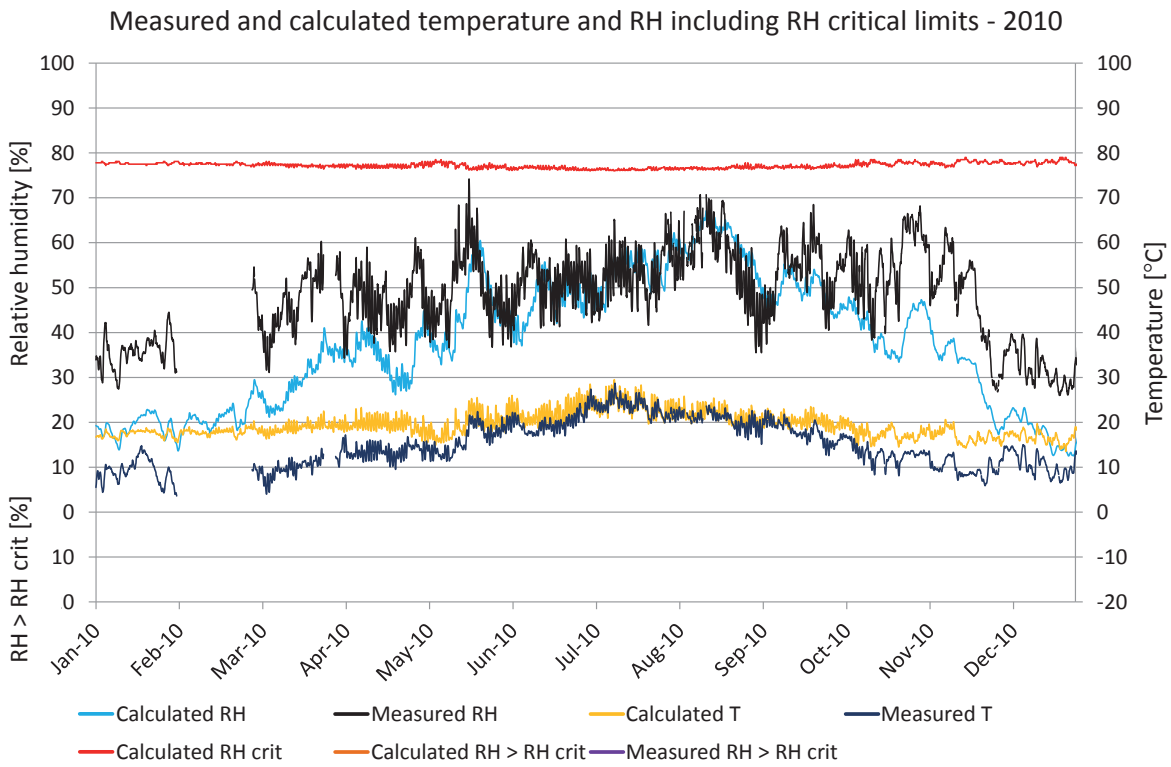


Figure 7.20.7. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

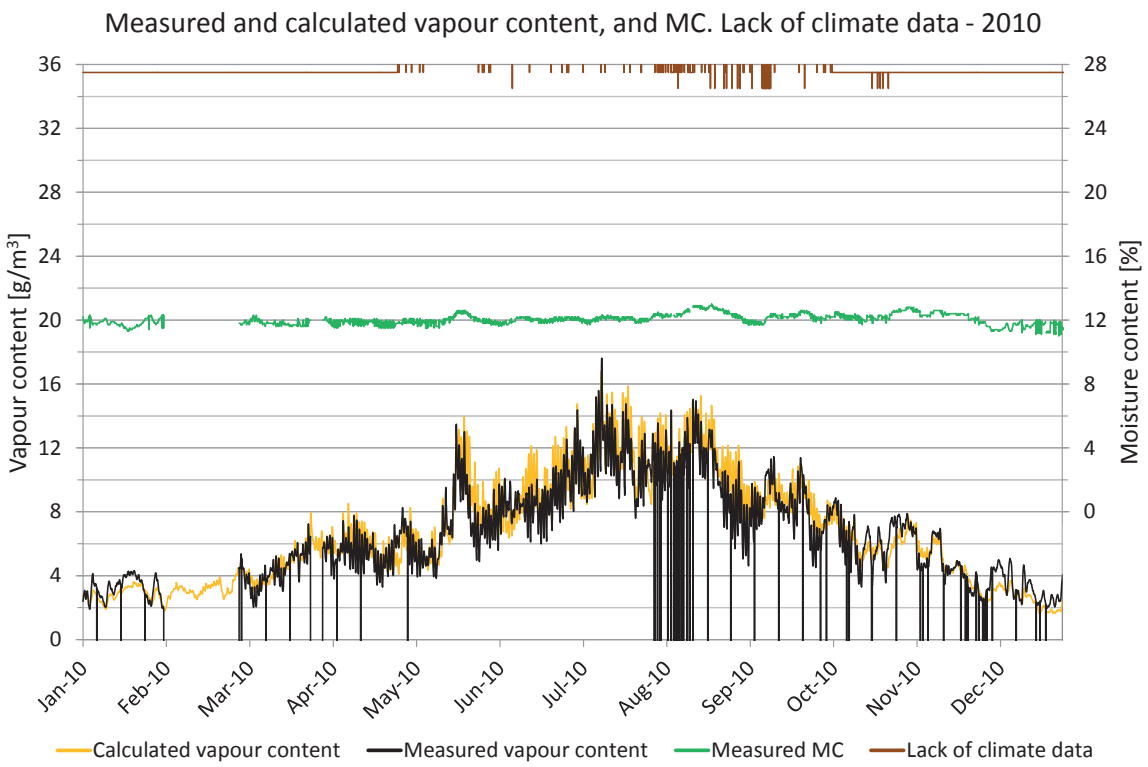


Figure 7.20.8. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

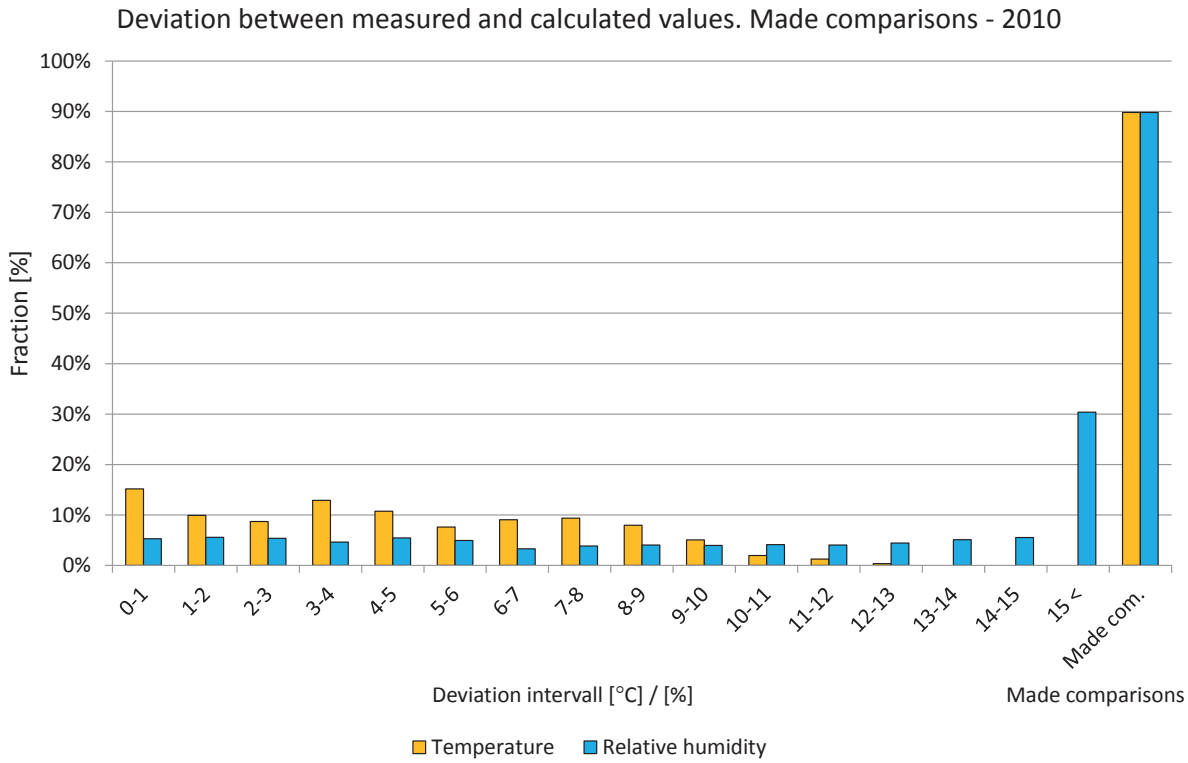


Figure 7.20.9. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

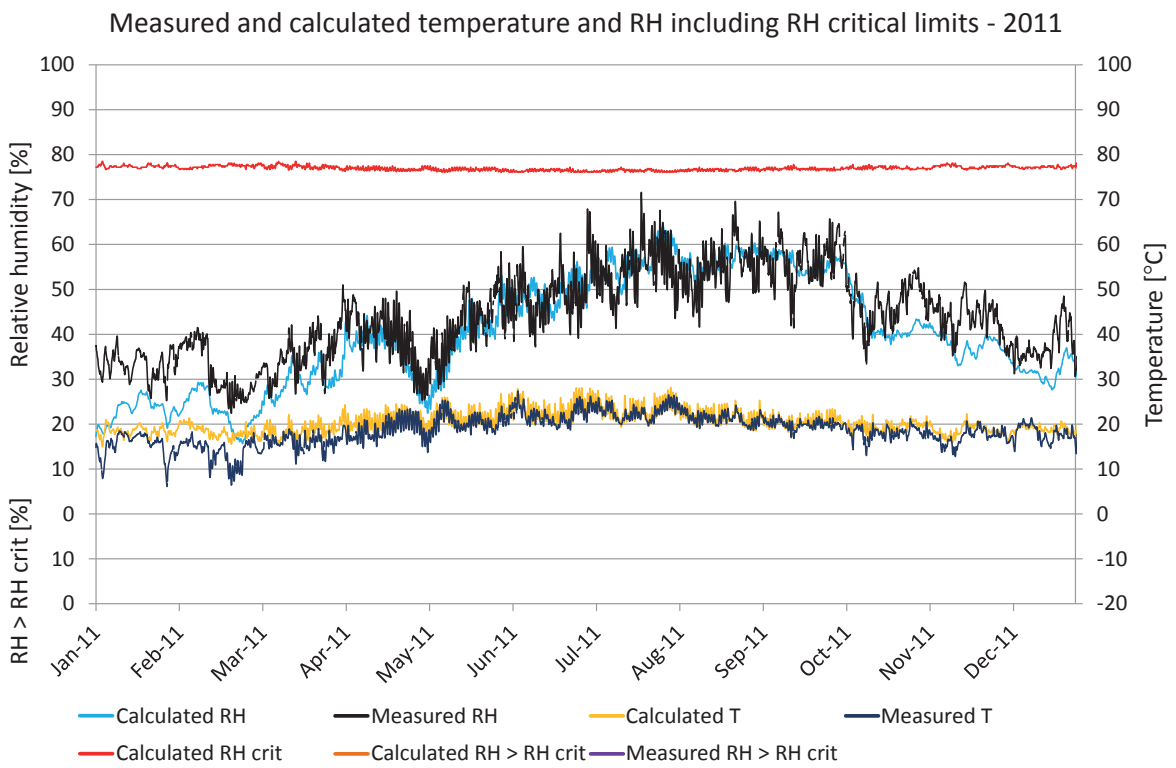


Figure 7.20.10. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

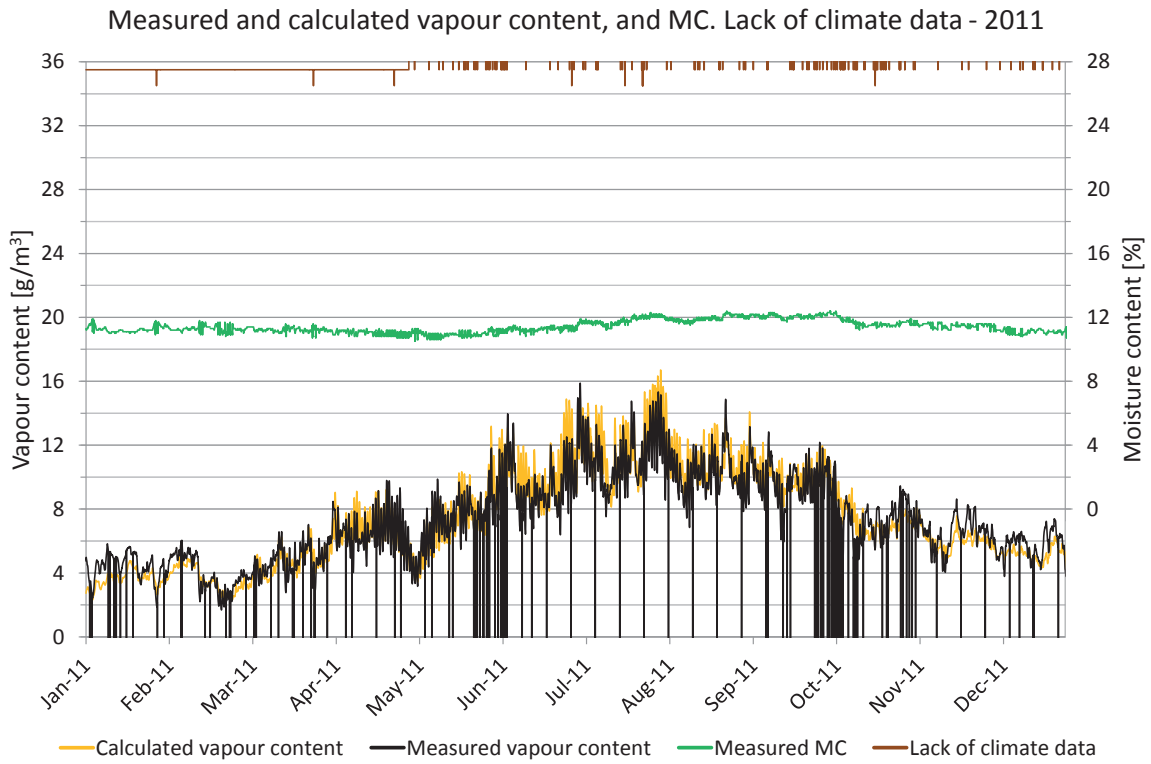


Figure 7.20.11.Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

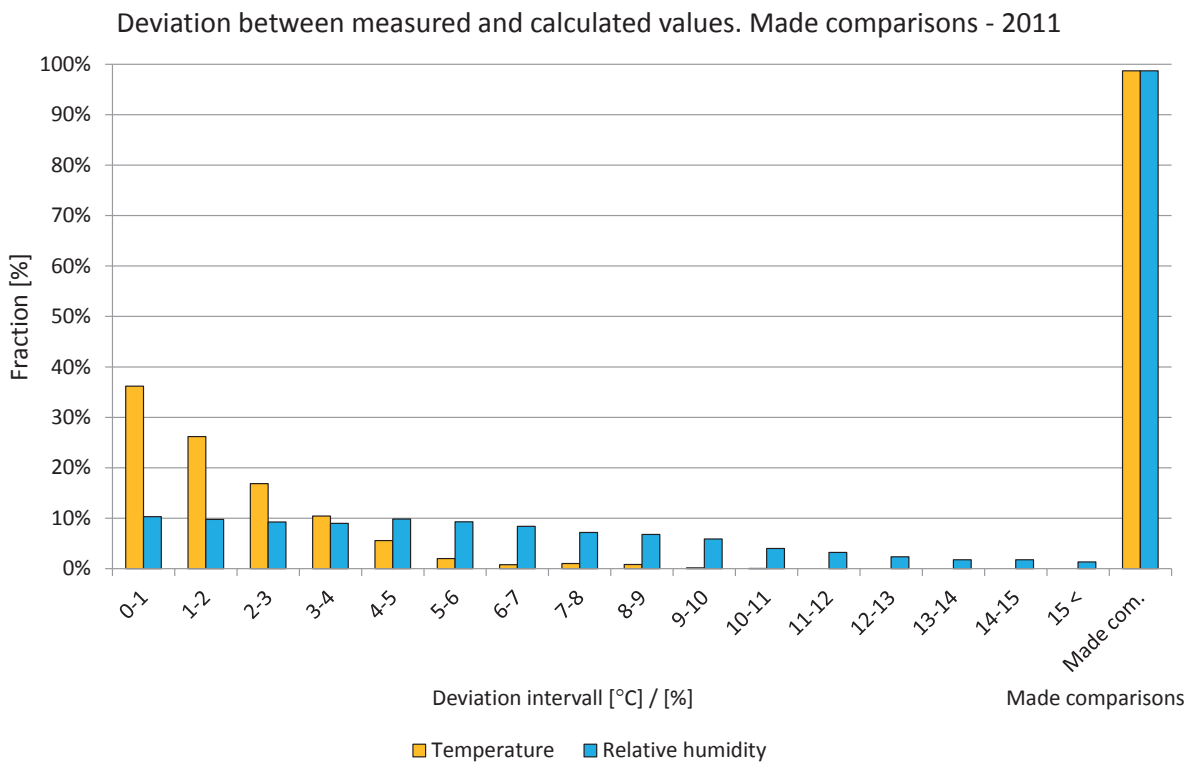
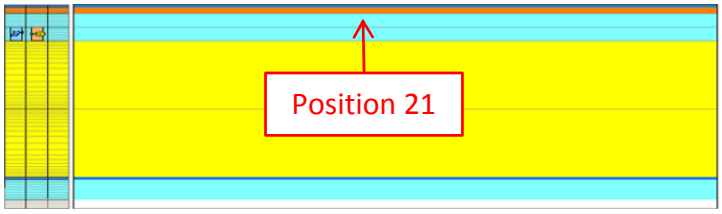


Figure 7.20.12. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.21 Position 21

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing southeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
20 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
20 mm Air gap[1] with 20 ACH
200 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[2]

Figure 7.21.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

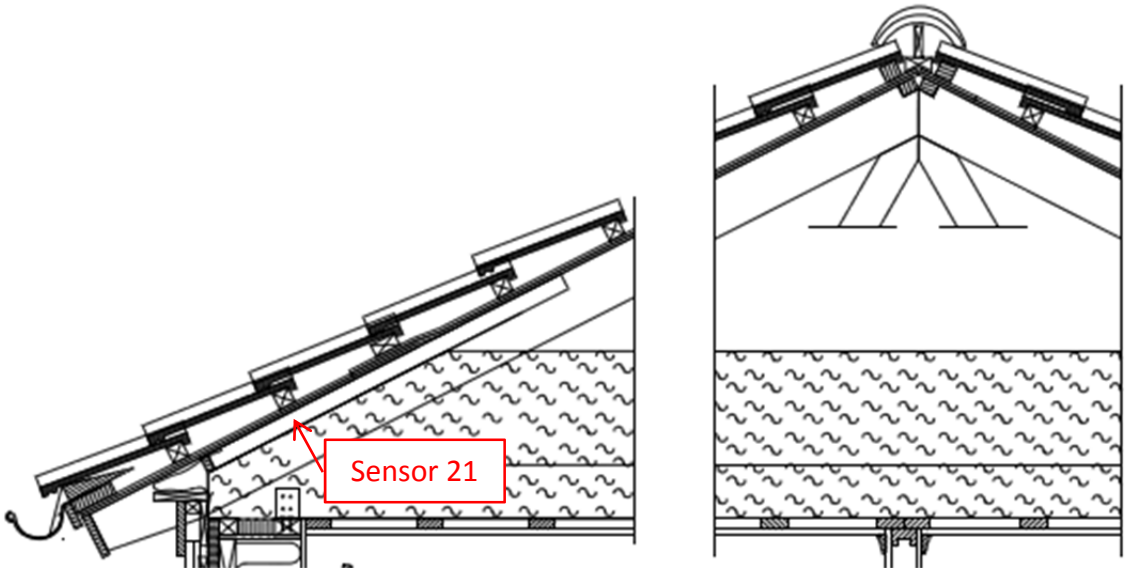


Figure 7.21.2. Location of the studied position.

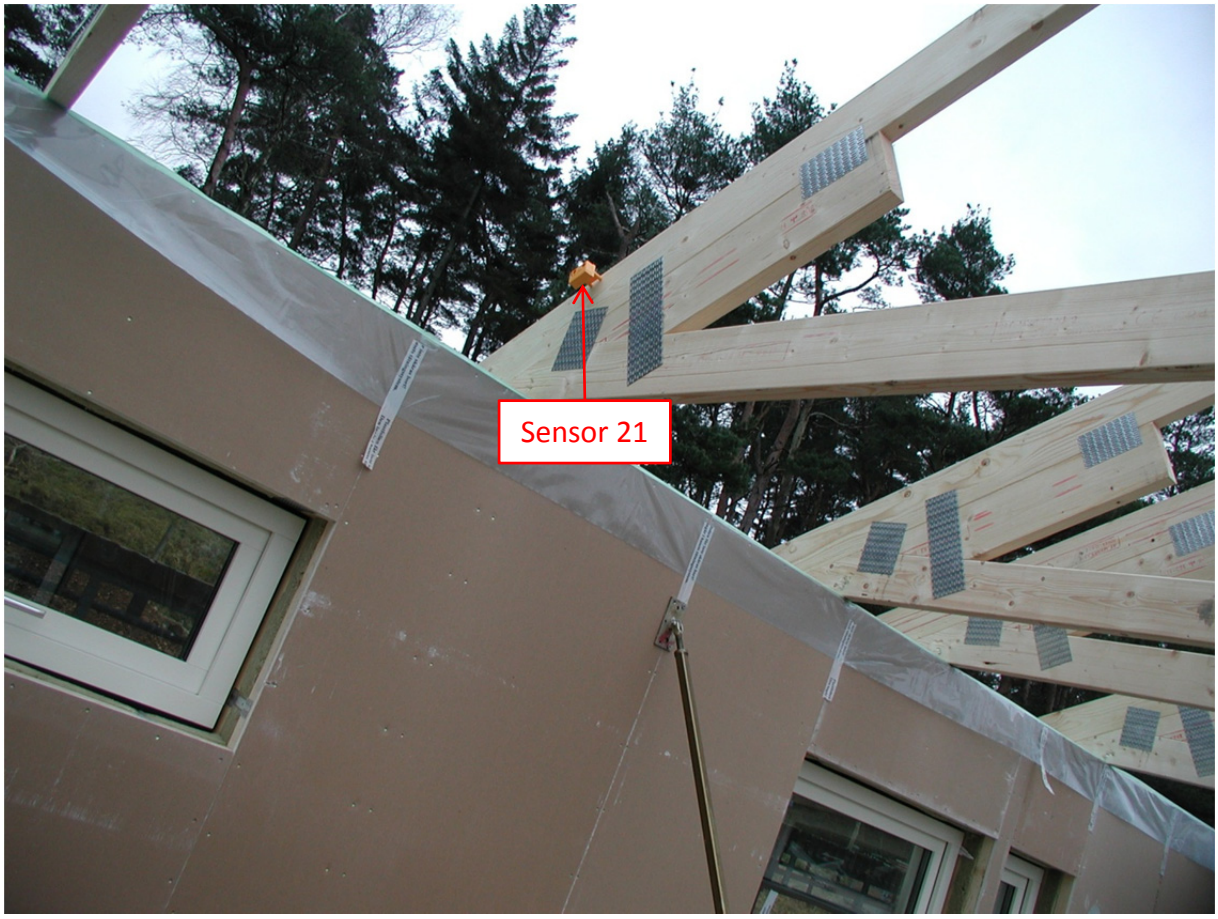


Figure 7.21.3. Location of the studied position.

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 2009

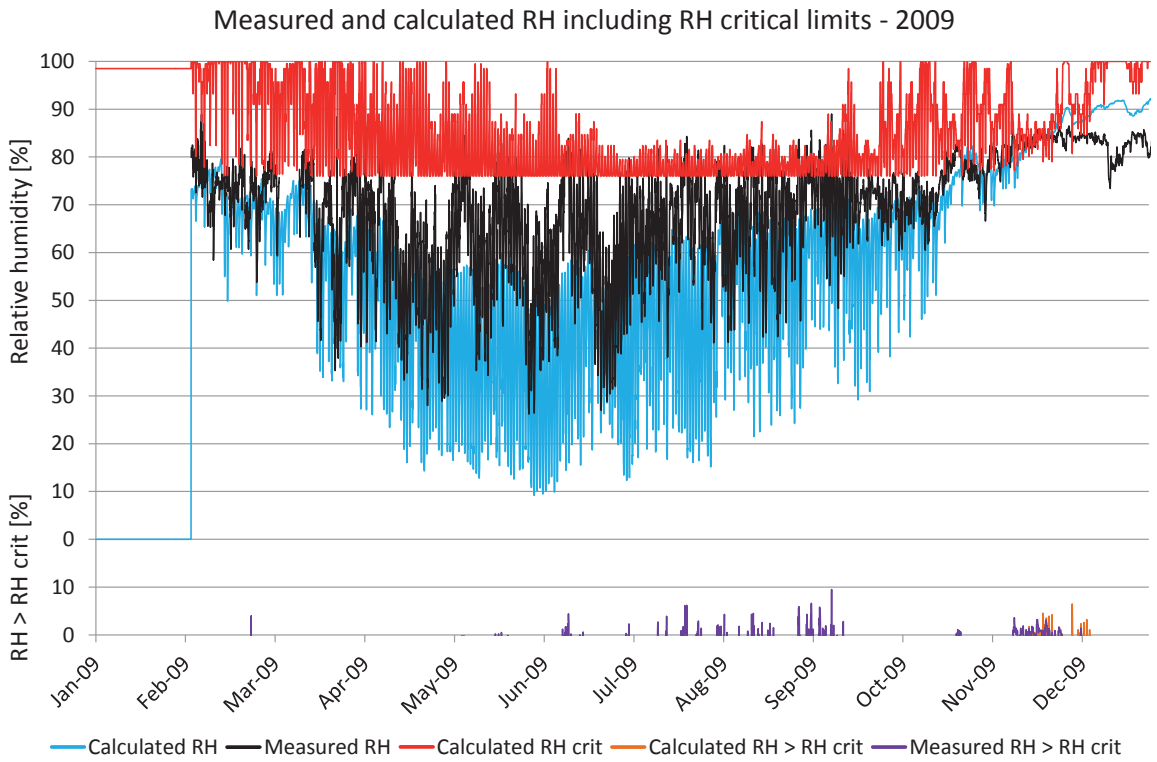


Figure 7.21.4. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

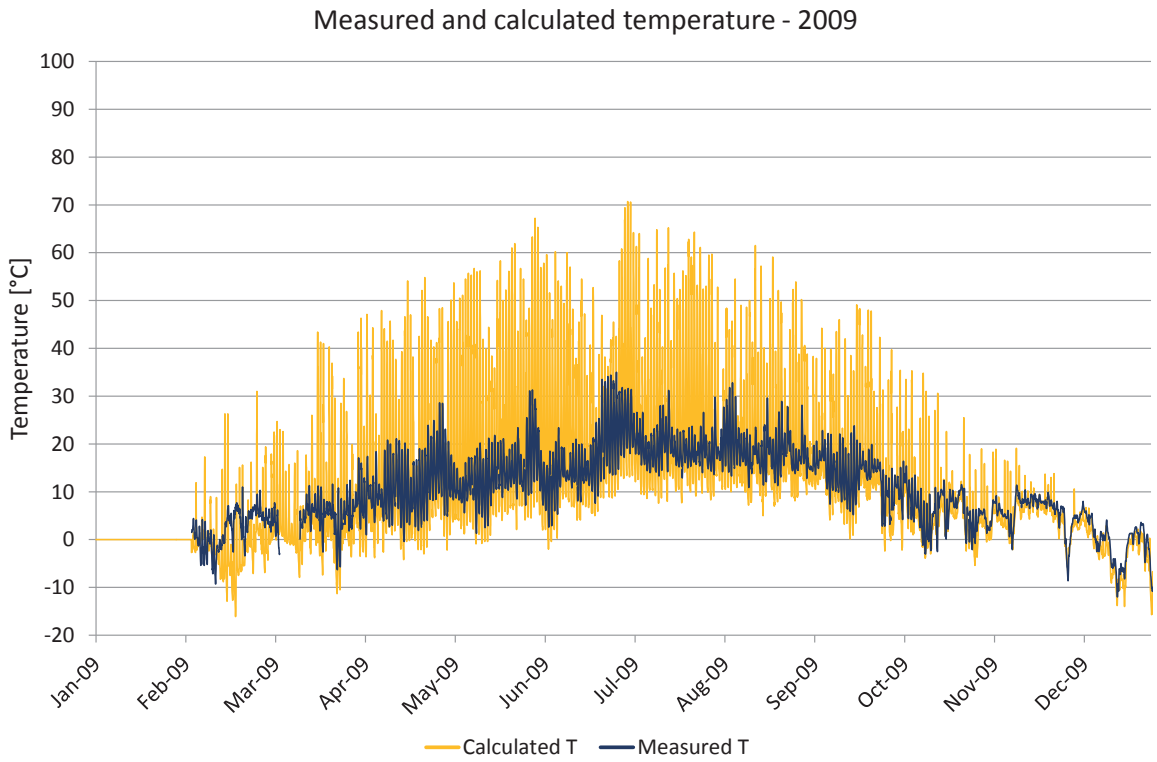


Figure 7.21.5. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

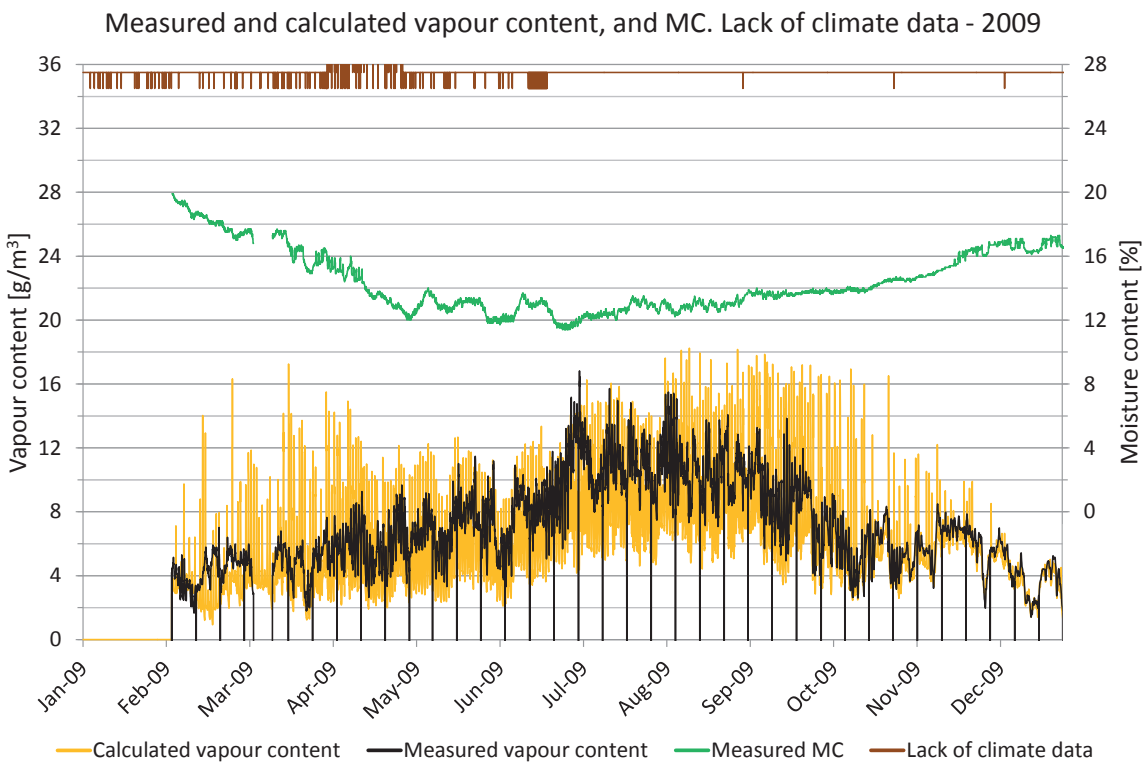


Figure 7.21.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

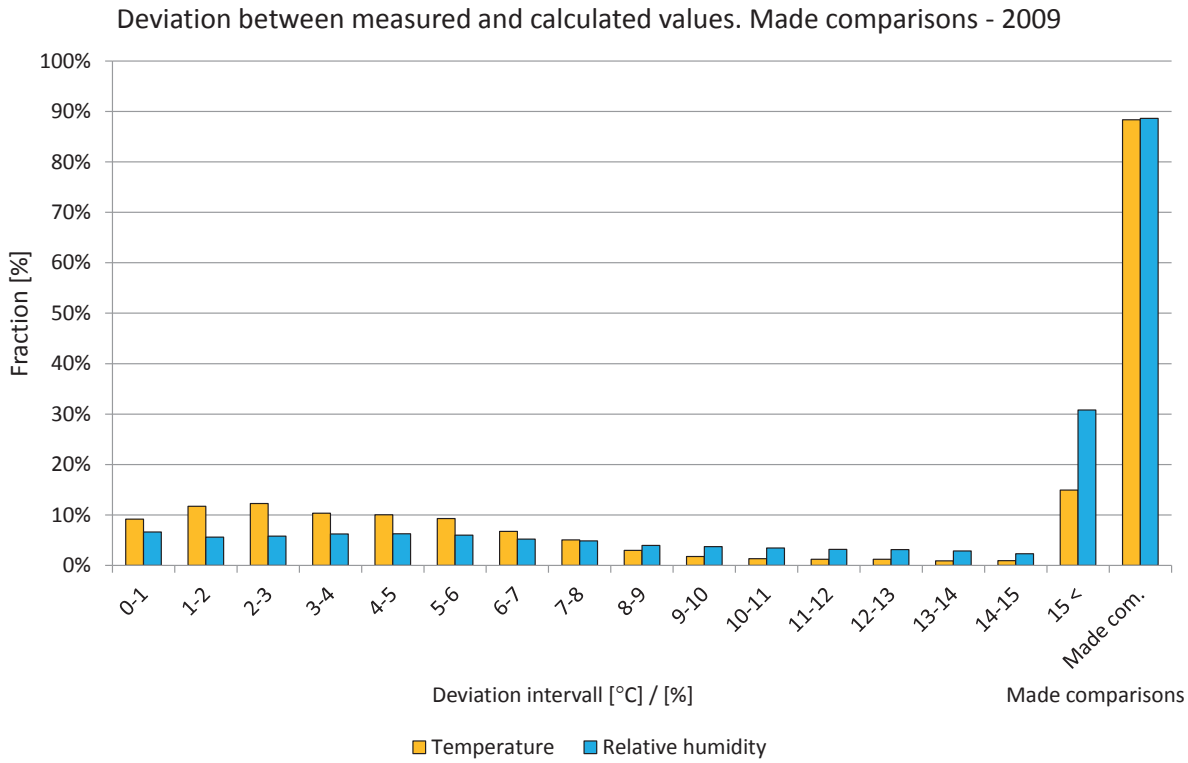


Figure 7.21.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

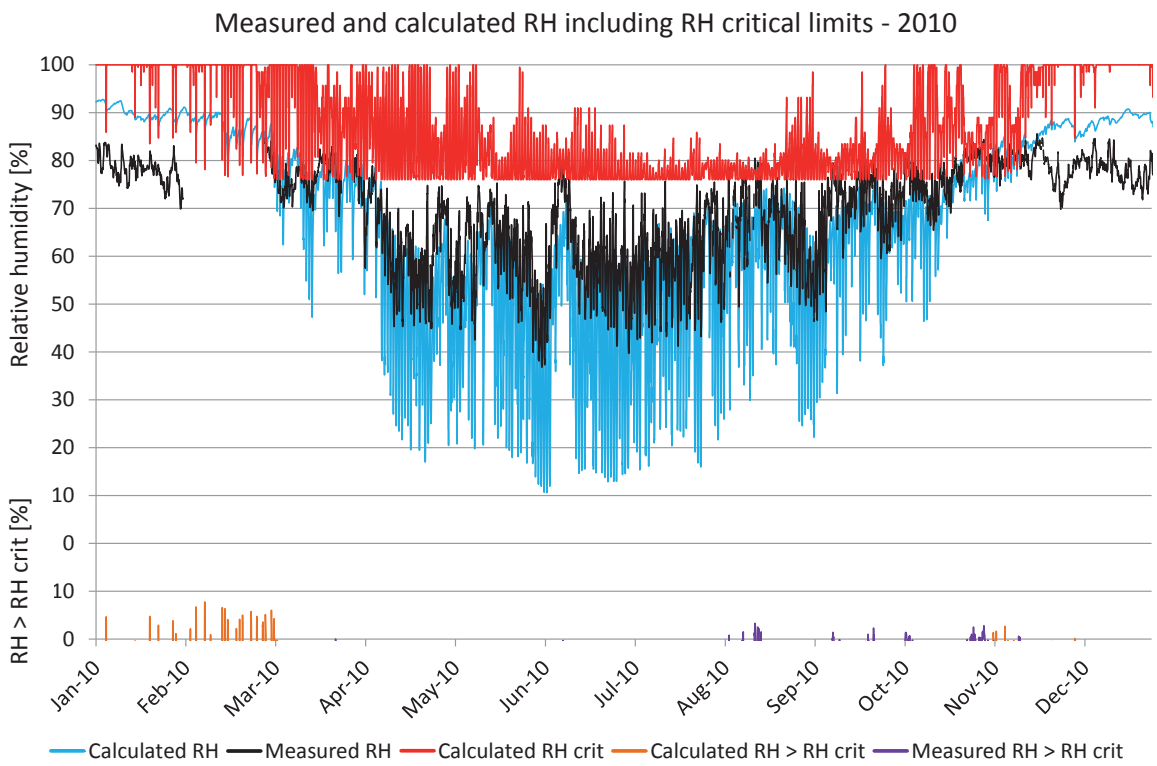


Figure 7.21.8. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

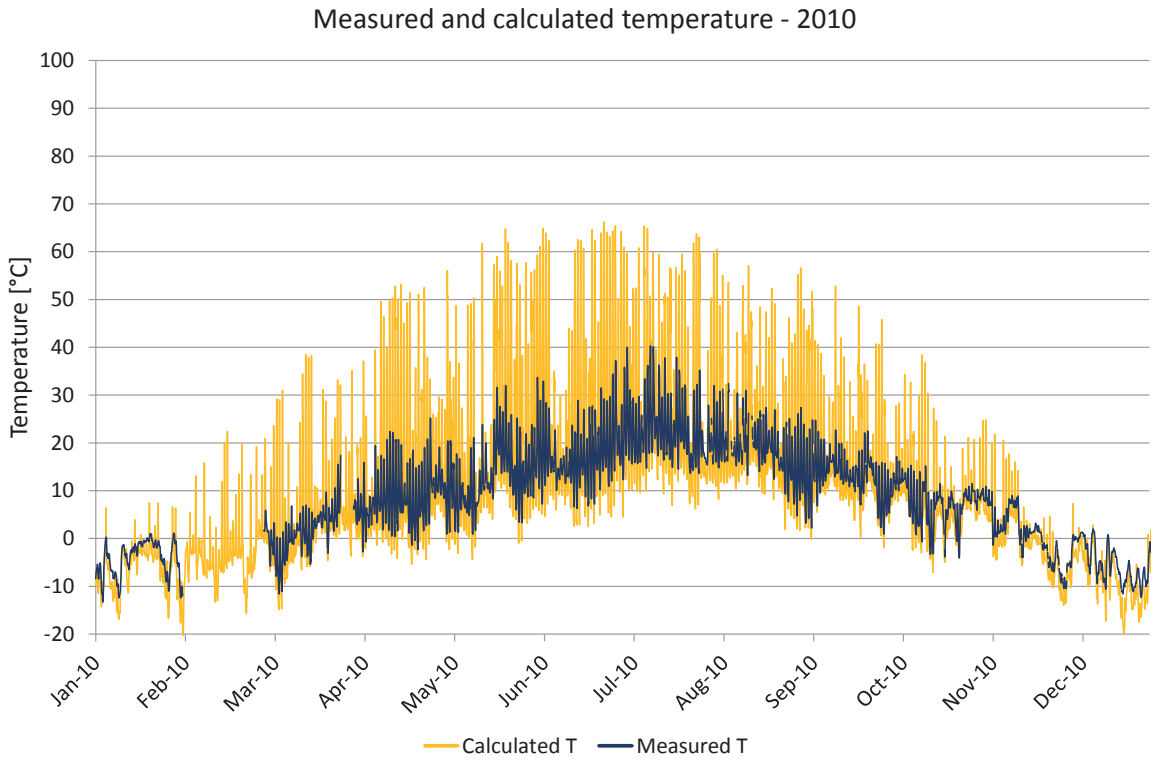


Figure 7.21.9. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

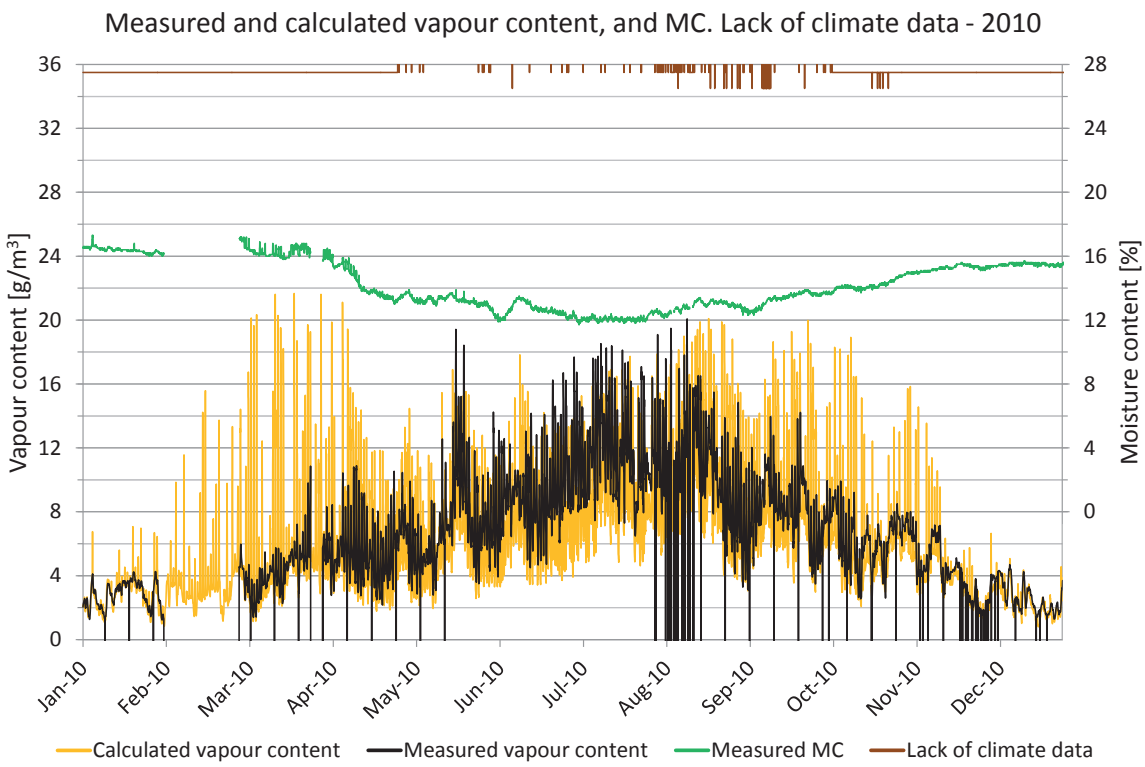


Figure 7.21.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

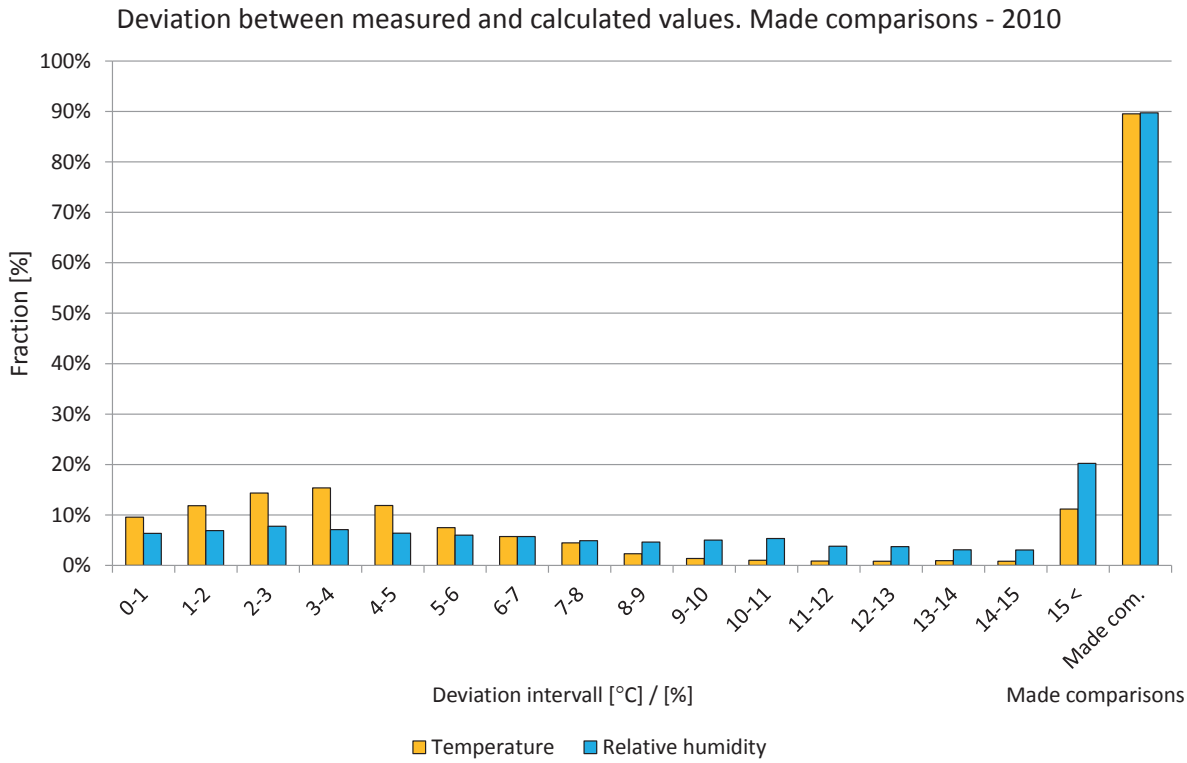


Figure 7.21.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

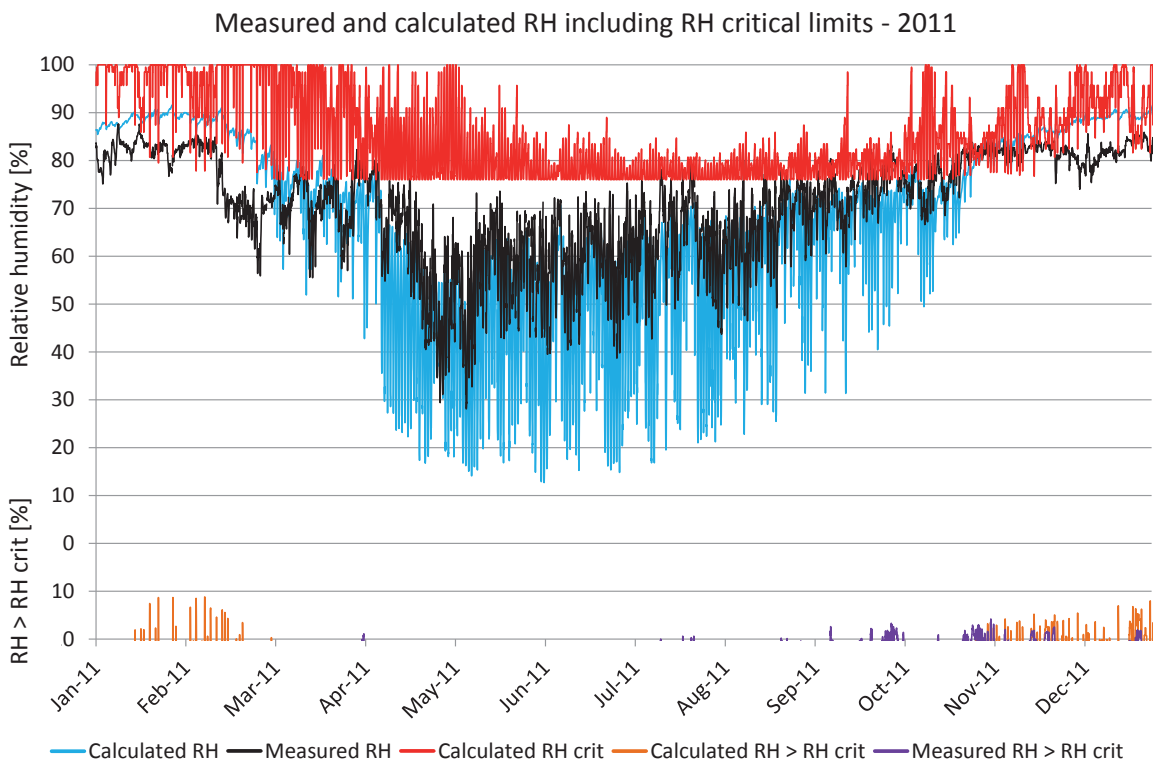


Figure 7.21.12. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

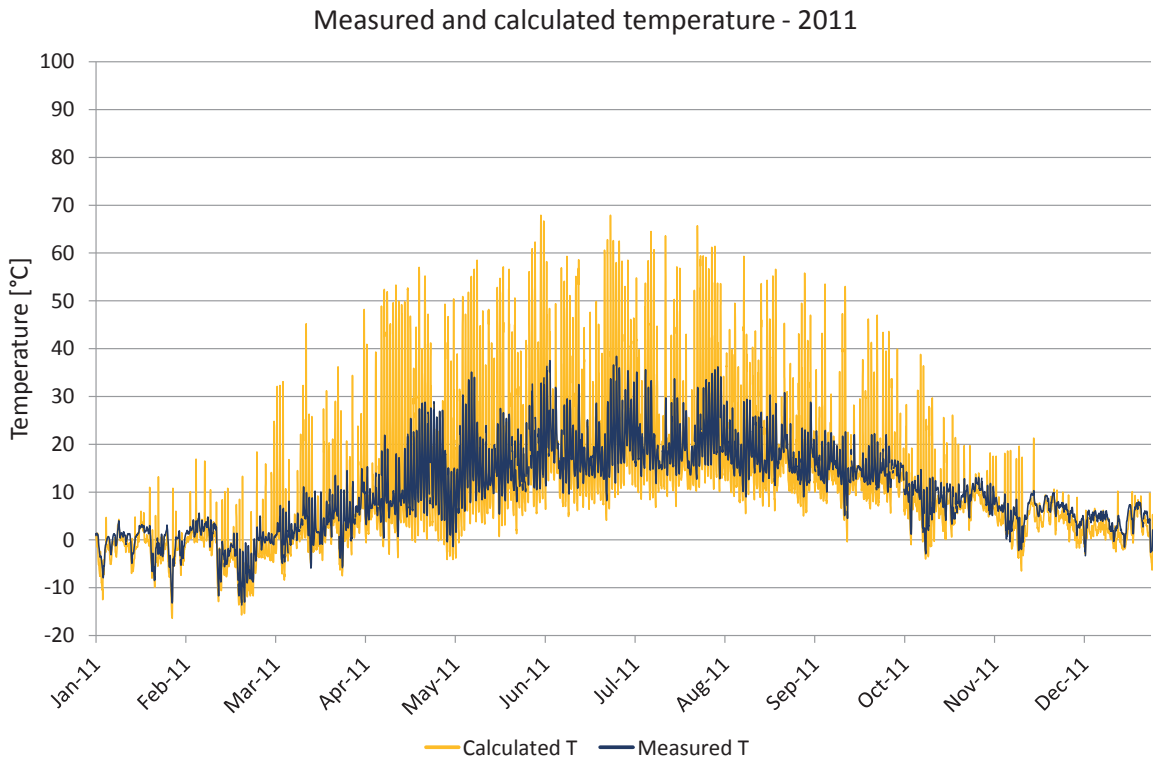


Figure 7.22.13. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

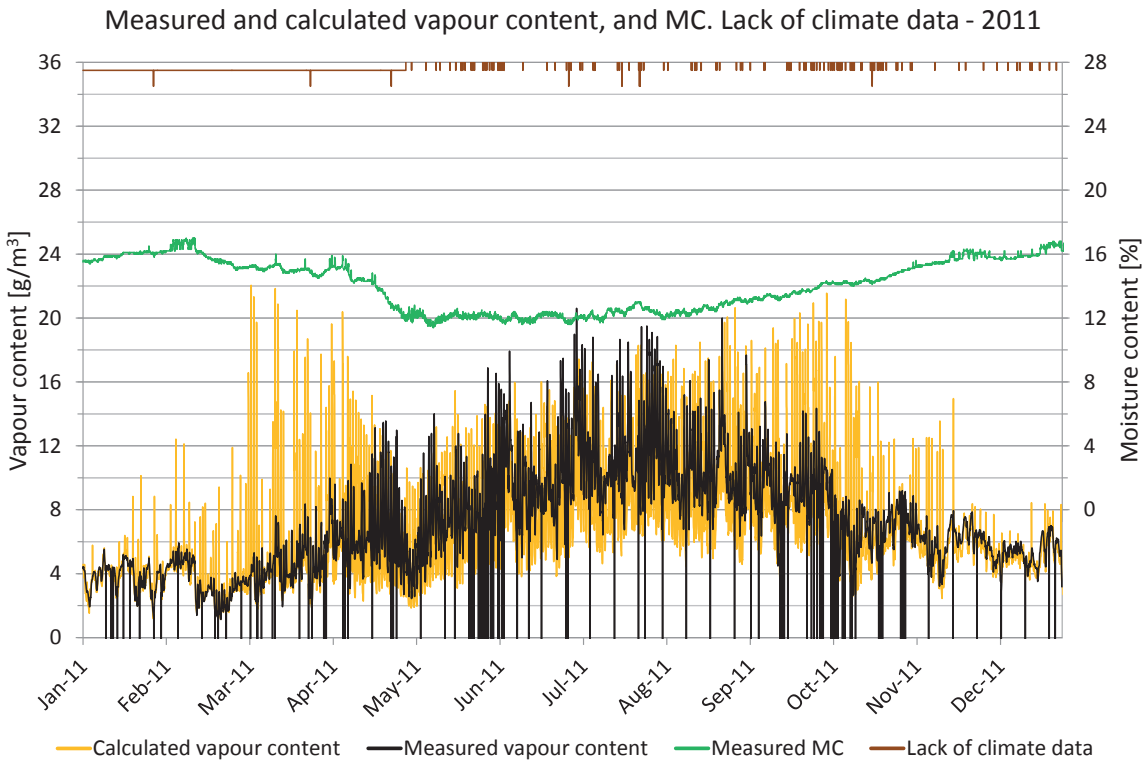


Figure 7.21.14. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

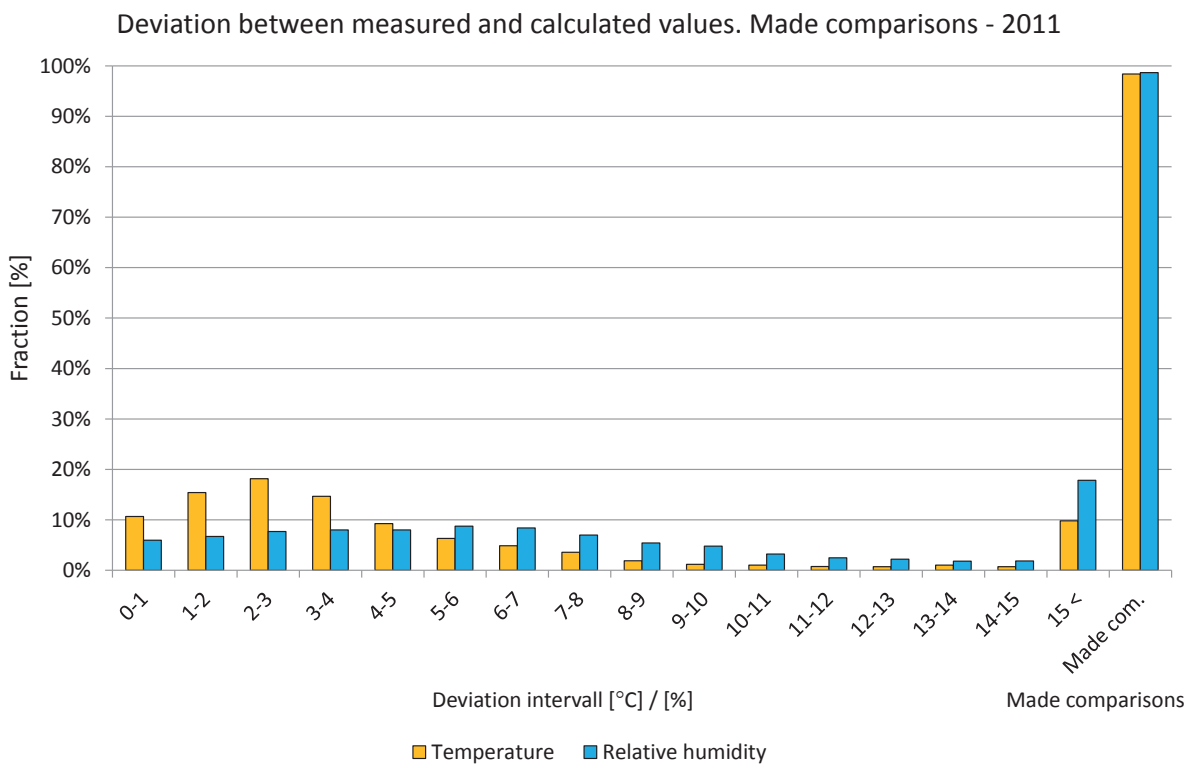
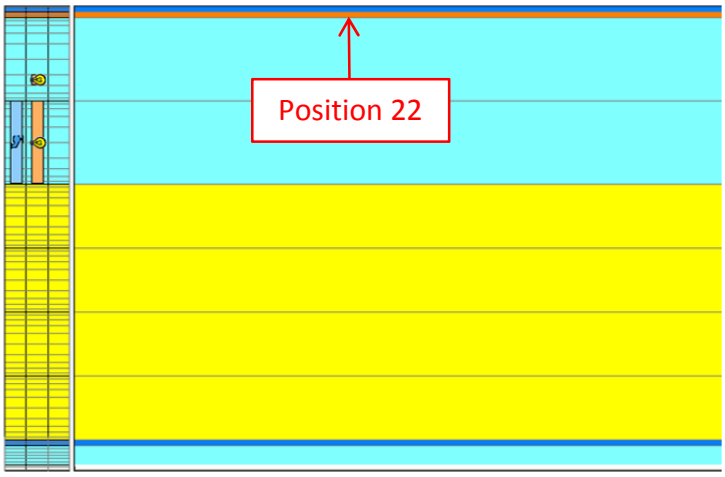


Figure 7.21.15. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.22 Position 22

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing northeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.17.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

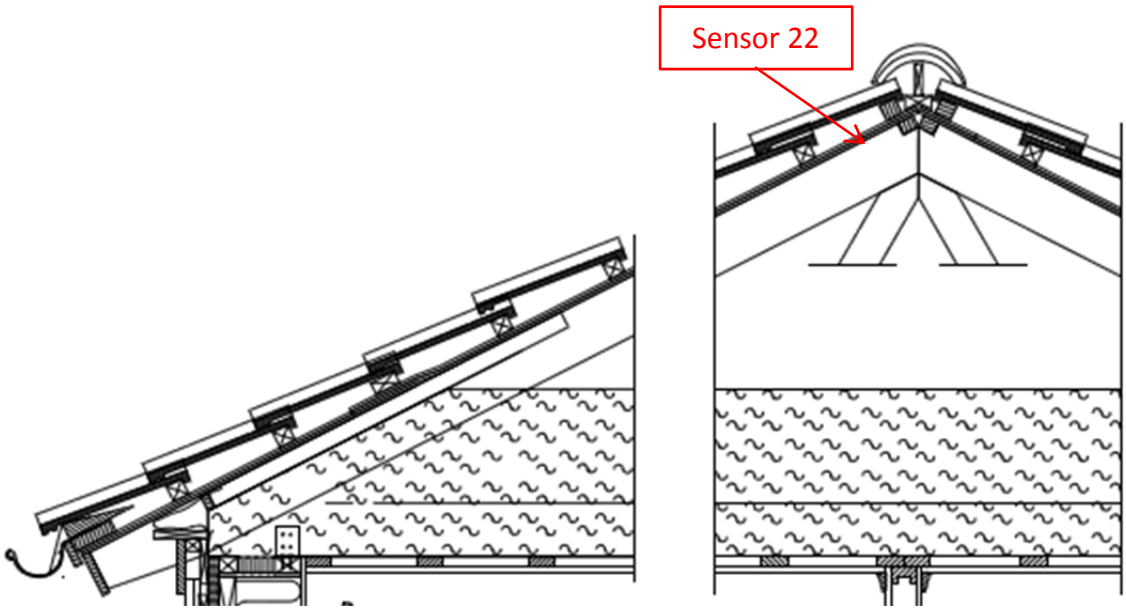


Figure 7.22.2. Location of the studied position.

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 plywood roofing boards which do not have the same properties as tongued and grooved wood.

Year 2009

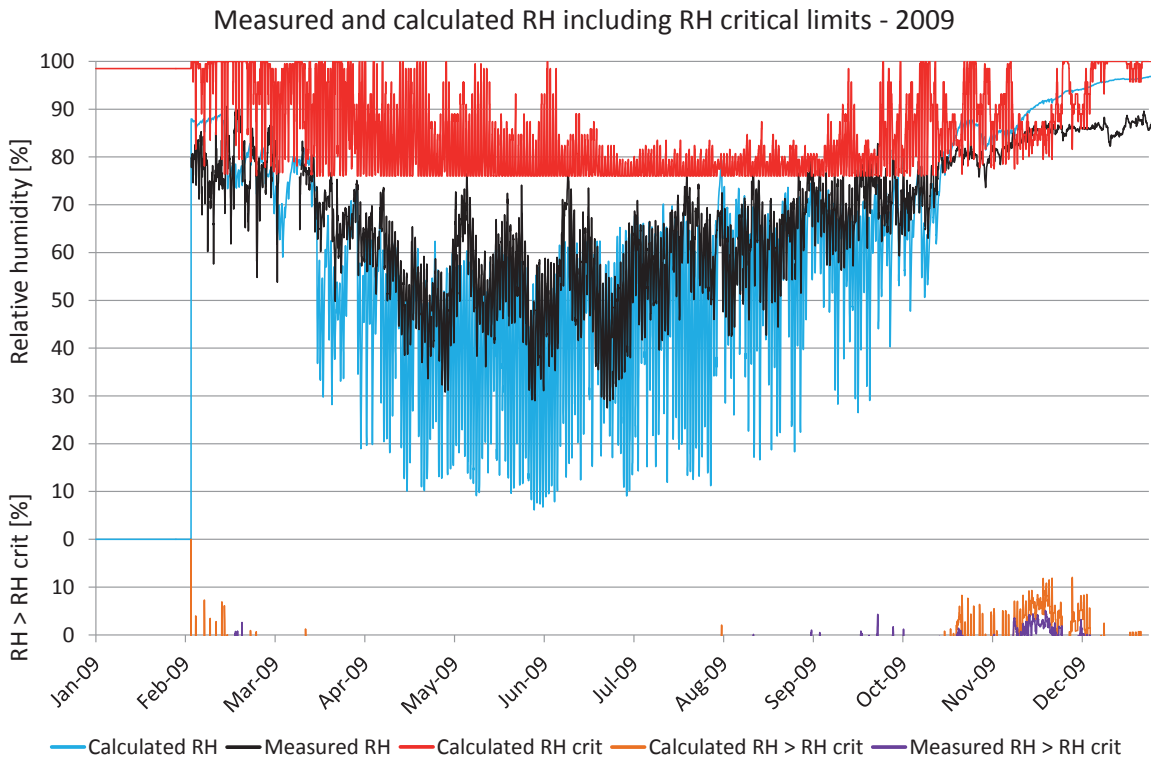


Figure 7.22.3. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

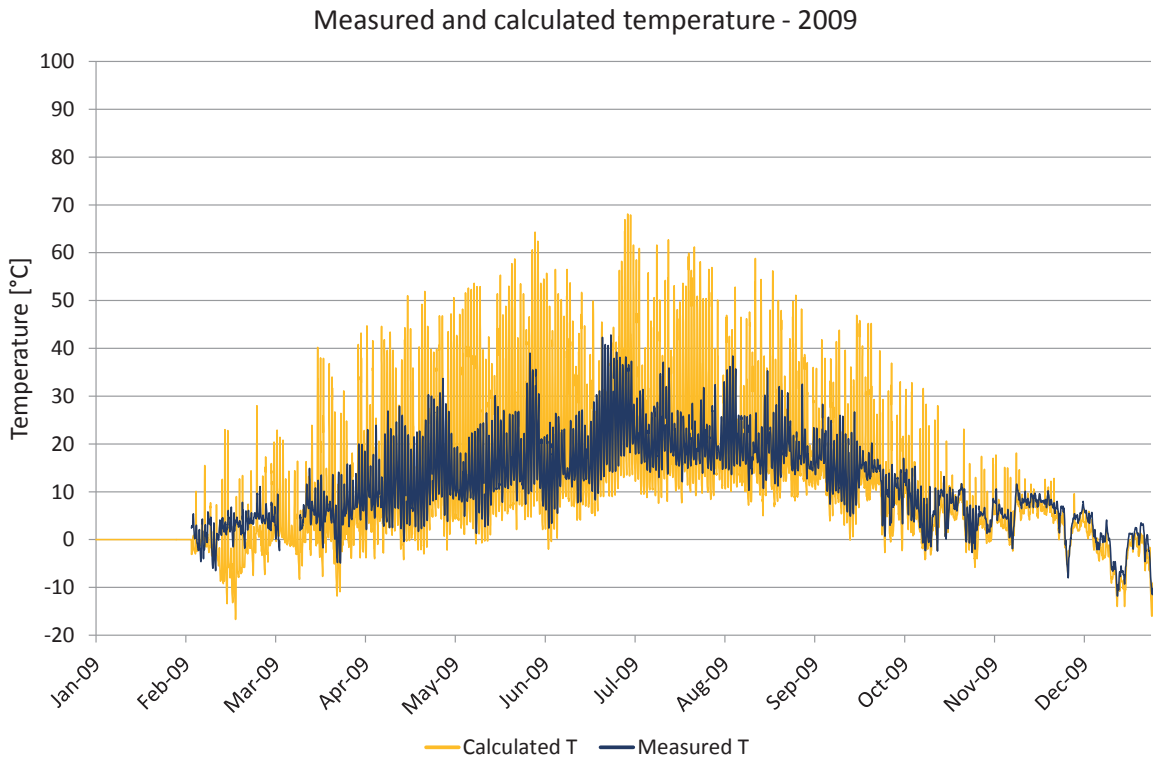


Figure 7.22.4. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

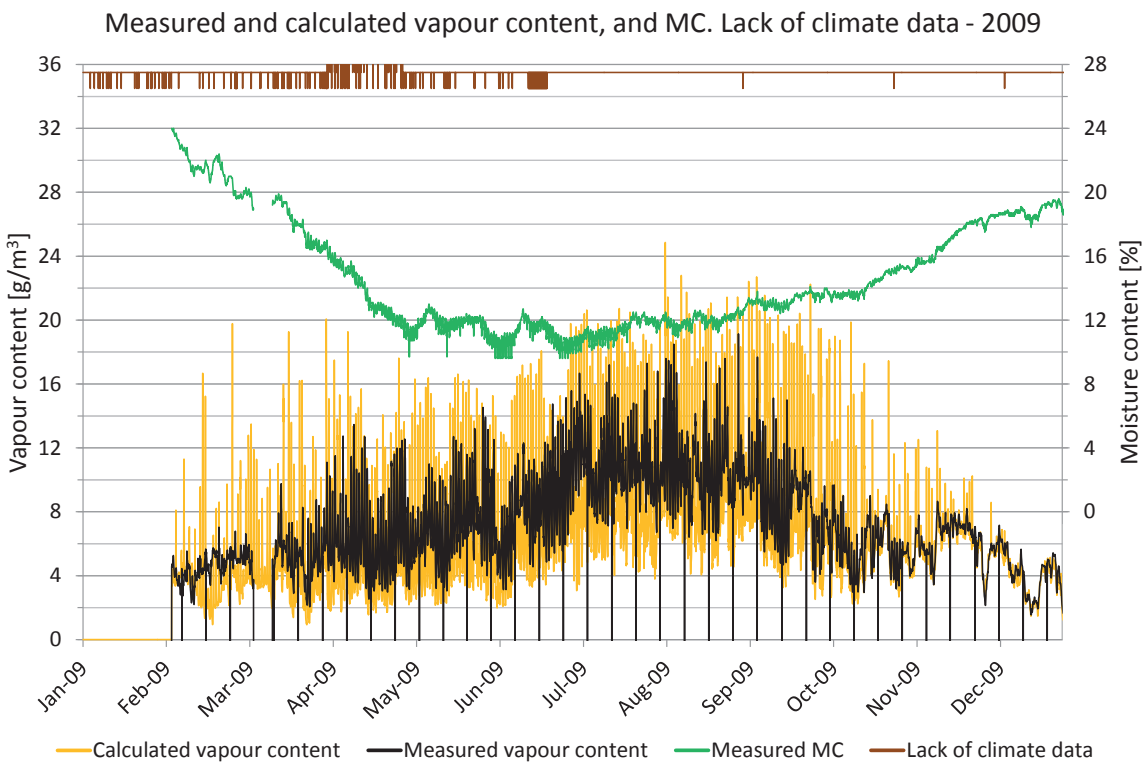


Figure 7.22.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

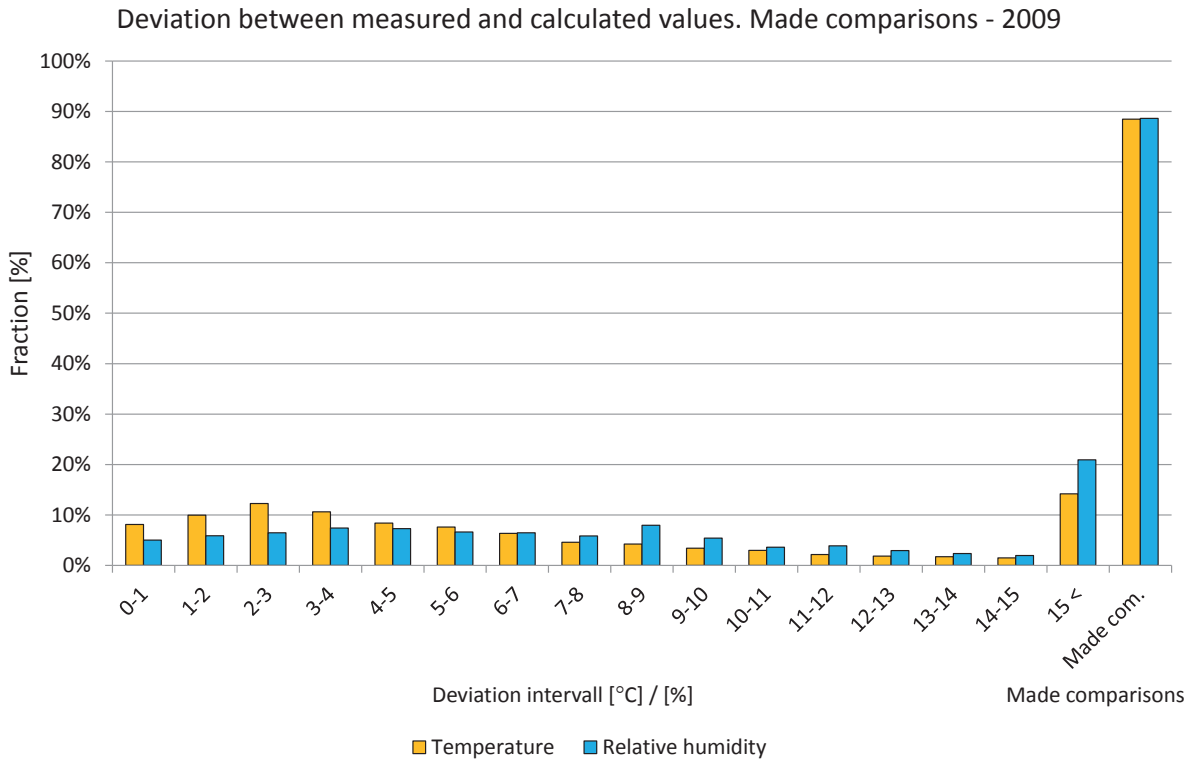


Figure 7.22.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

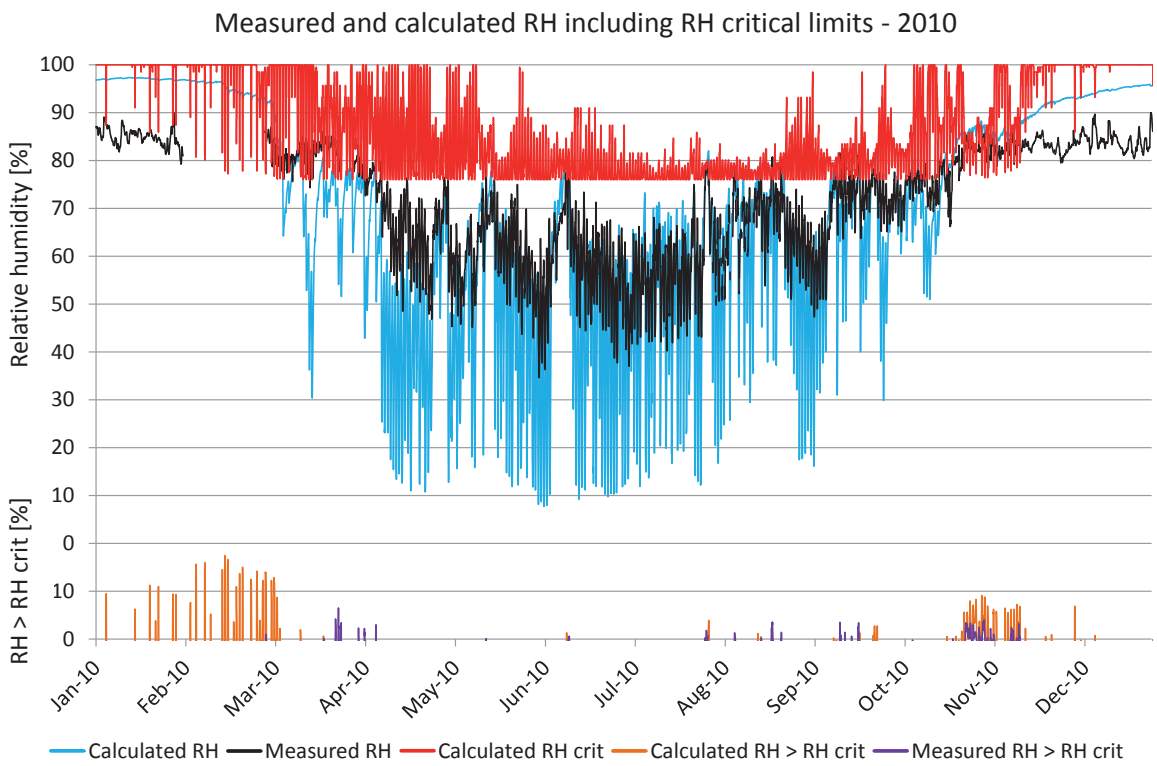


Figure 7.22.7. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

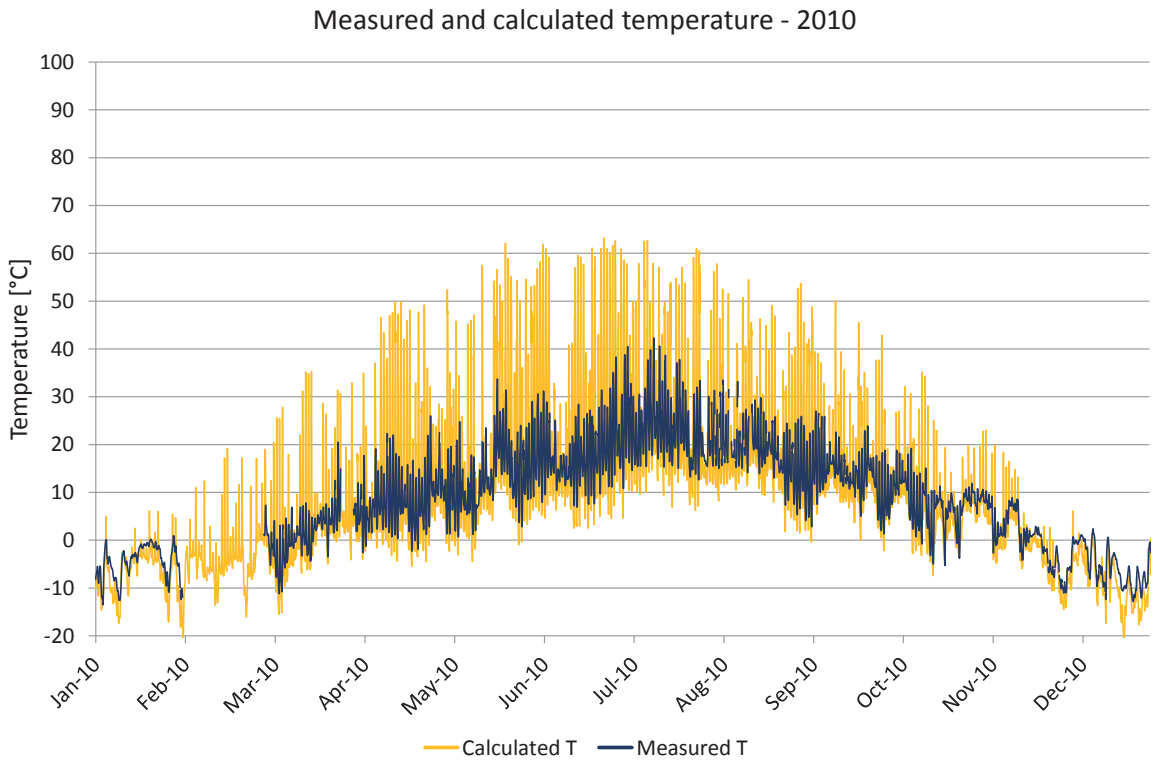


Figure 7.22.8. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

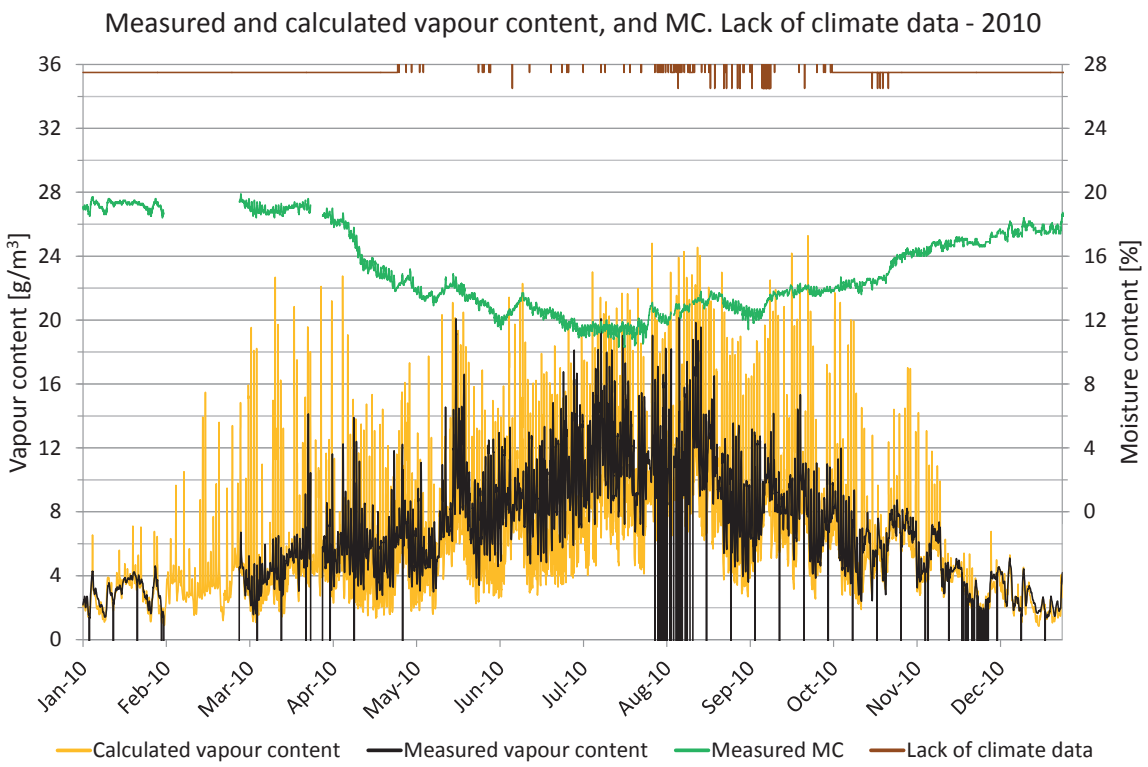


Figure 7.22.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

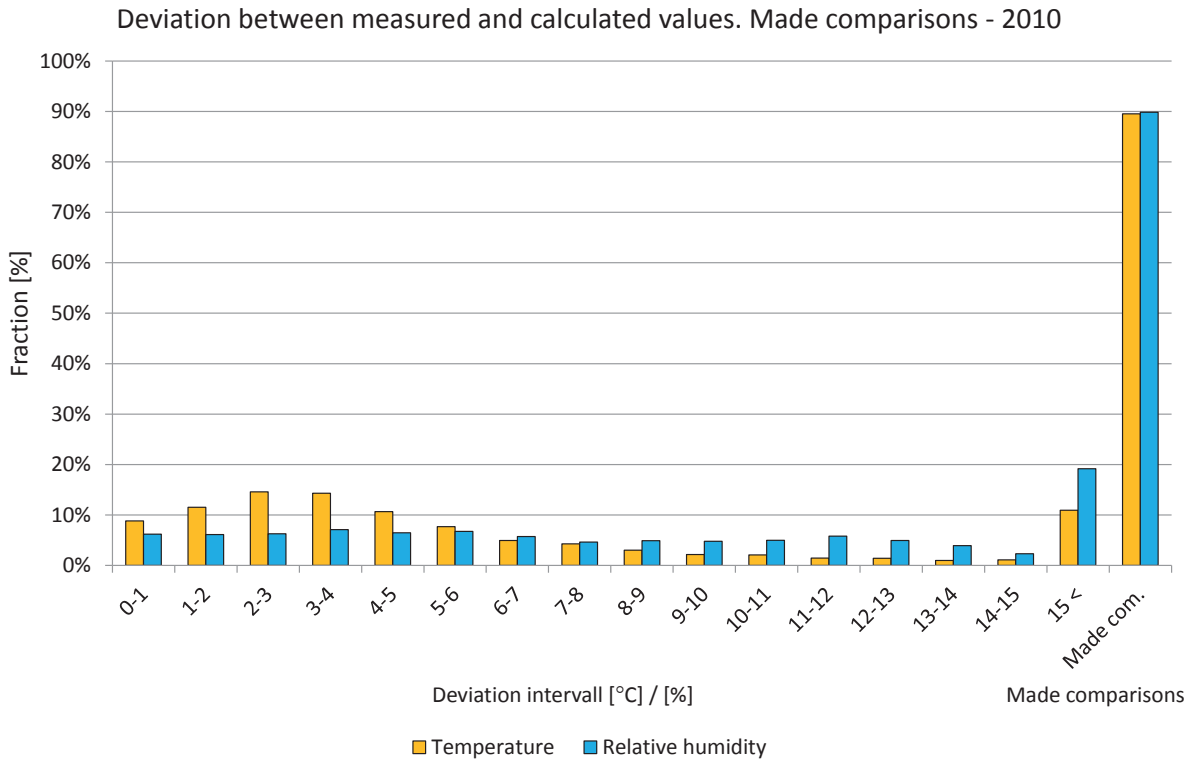


Figure 7.22.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

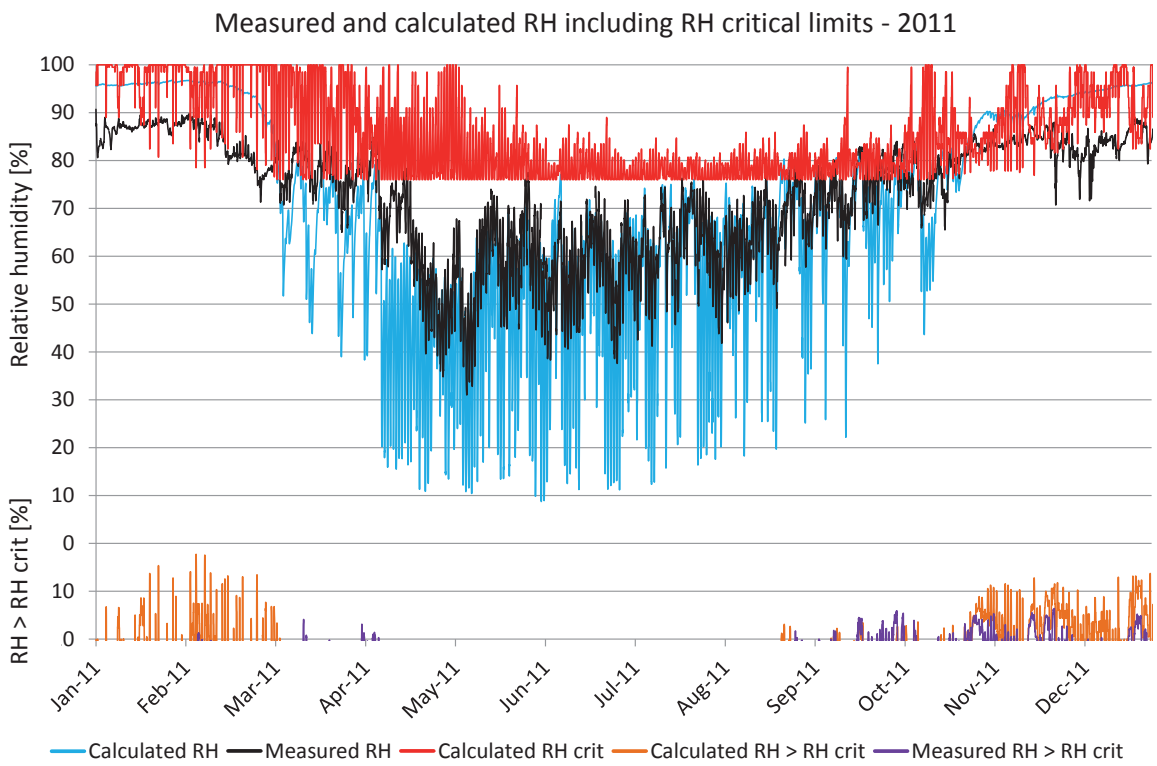


Figure 7.22.11. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

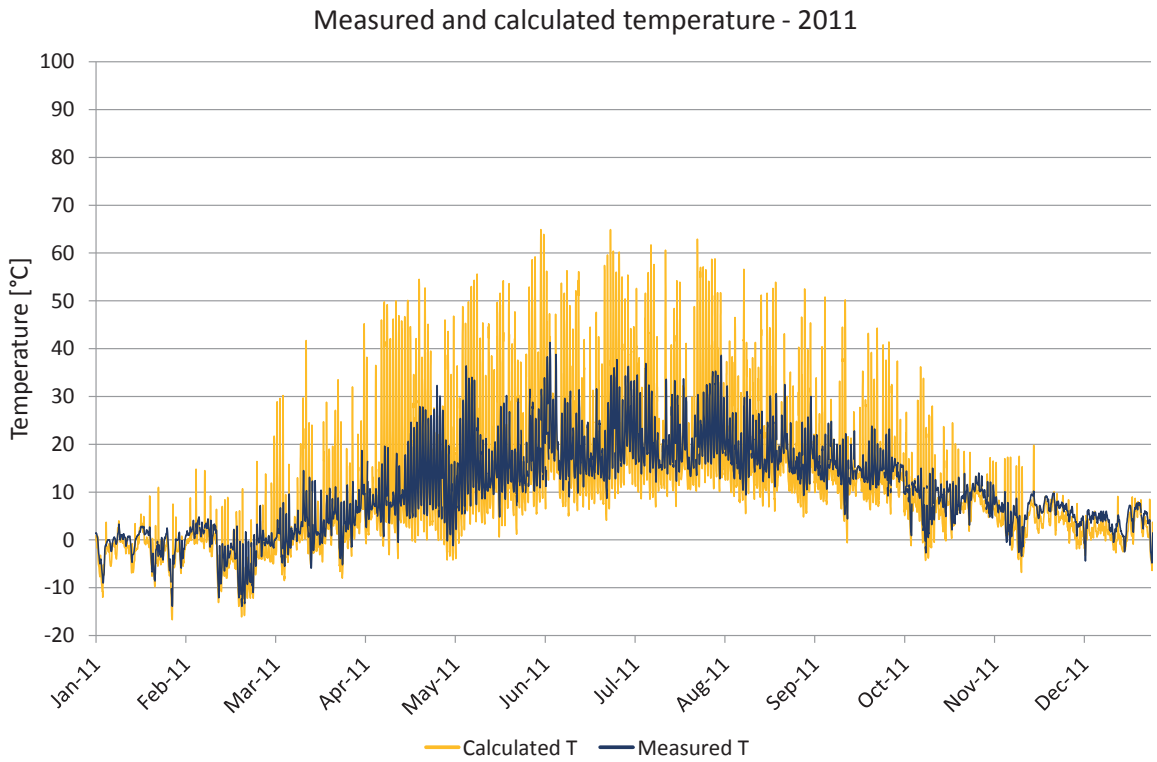


Figure 7.22.12. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

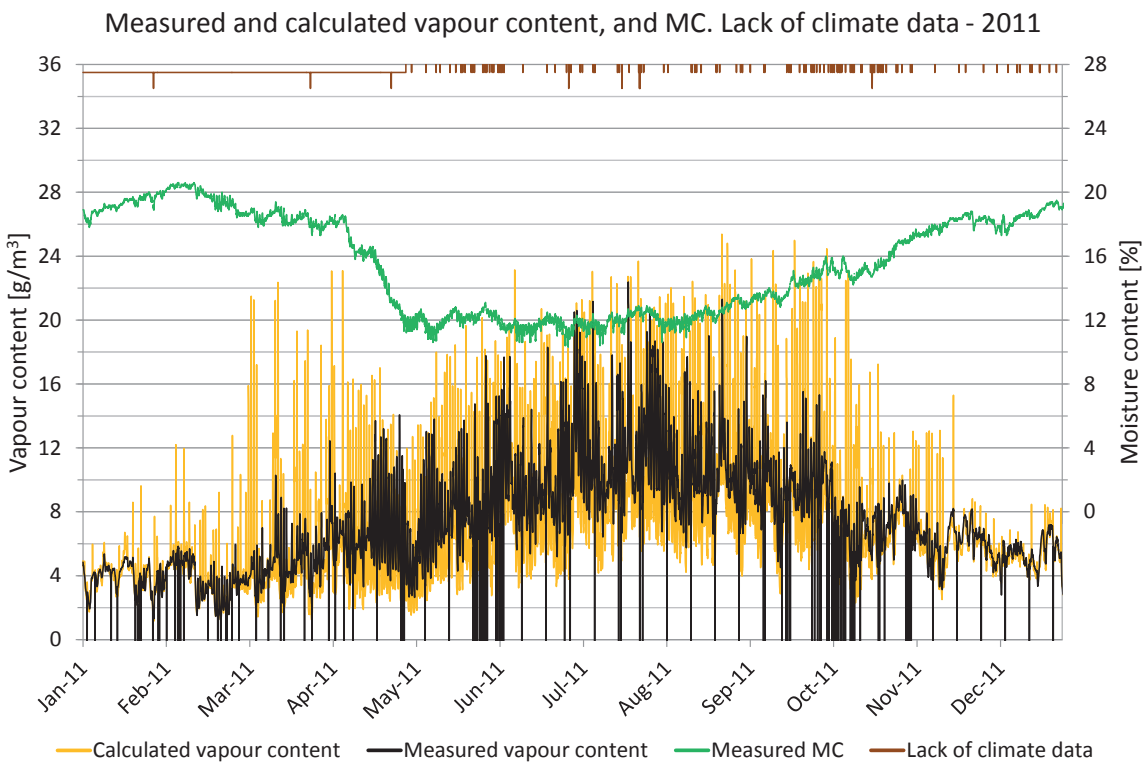


Figure 7.22.13. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

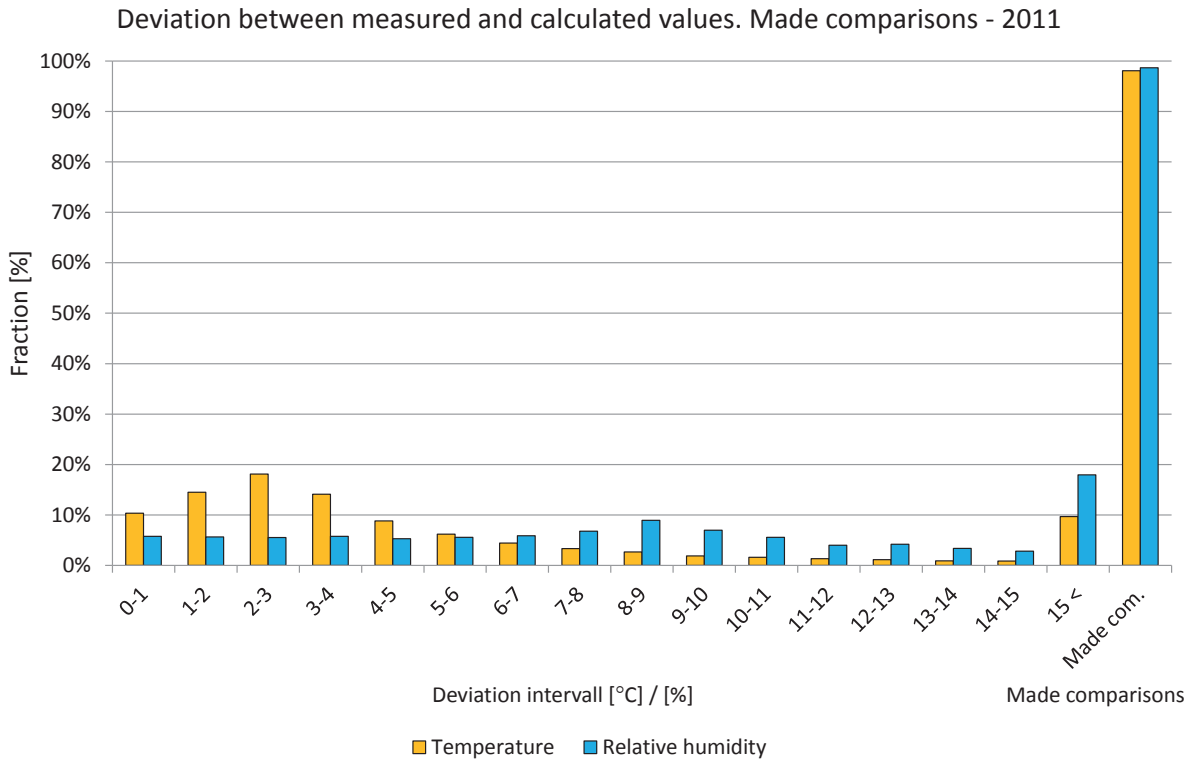
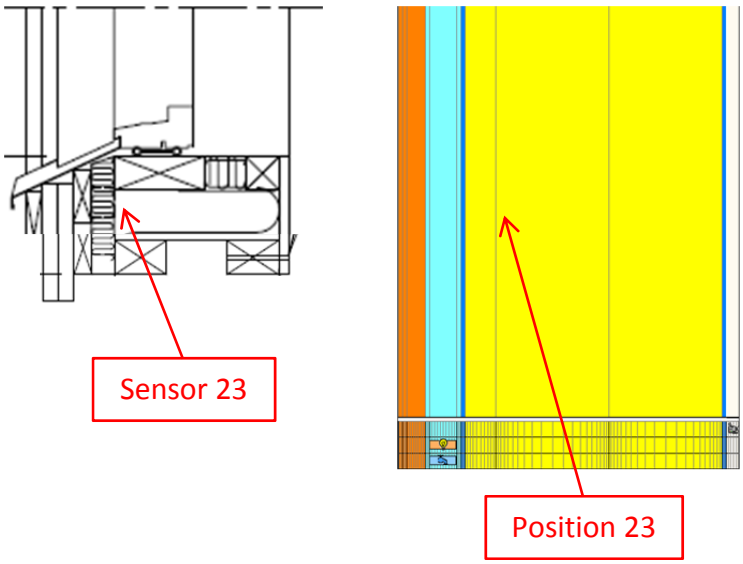


Figure 7.22.14. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.23 Position 23

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a wall facing southwest.



Wall, from the outside:
15/21 mm Facade panel - Spruce radial[1] including paint Sd = 1 m[2]
24 mm Air gap[1] with 30 ACH
1 mm Weather resistive barrier[1], Sd = 0,2 m
30 mm Mineral insulation board, λ = 0,037 W/mK[3 4]
220 mm Light studs/ Mineral insulation, λ = 0,037 W/mK[3 4]
1 mm Vapour retarder[1], Sd = 50 m
13 mm Gypsum board[5]

Figure 7.23.1. 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.

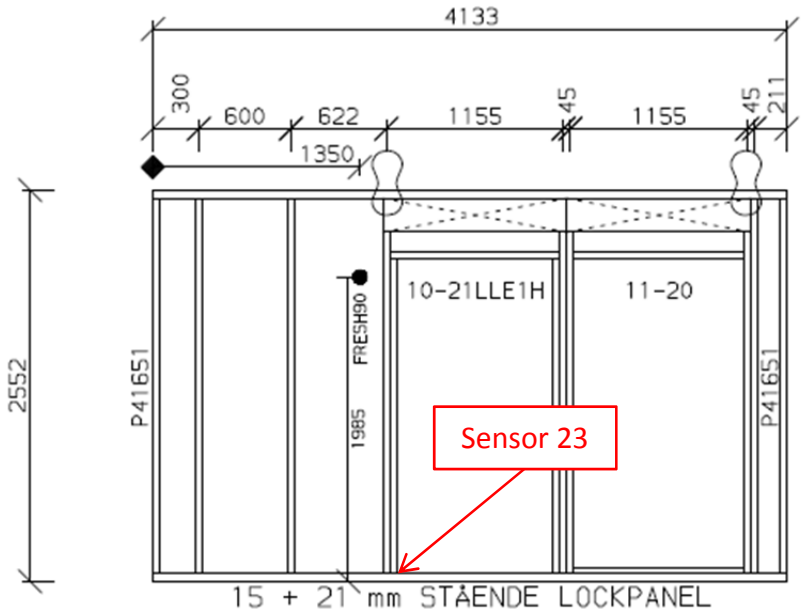


Figure 7.23.2. Location of the studied position.

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 2009

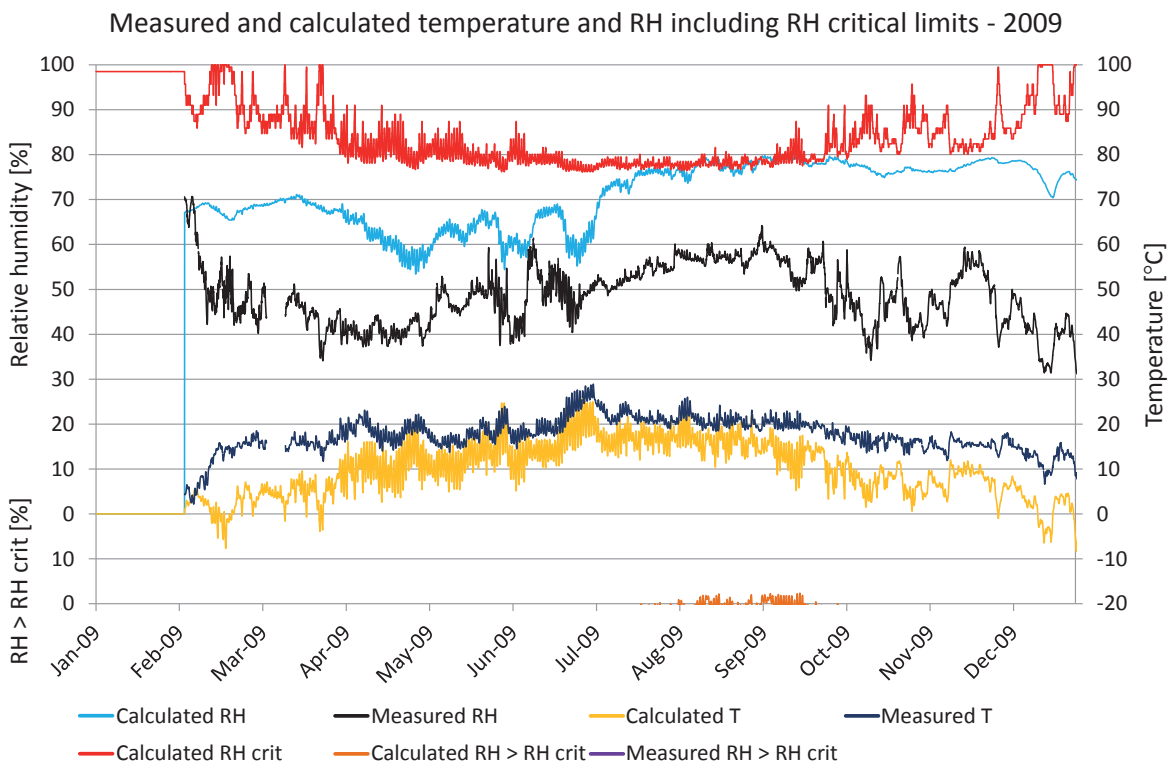


Figure 7.23.3 Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

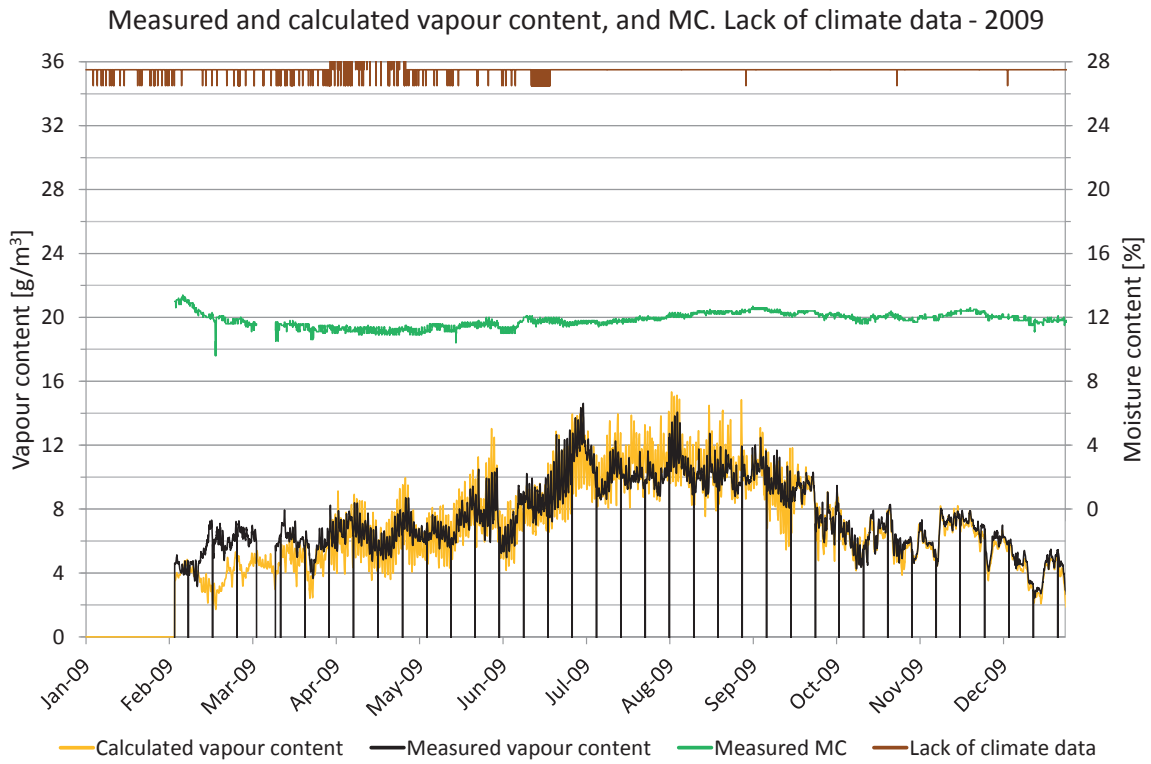


Figure 7.23.4. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

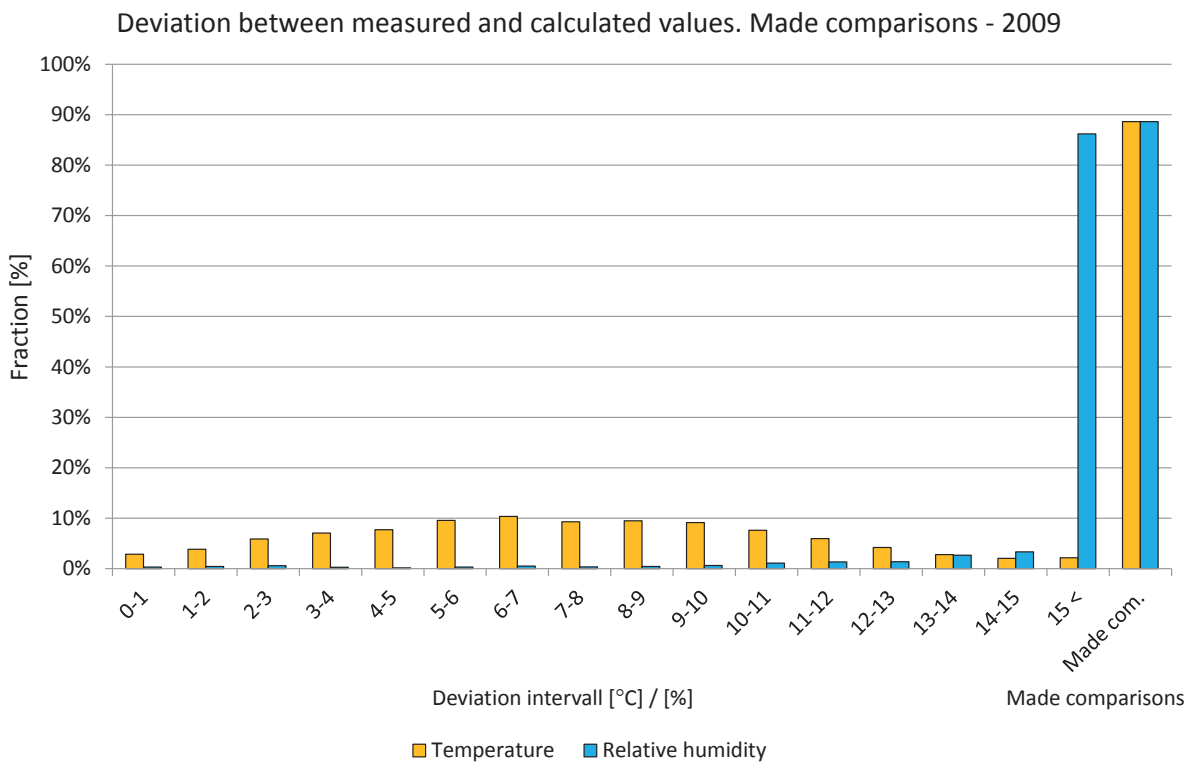


Figure 7.23.5. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

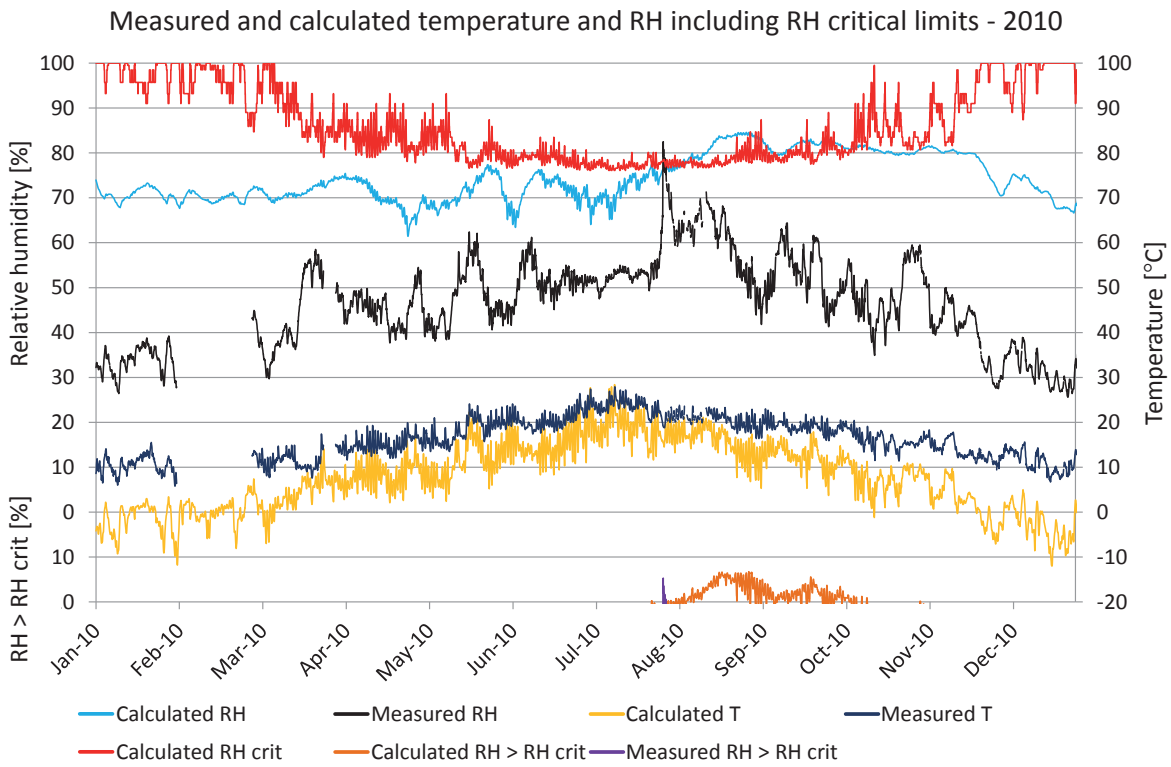


Figure 7.23.6. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

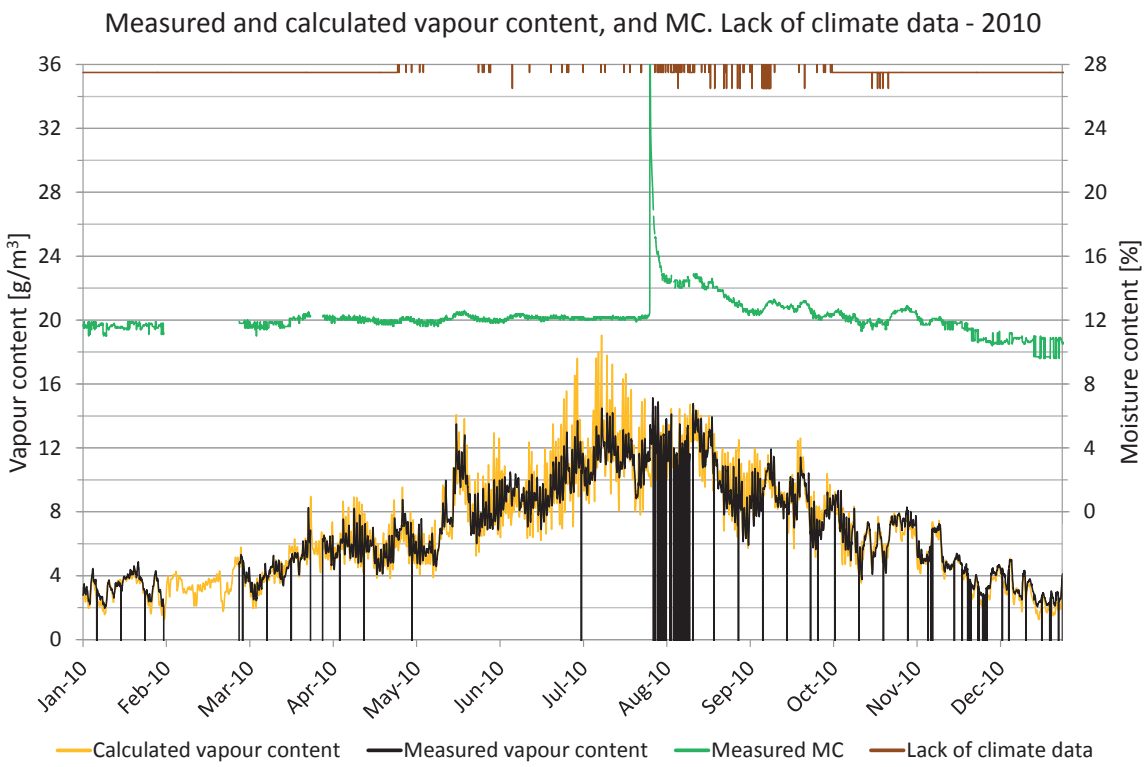


Figure 7.23.7 Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

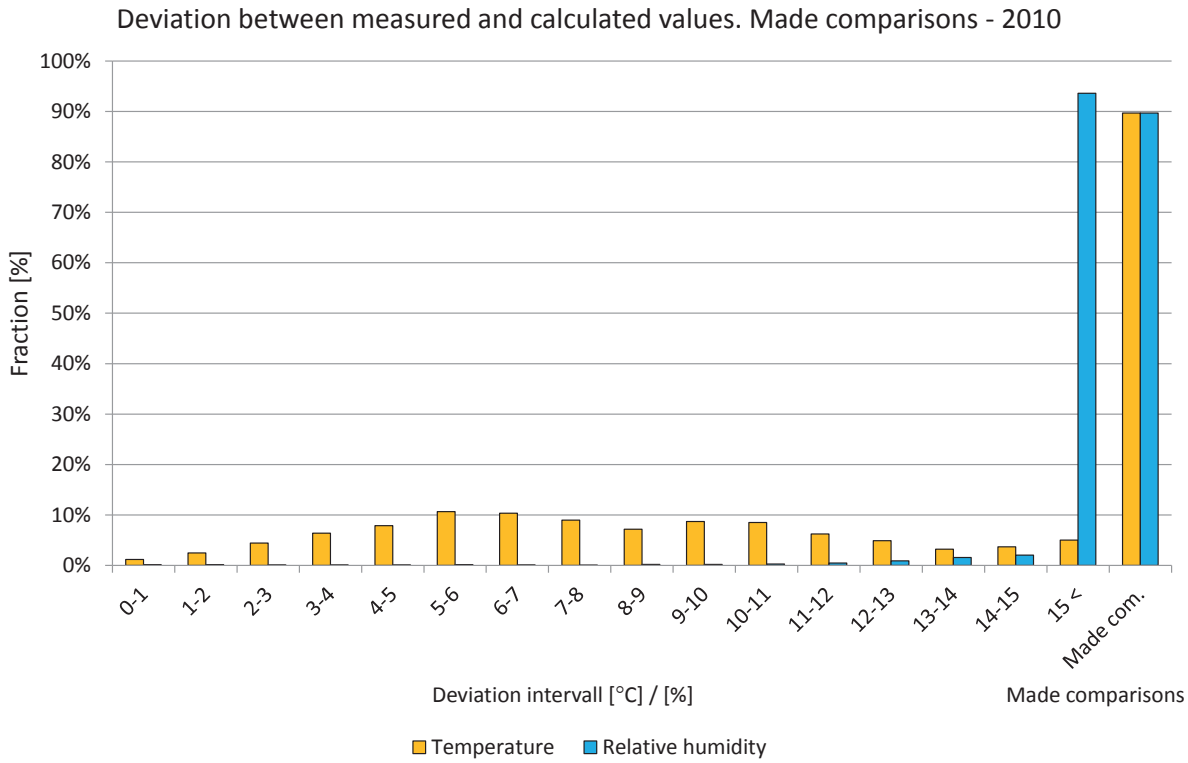


Figure 7.23.8. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

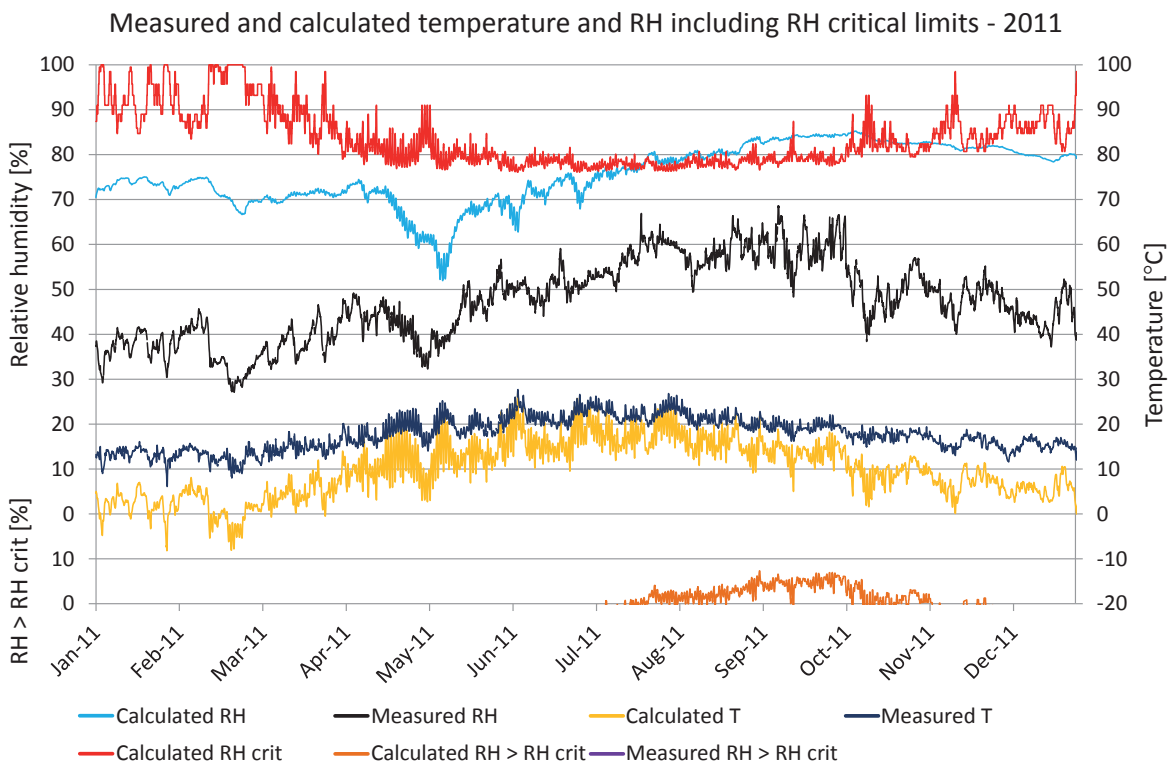


Figure 7.23.9. Comparisons between measured and calculated temperature and relative humidity. Calculated temperature (yellow), measured temperature (dark blue), calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

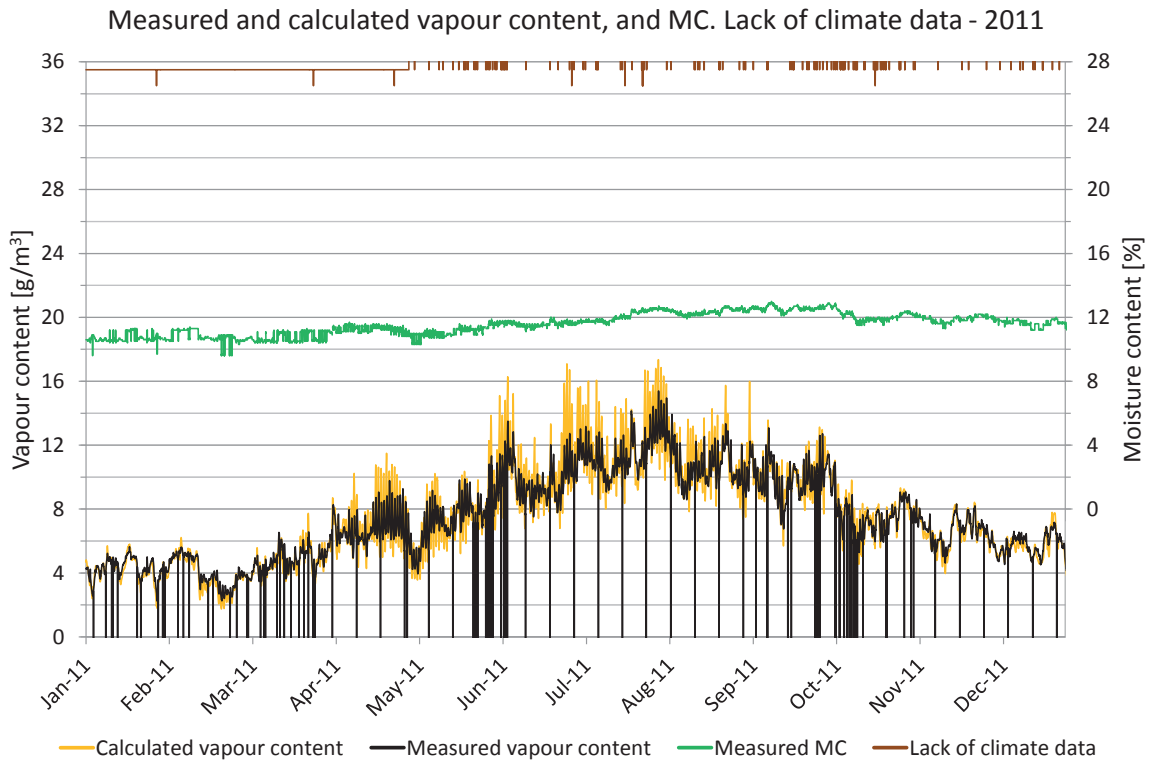


Figure 7.23.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

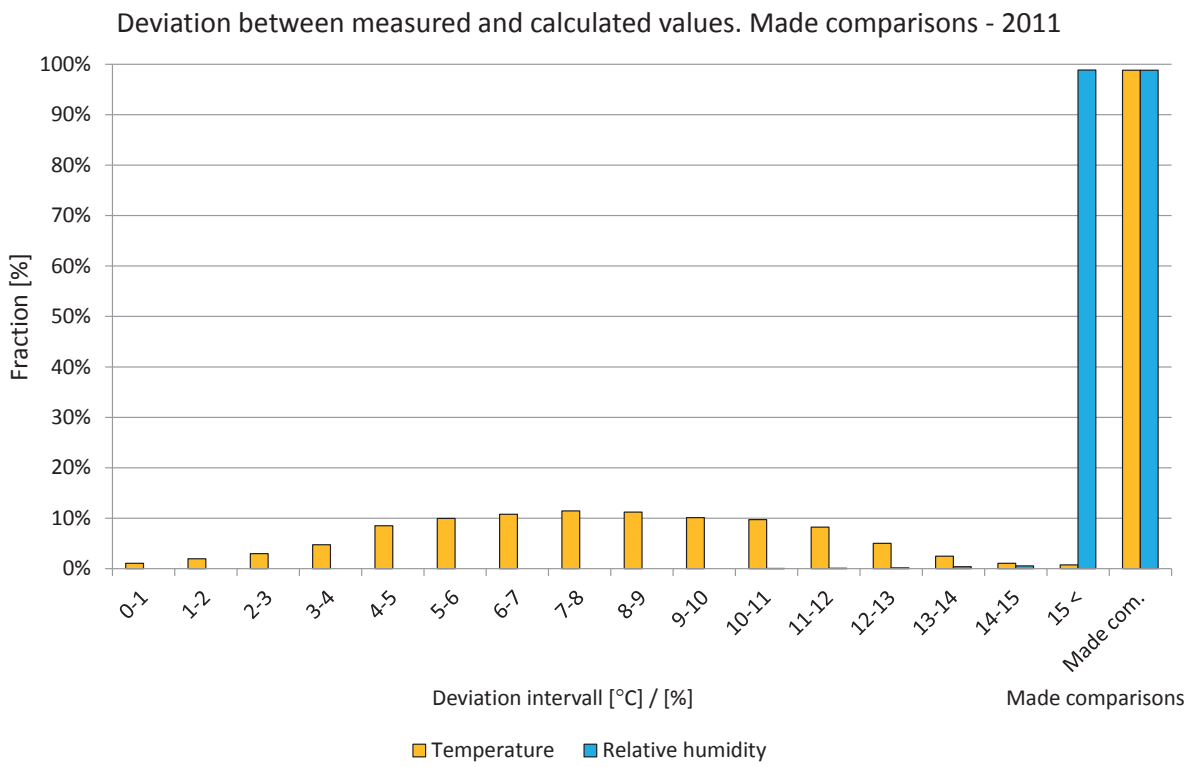
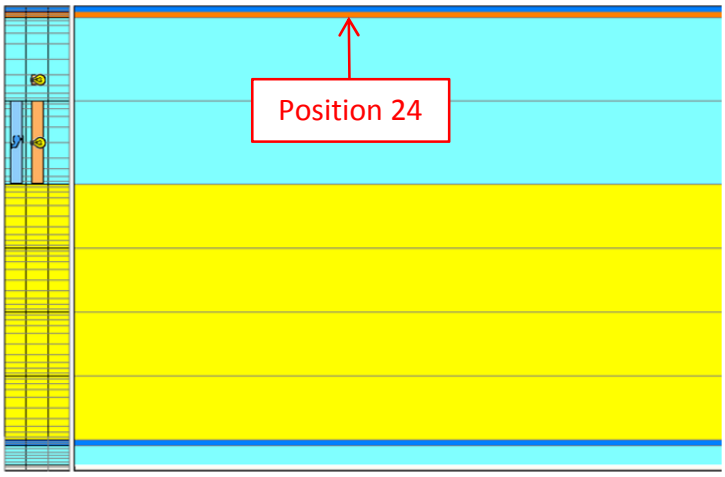


Figure 7.23.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.24 Position 24

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing northwest.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
130 mm Air gap[1], heat source[2] of 20 W/m^2 September - March
130 mm Air gap[1] with 20 ACH
400 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[5]

Figure 7.24.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Trygghetsvakten, 2012, 3. IEA Annex 24, 1996, 4. Paroc, 2002, 5. Krus, M., 1996.

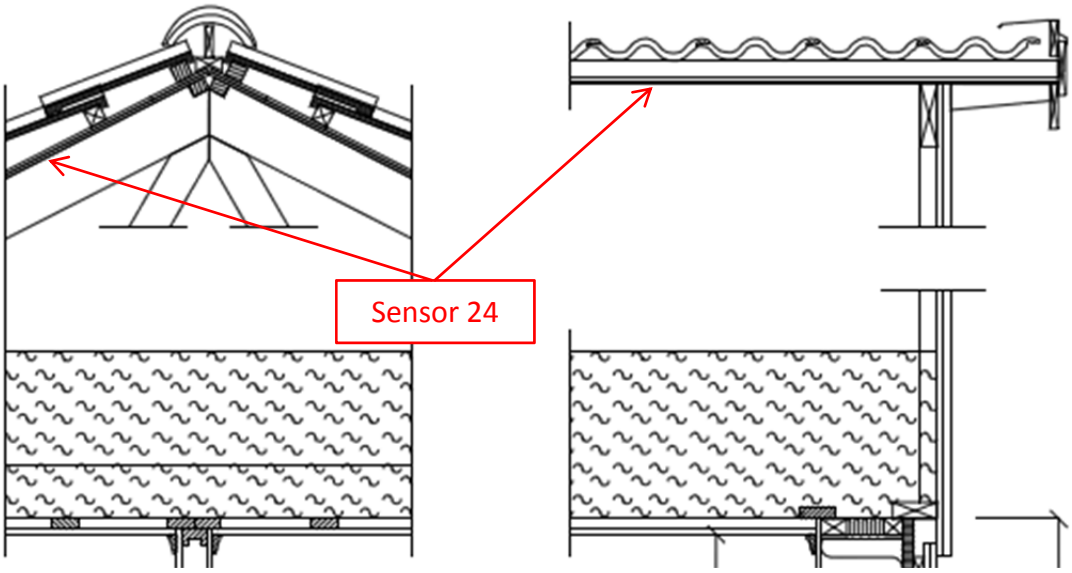


Figure 7.24.2. Location of the studied position.

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 plywood roofing boards which do not have the same properties as tongued and grooved wood.

Year 2009

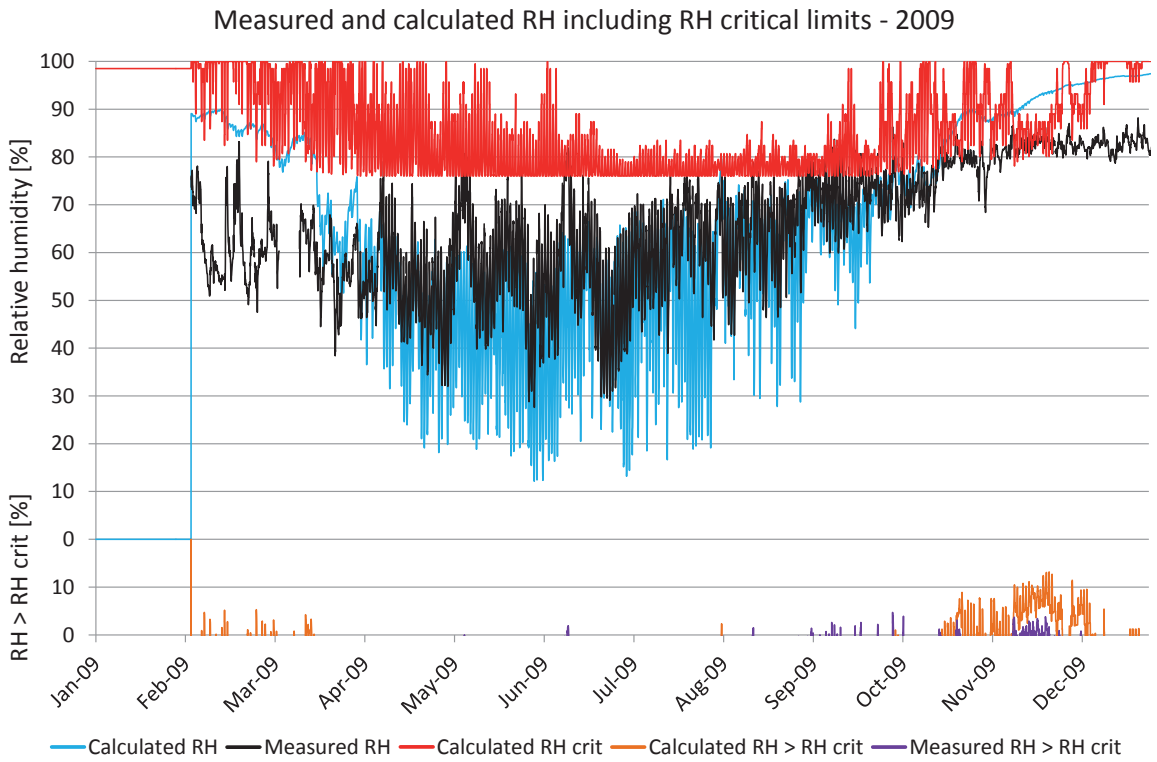


Figure 7.24.3. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

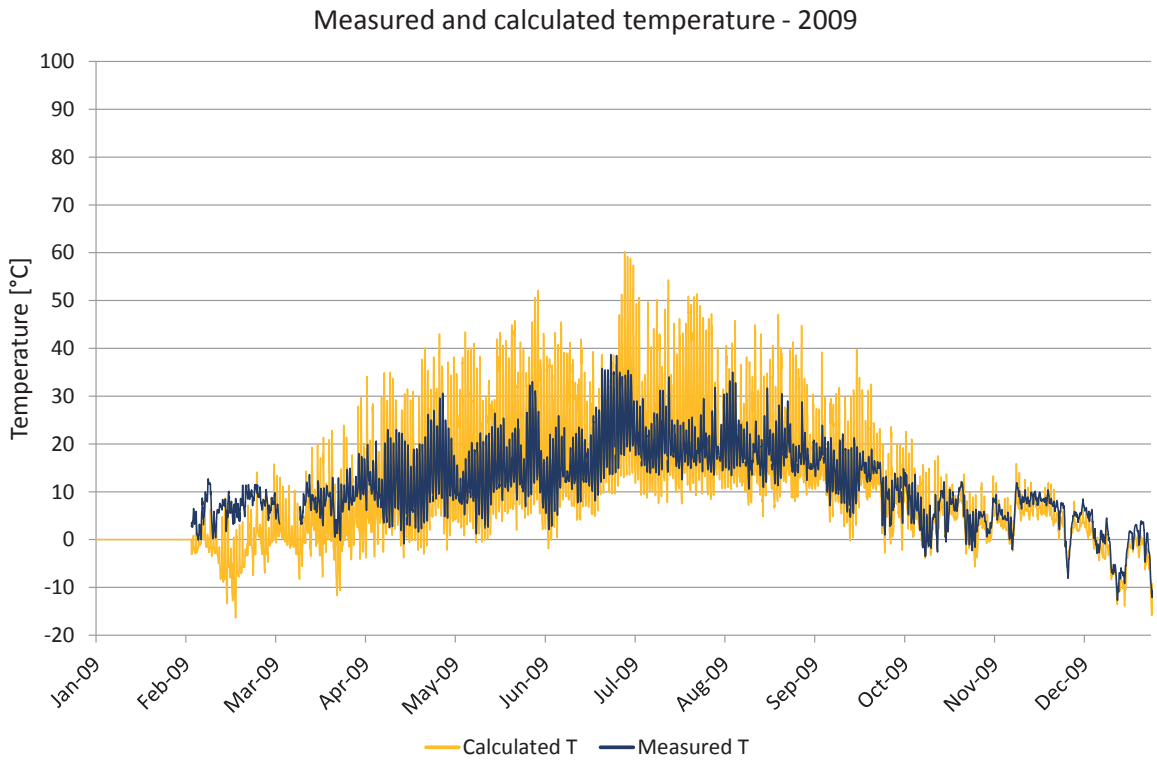


Figure 7.24.4. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

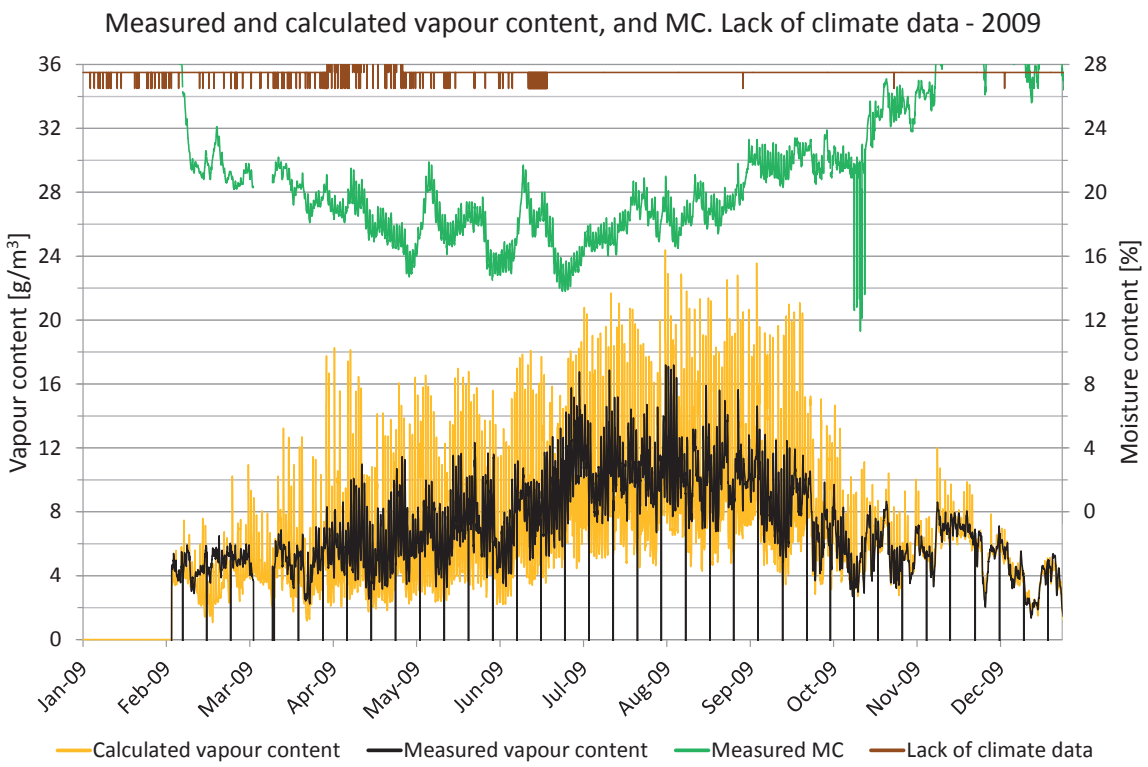


Figure 7.24.5. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

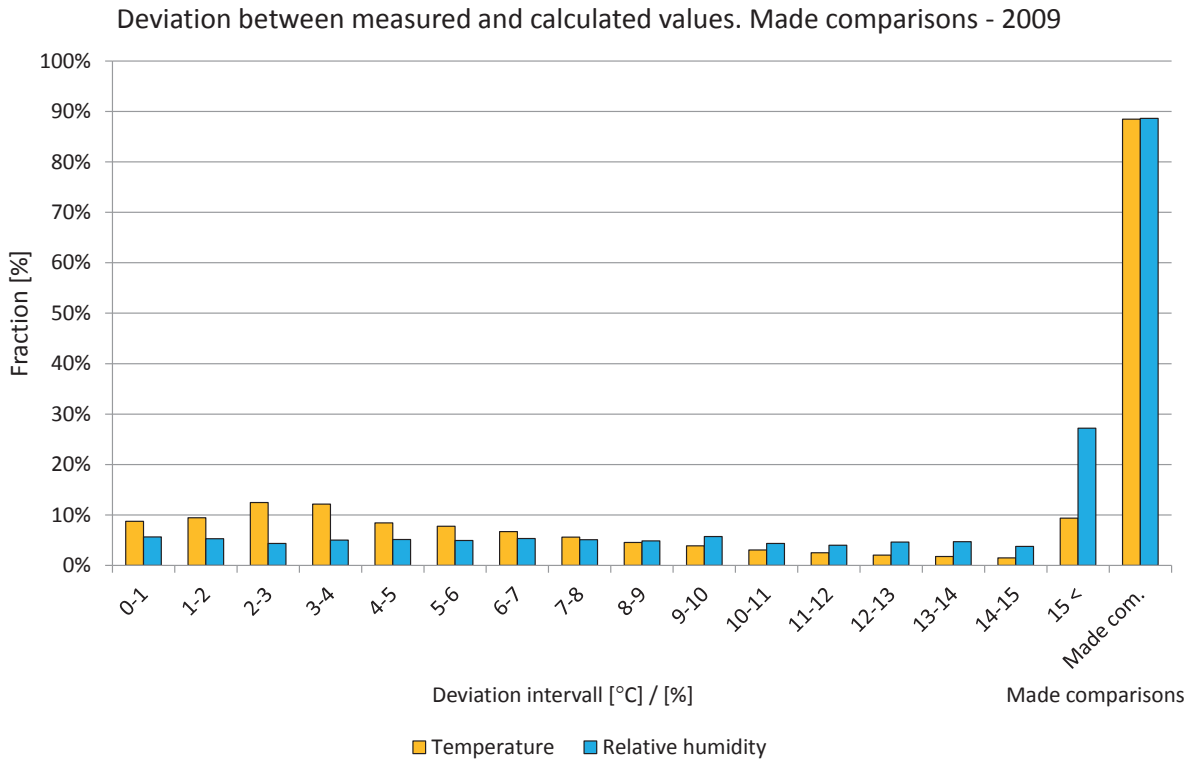


Figure 7.24.6. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

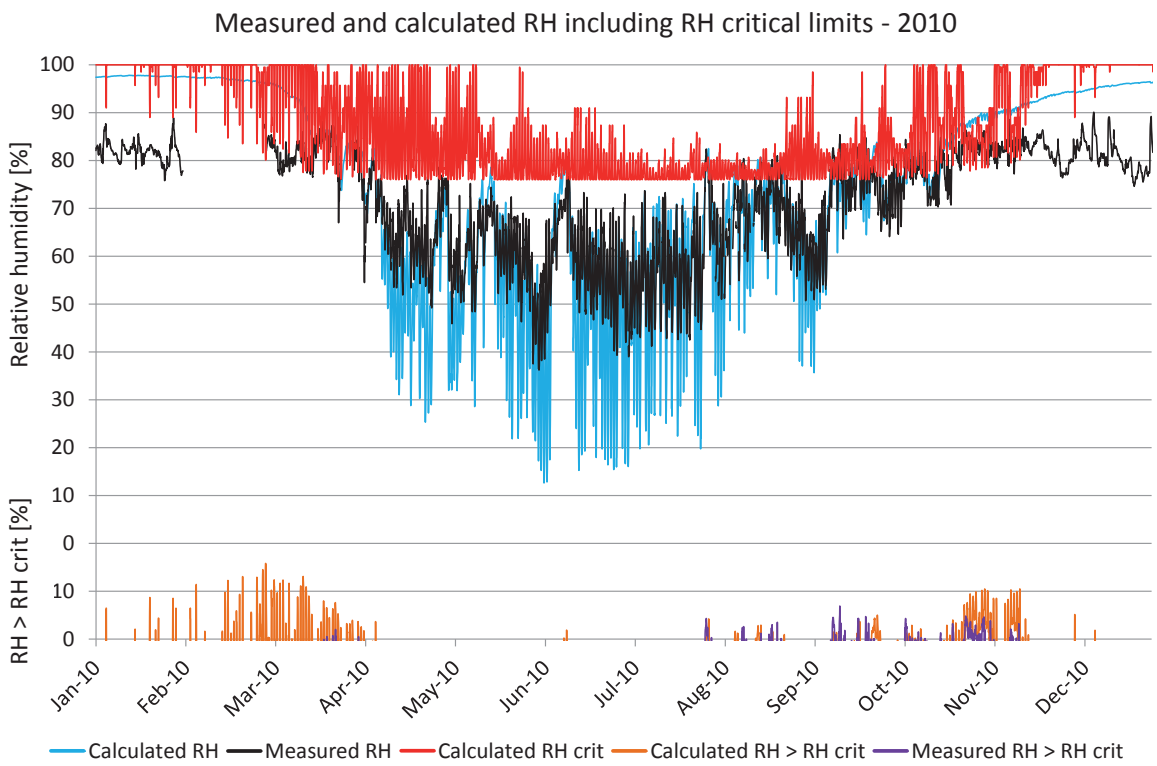


Figure 7.24.7. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

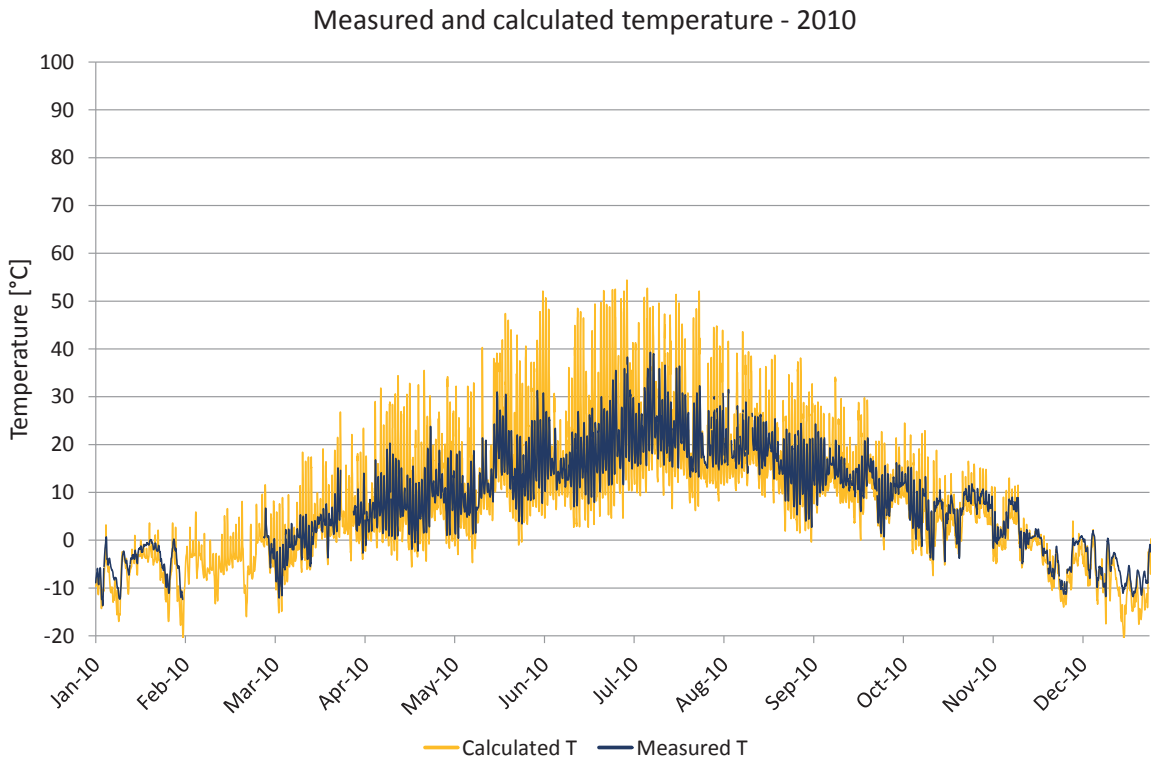


Figure 7.24.8. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

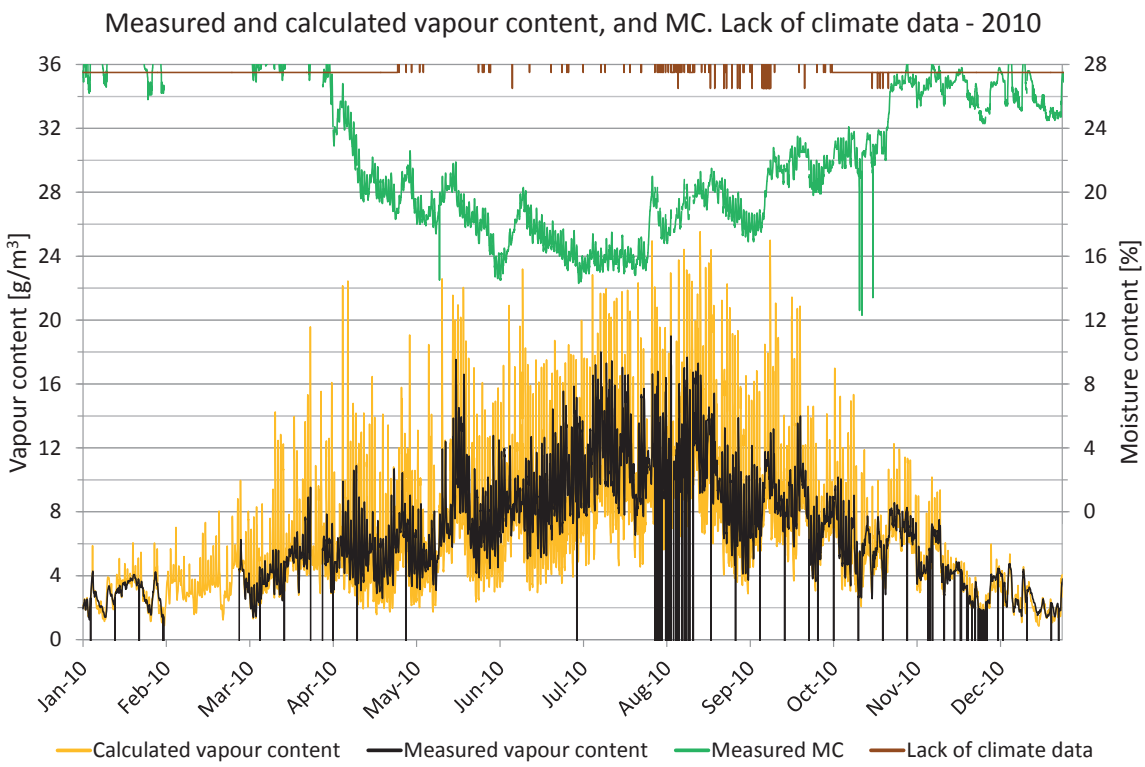


Figure 7.24.9. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

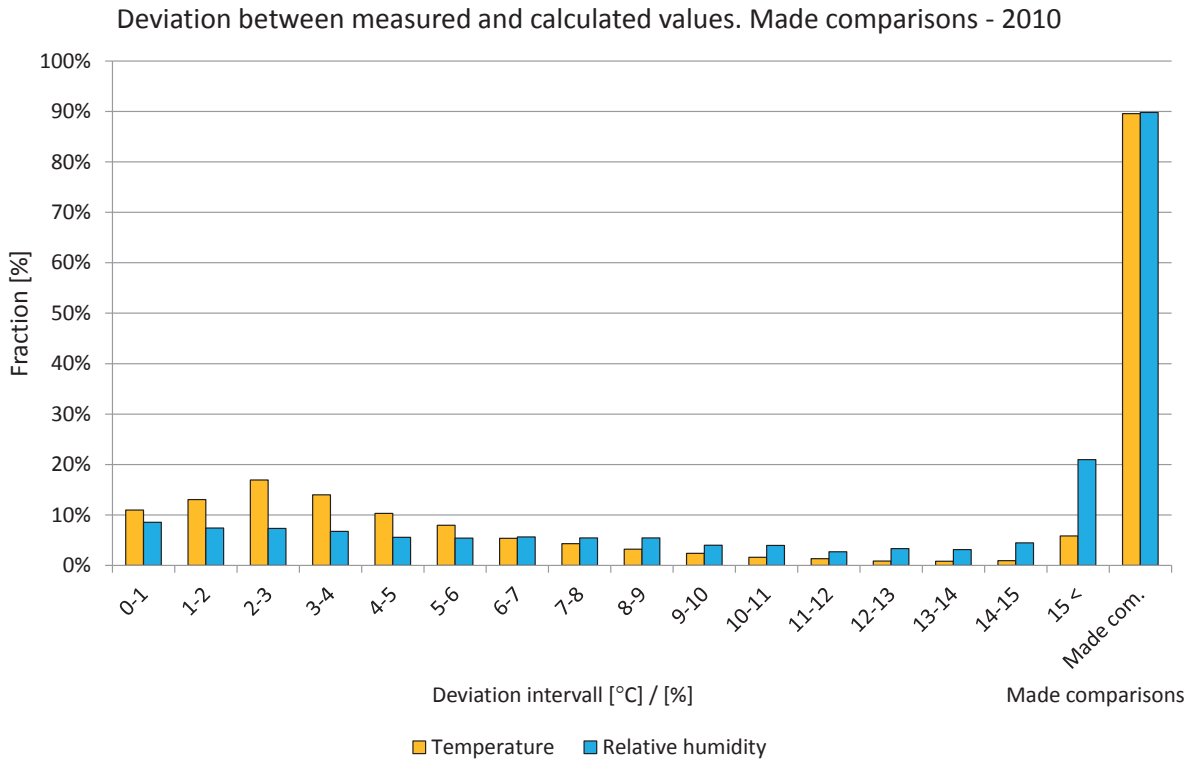


Figure 7.24.10. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

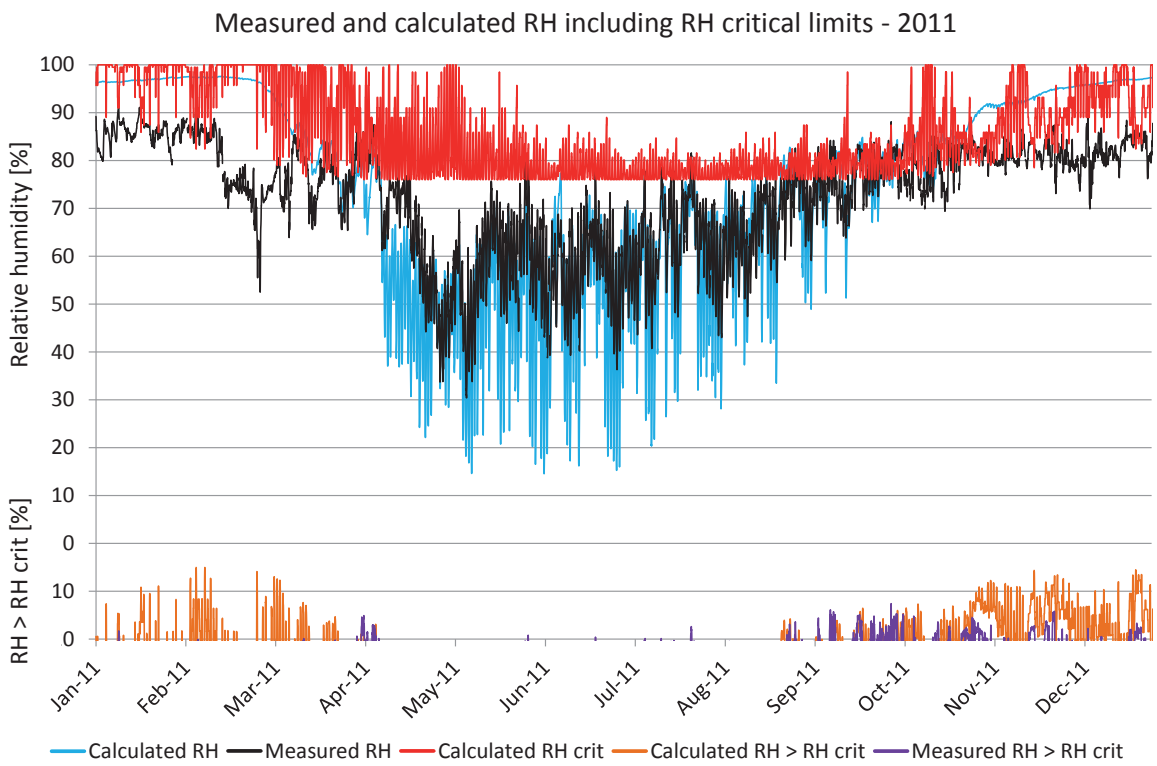


Figure 7.24.11. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

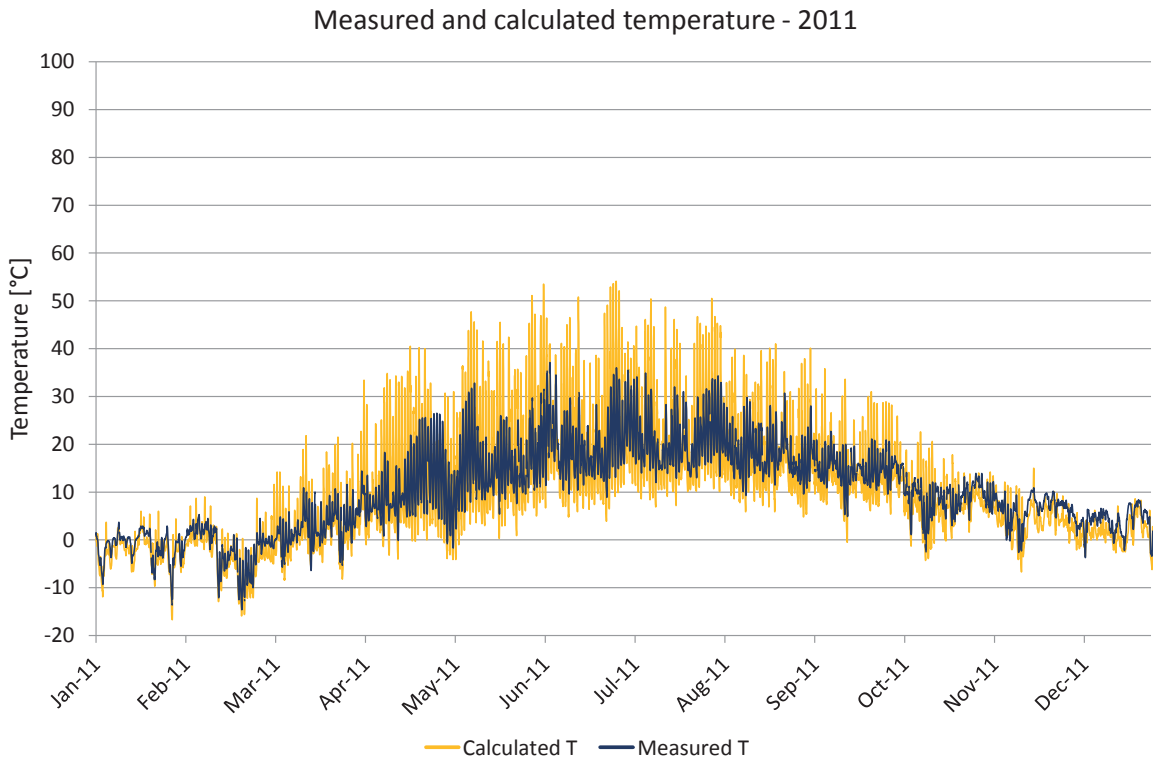


Figure 7.24.12. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

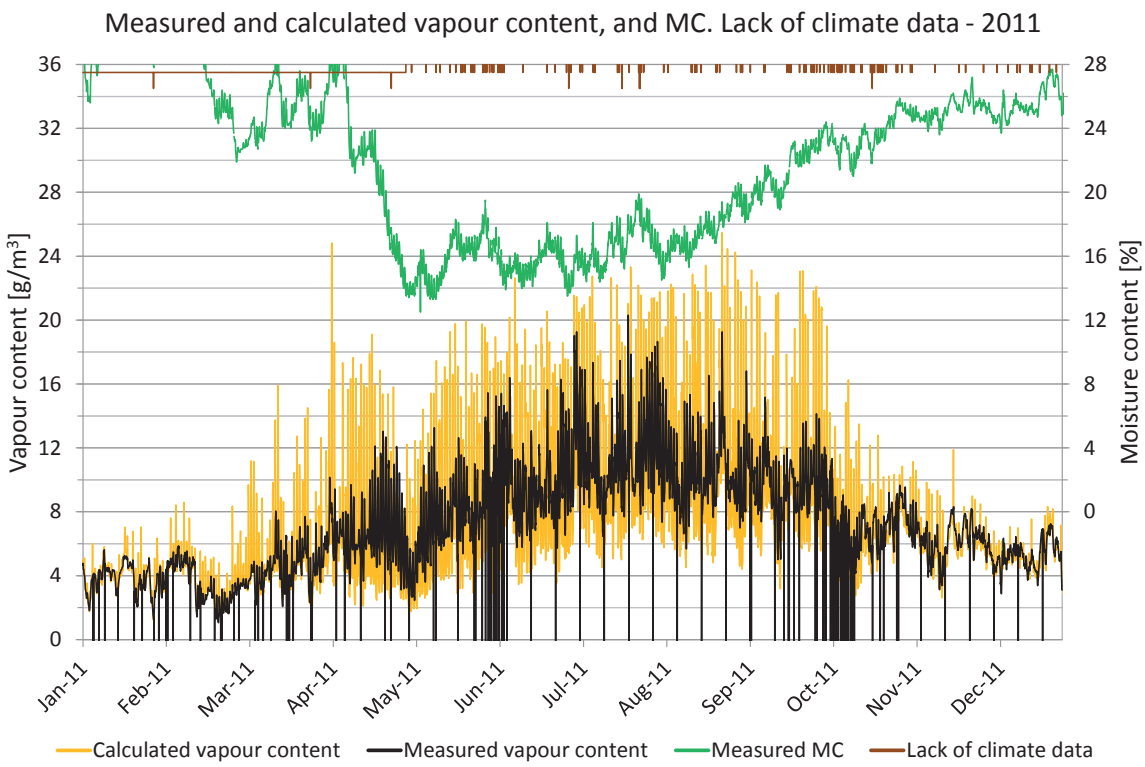


Figure 7.24.13. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

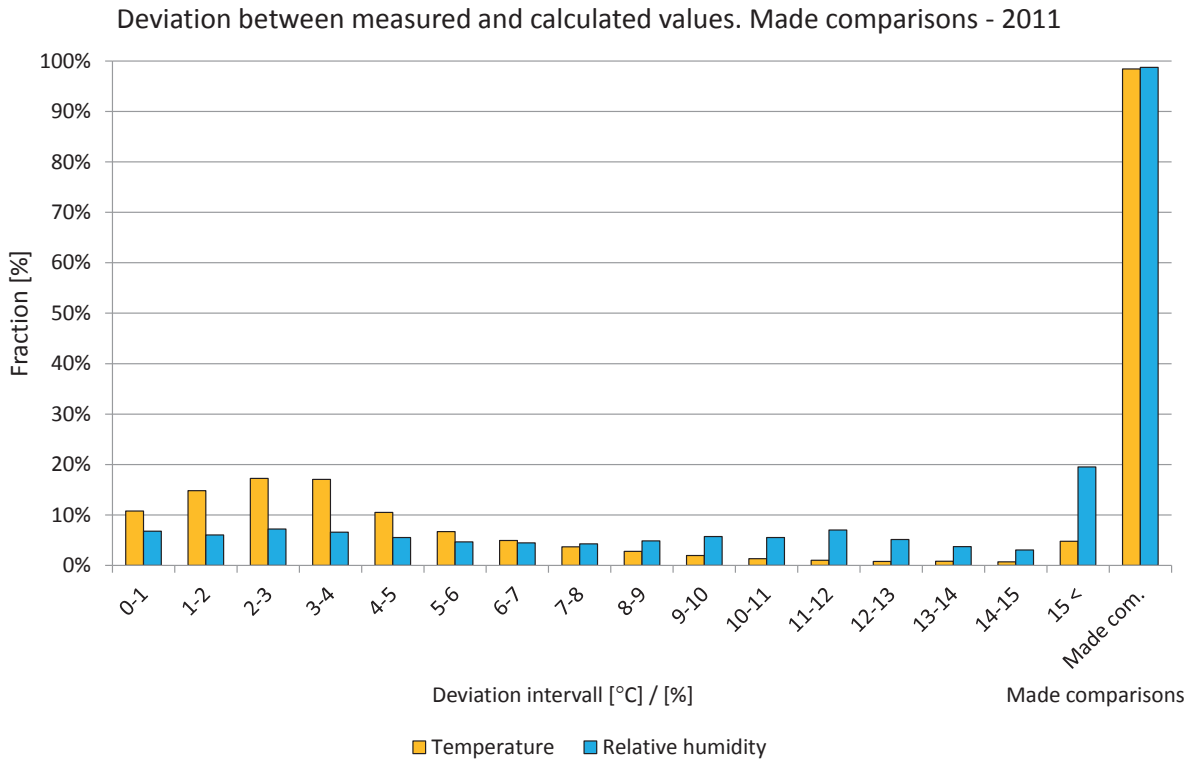
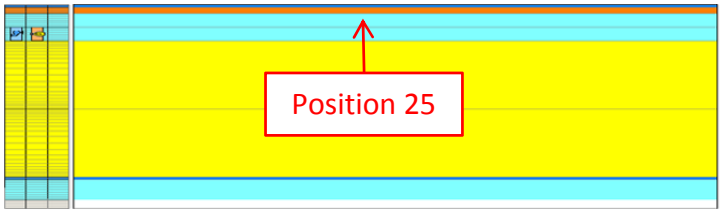


Figure 7.24.14. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

7.25 Position 25

The locations of the measured and calculated position are shown in the drawings and figures below. The studied position is located in a roof with 27 degrees roof angle facing northeast.



Roof, from the outside:
Tiles[1], part of outer Sd value
1 mm PVC roof membrane[1], Sd = 15 m
9 mm Plywood board[1]
20 mm Air gap[1], heat source[2] of 4 W/m^2 September - March
20 mm Air gap[1] with 20 ACH
200 mm Mineral insulation, λ = 0,037 W/mK[3 4], including roof beams
1 mm Vapour retarder[1], Sd = 50 m
30 mm Air gap[1], no ACH
13 mm Gypsum board[2]

Figure 7.25.1. WUFI calculation model showing the studied position. 1. IBP, 2012, 2. Krus, M., 1996, 3. IEA Annex 24, 1996, 4. Paroc, 2002.

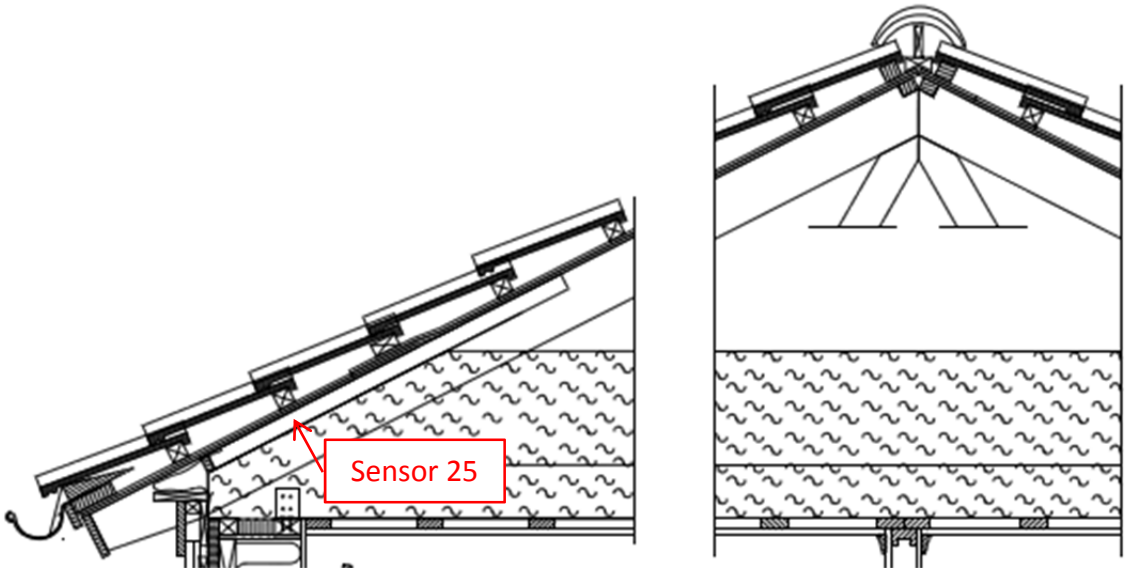


Figure 7.25.1. Location of the studied position.

Figure 7.25.3. Location of the studied position.

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 2009

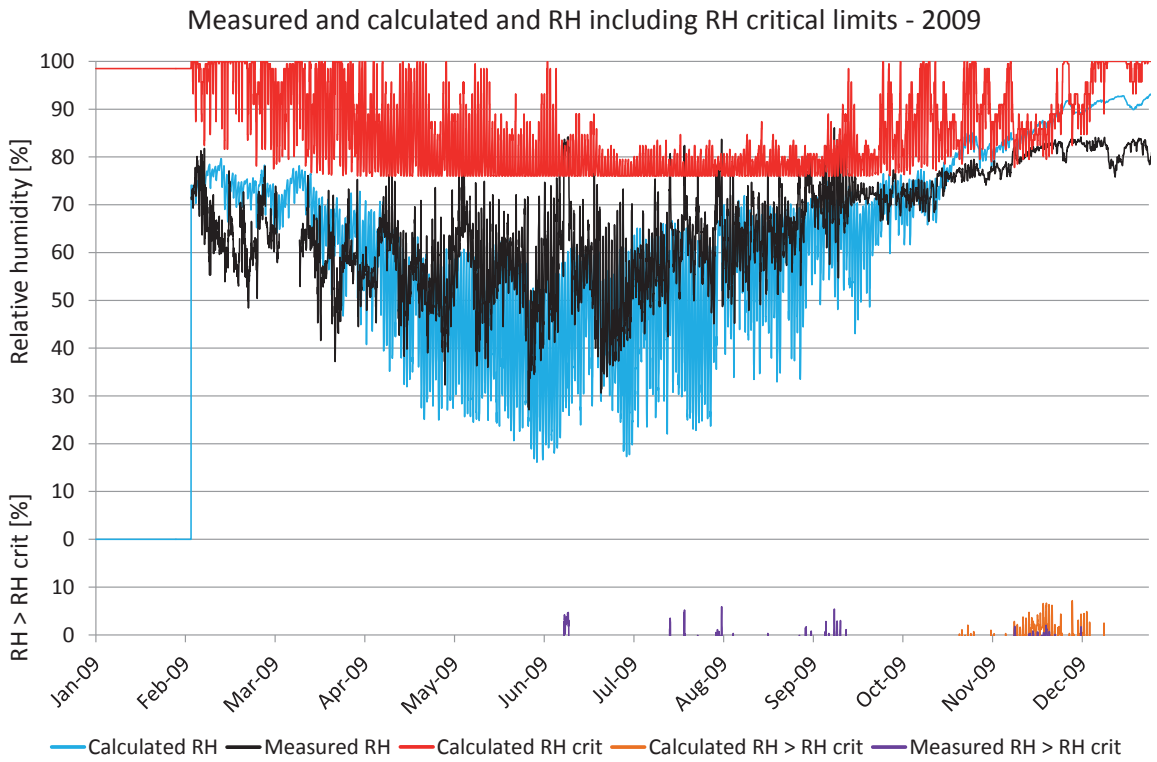


Figure 7.25.4. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

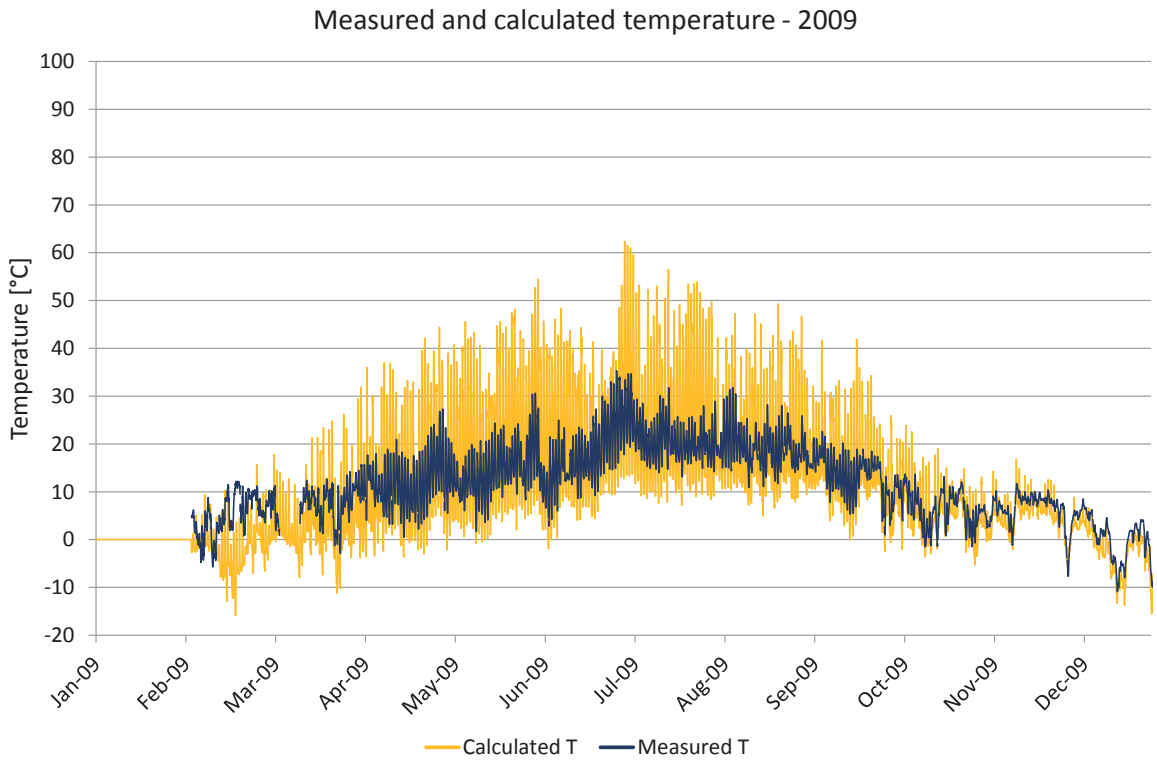


Figure 7.25.5. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

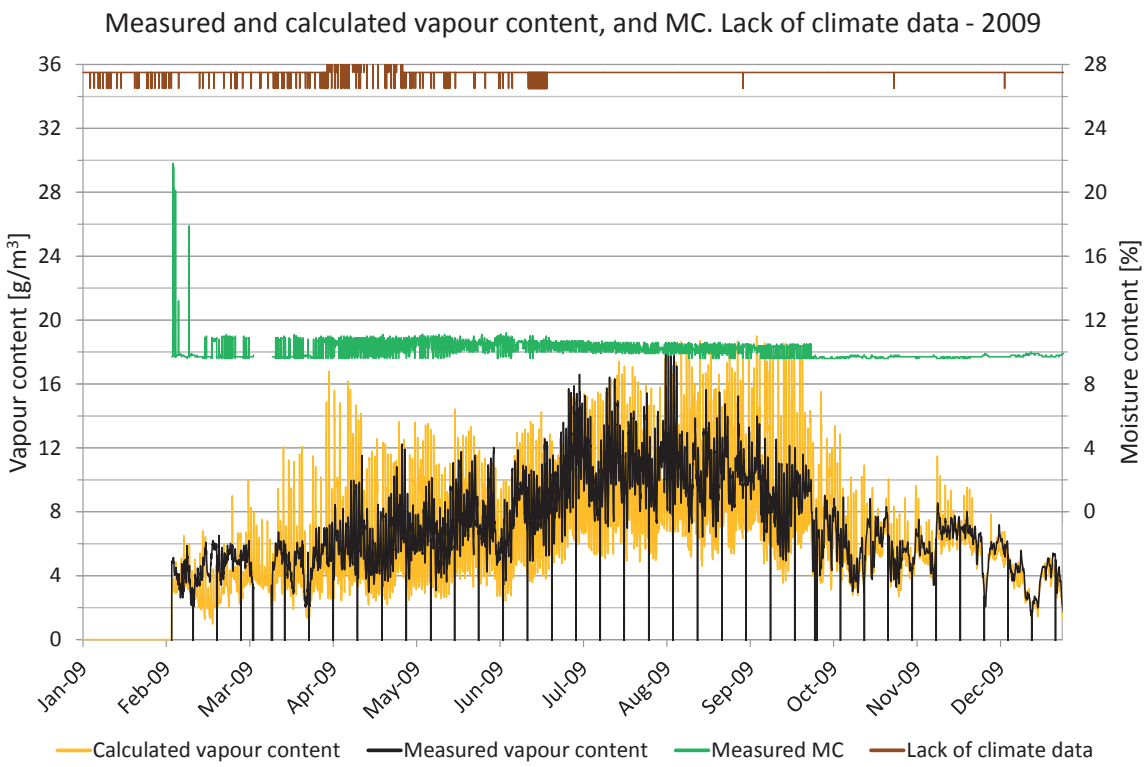


Figure7.25.6. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

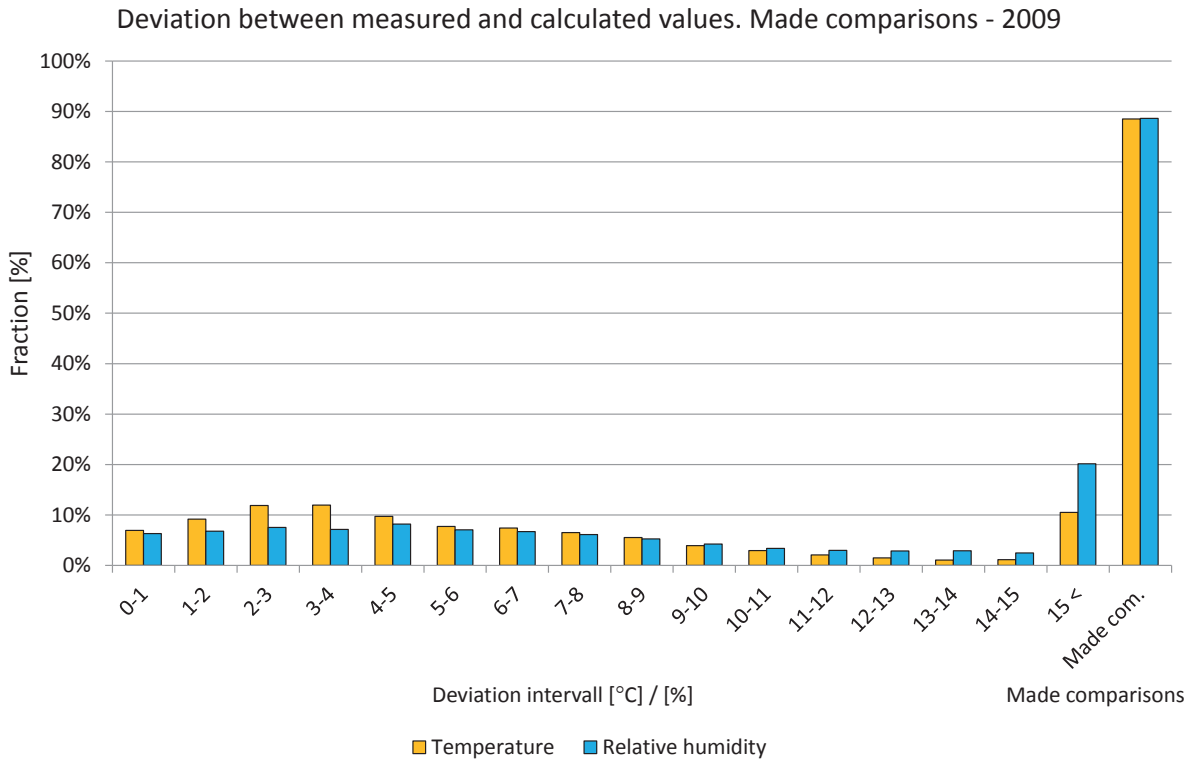


Figure 7.25.7. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2010

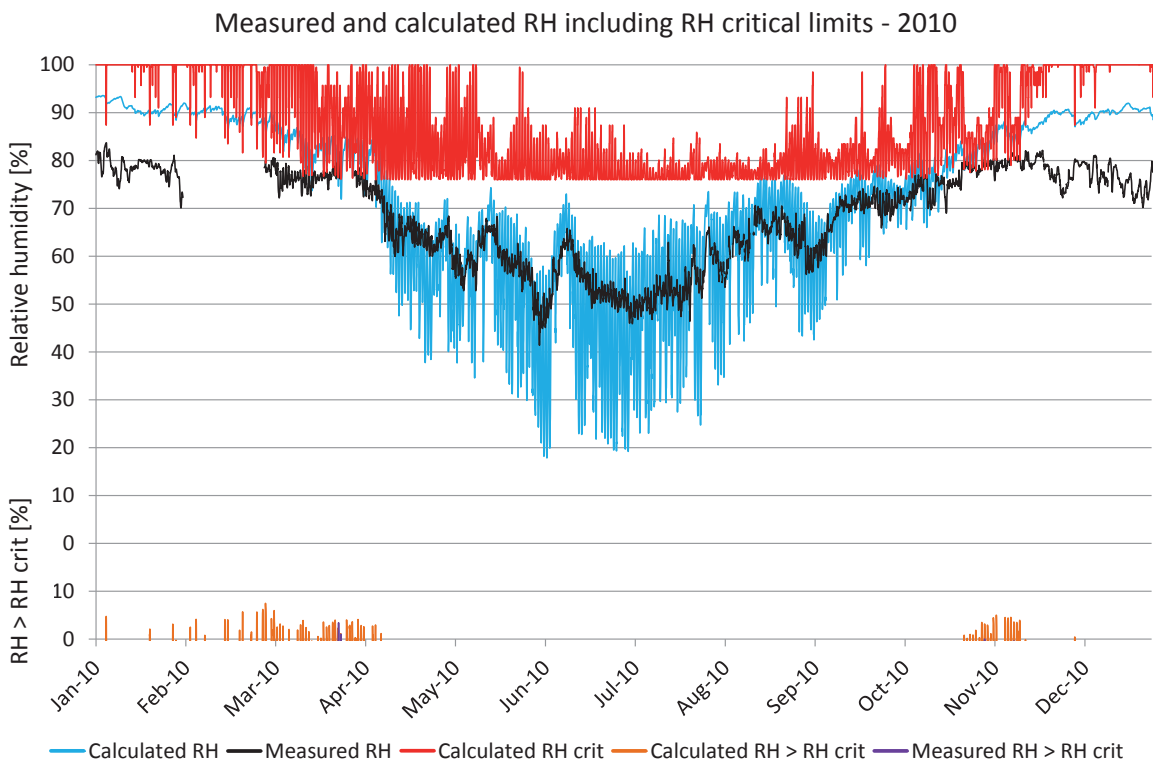


Figure 7.25.8. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

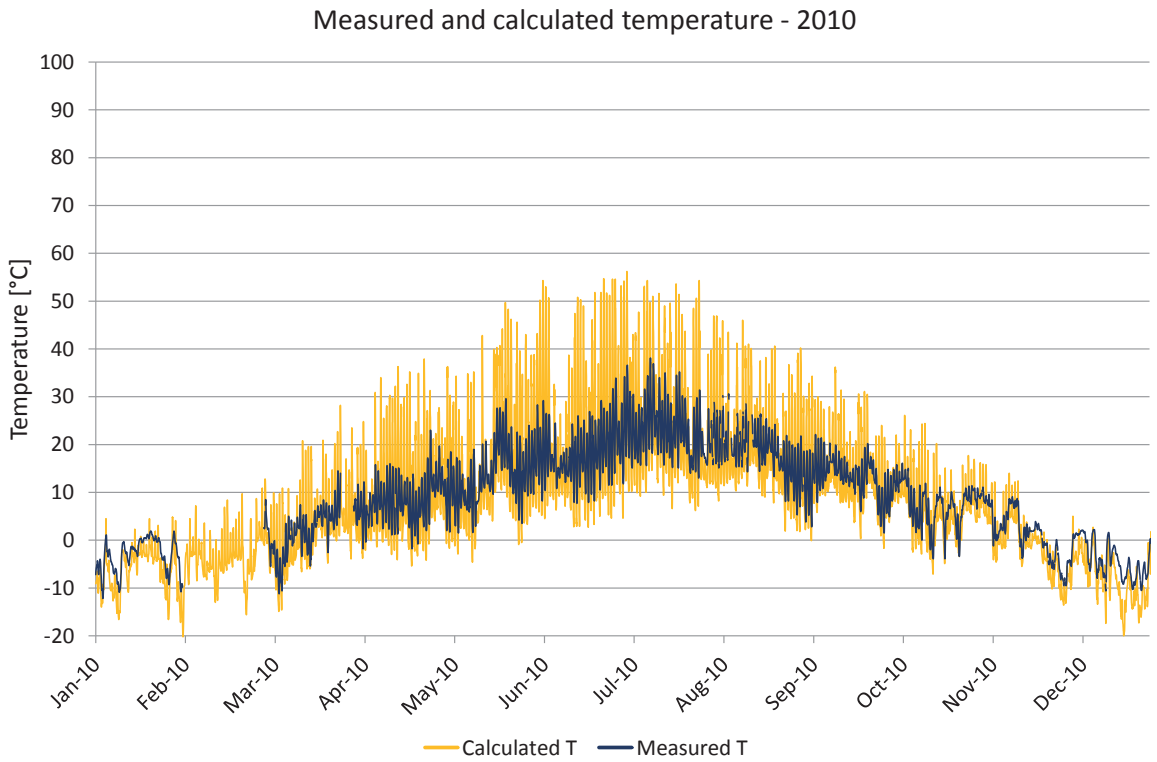


Figure 7.25.9. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

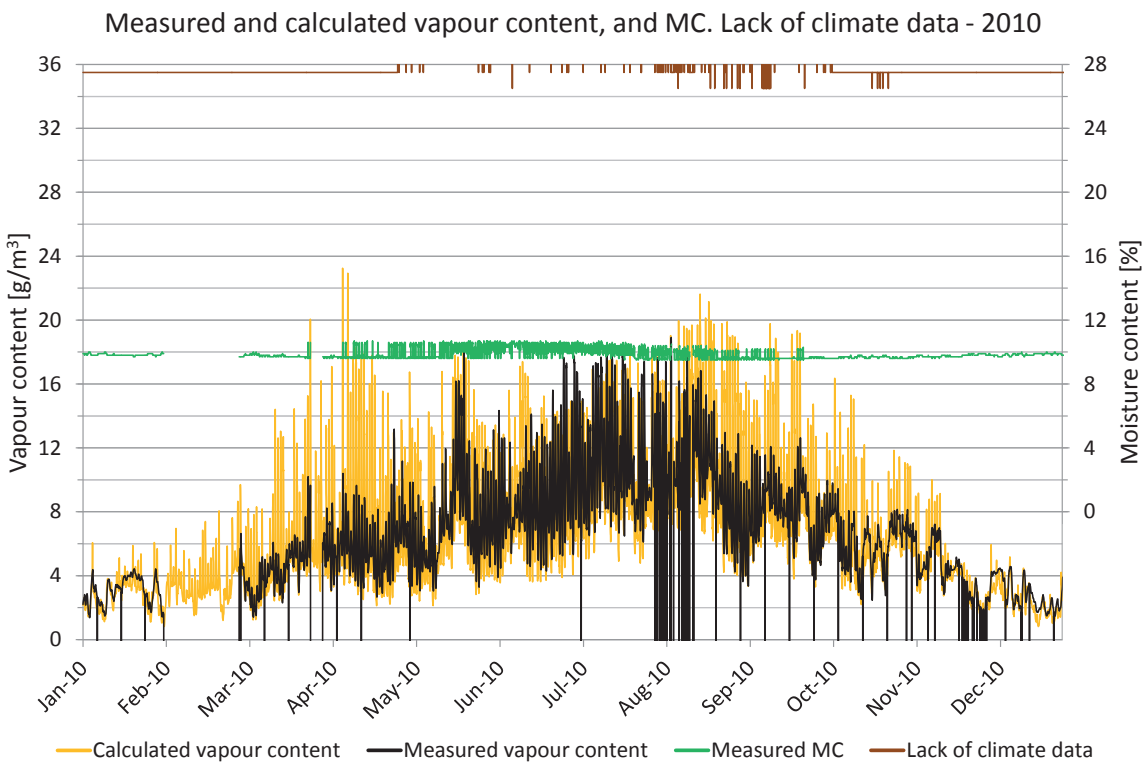


Figure 7.25.10. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

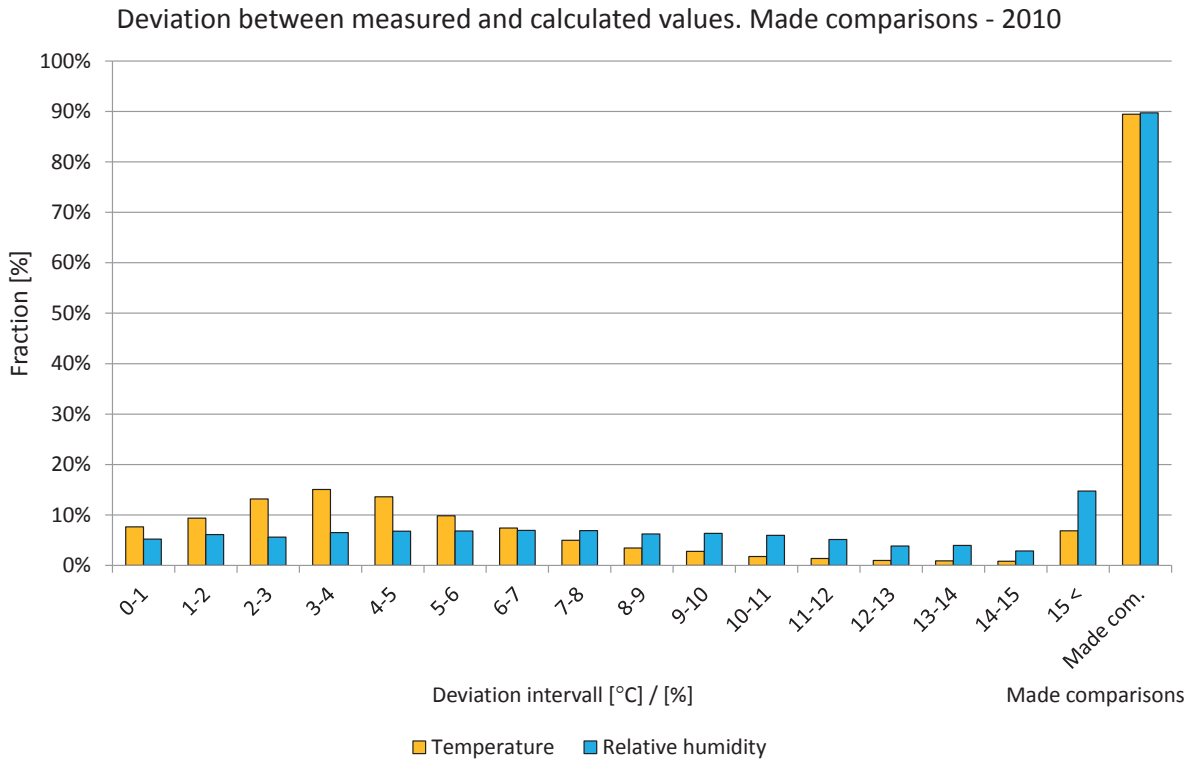


Figure 7.25.11. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

Year 2011

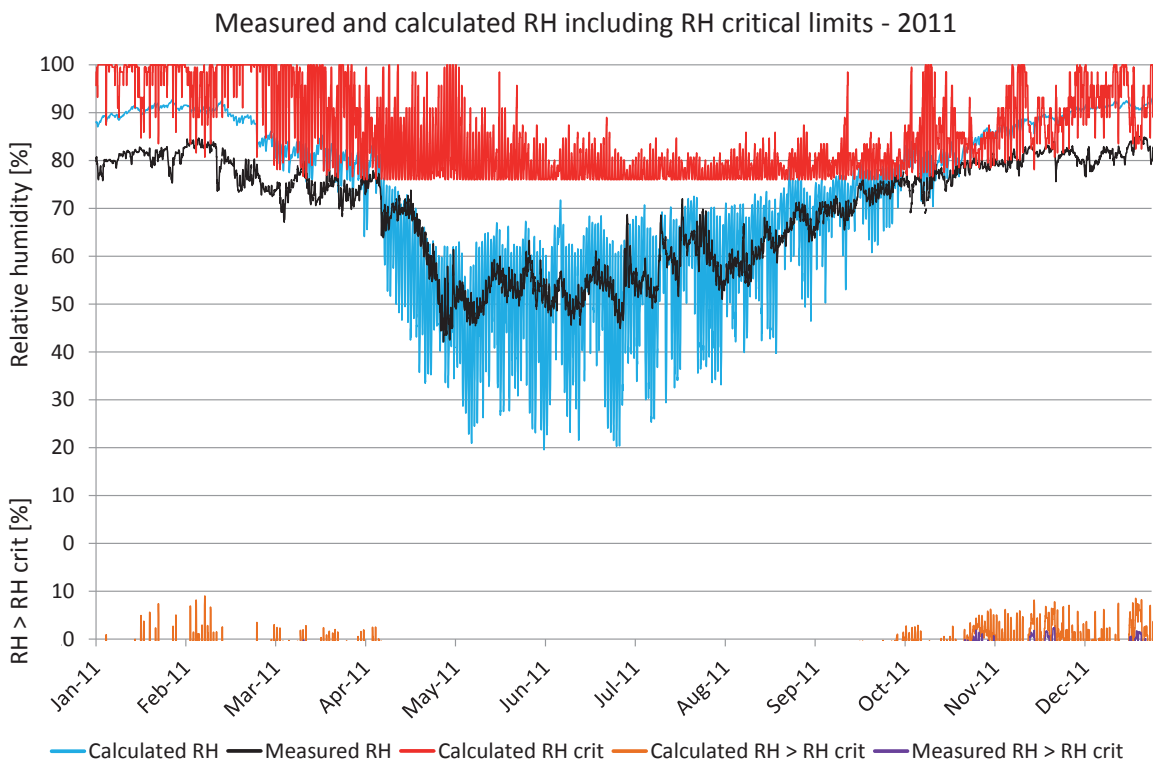


Figure 7.25.12. Comparisons between measured and calculated relative humidity. Calculated RH (turquoise), measured RH (black), RH_{crit} for calculated values (red), calculated RH > RH_{crit} (light brown), measured RH > RH_{crit} (purple).

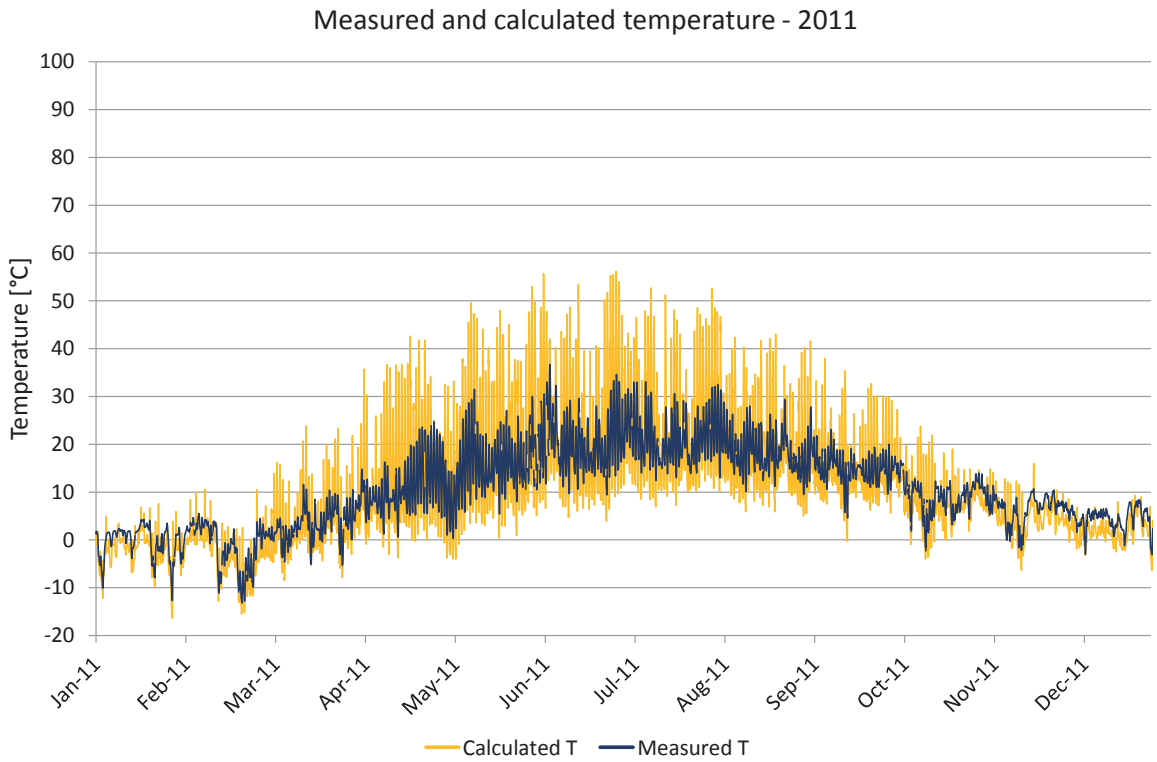


Figure 7.25.13. Comparisons between measured and calculated temperature. Calculated temperature (yellow), measured temperature (dark blue).

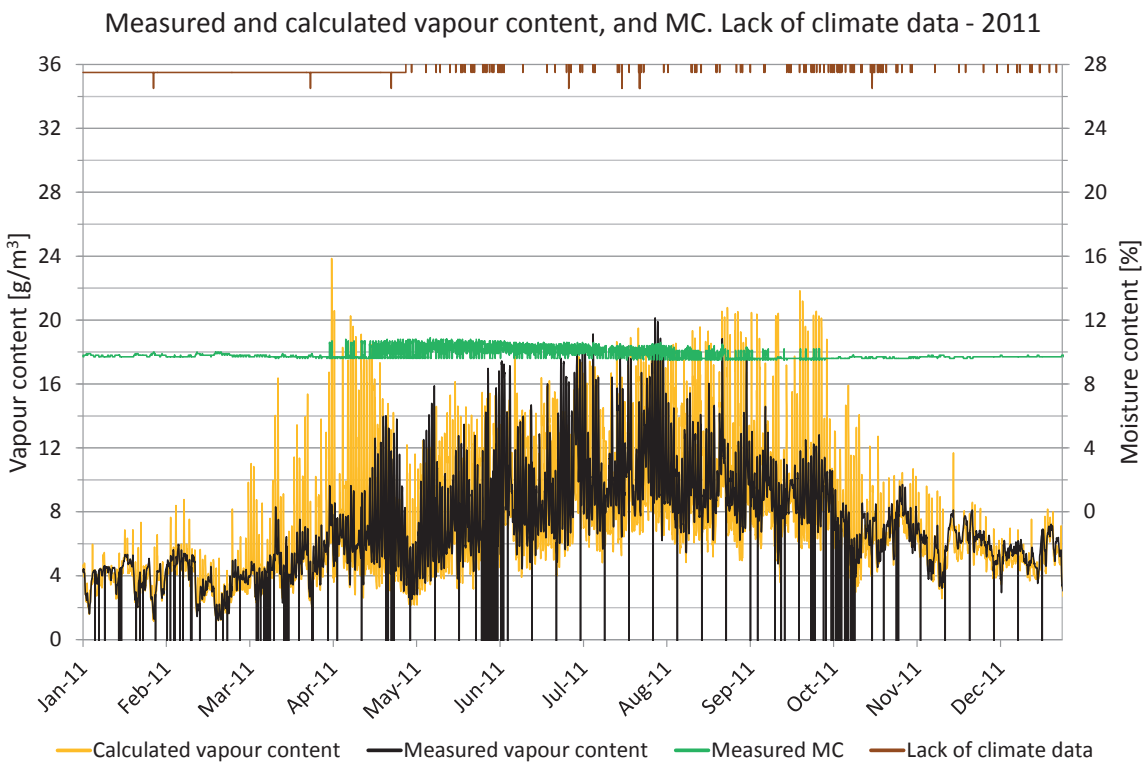


Figure 7.25.14. Measured moisture content, periods lacking climate data and comparisons of vapour content. Vapour content for calculated values (yellow) and measured values (black). Moisture content (green), periods with lack of climate data (brown).

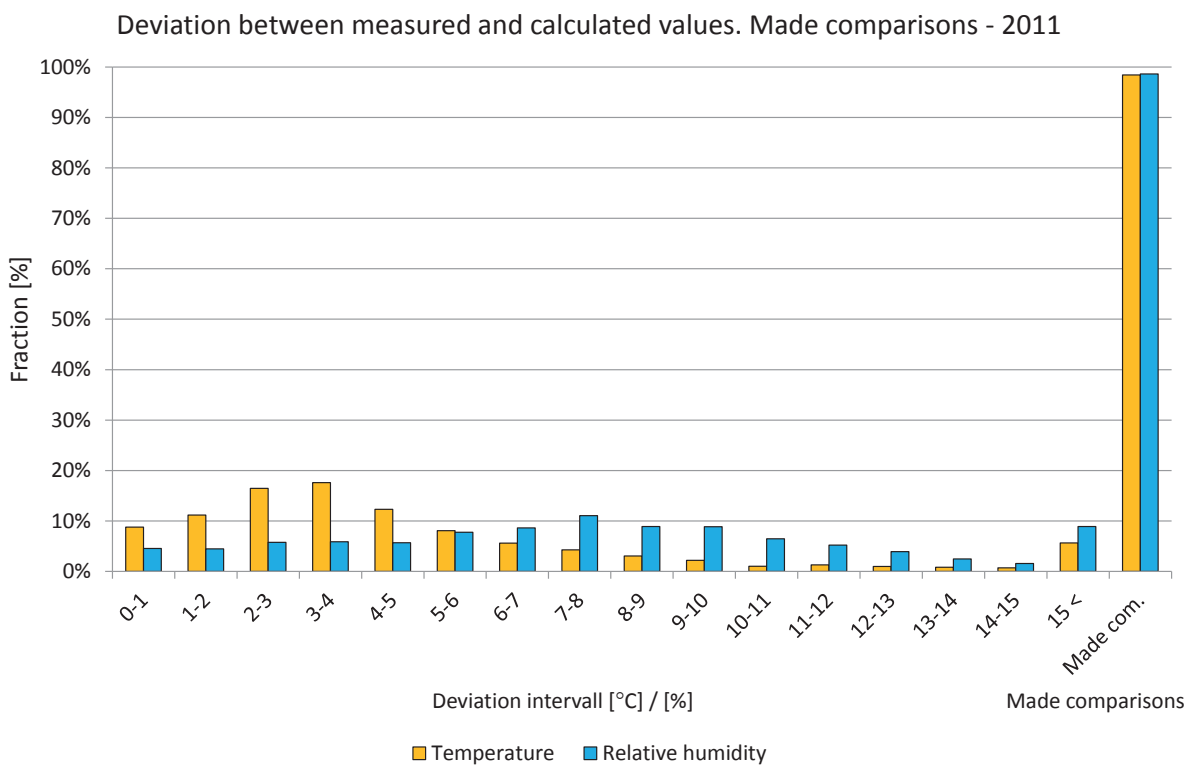


Figure 7.25.15. Deviations in comparisons shown in intervals from 0 to 15 °C or %. The two right-hand bars show the percentage of comparisons during the year. Temperature (yellow) and relative humidity (light blue).

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. 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 behaviour or similar daily amplitudes. 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.

Blind calculations in the air gap and in the exterior part of the wall, on the inside of the weather resistive barrier, provided results that followed the measured values. In some positions there were good correlations. However, there were positions with more or less constant deviations of up to 10 percent lower than the measured relative humidity. 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 vapour content was the same but different measured and blindly calculated temperatures indicate different vapour contents at saturation. Consequently this creates differences between the measured and blindly calculated relative humidity.

Measurements carried out in the insulation between two thin horizontal top plate beams on top of the wood frame wall also showed up to 10 percent lower relative humidity compared with the blindly calculated values during some periods. However, in those two positions the decreasing vapor content was caused by reduced relative humidity.

Measurements located close to the horizontal bottom (sill) beams in the walls show significantly 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 created in the area close to the sill which affects the vapour content at saturation and, consequently, greatly reduces the relative humidity.

The daily variations in temperature and relative humidity in the air gap are, on the whole, the same when the measured and blindly calculated values were compared. However, on the inside of the weather resistive barrier, there were larger amplitudes in the measured temperature and relative humidity than in the blindly calculated values in the construction. Close to the inside of the wall the amplitudes were mainly low in both the measured and blindly calculated values. In the middle of the wall, the amplitudes were slightly larger, mainly those of the measured values. Closer to the air gap, the amplitudes, mainly of the measured values, became significantly greater. These variations and differences in amplitude may have depended on several factors. However, the variations in relative humidity could mainly be connected to the differences in temperature.

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 area, after the house had become occupied in April 2009. Similarly to the results from the walls, some positions show better correlations and other positions 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.

The measured results close to the interior, on the outside of the vapour barrier, and in the middle of the roof insulation correlate well to the blindly calculated values during the warm period of the year. However, during the colder period of the year there were deviations between both the measured and blindly calculated temperature and relative humidity. The lower measured temperature results in a higher relative humidity than the calculated values. The temperatures in these positions were unrealistically low. This might have been because the room, below the measurement sensors, might not have been in use and therefore had a low temperature during the measurement period.

Results from the positions in the middle of the cold attic space, on the interior surface of the plywood roofing boards and in the air gaps correlate well from April to October. During the colder periods of the year, the measured relative humidity was approximately 10 to 15 percent lower. This lower relative humidity was caused by a higher temperature in the middle of the cold attic space. Furthermore, critical conditions seem to be more frequent in the cold attic space than in the air gaps. This might be due to the thinner insulation that creates a warmer climate in the air gaps.

All positive deviations between the measured and blindly calculated values might be due to the moisture security guard with its heating cables and fan. The algorithm for the moisture security guard has been improved, as described in Section 5.4 Attic boundary conditions.

The daily variations in calculated temperature and relative humidity in the cold attic space, on the interior surface of the plywood roofing boards and in the air gaps, were mainly higher than the measured daily amplitudes. The trees that shadow the roof might have limited the daily amplitudes in temperature and relative humidity in comparison with the calculation conditions, in which these shadows were neglected. In the insulation below the cold attic space the situation was the opposite, with 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.

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