PRIFYSGOL BANGOR / BANGOR UNIVERSITY

PRIFYSGOL
BANGOR
UNIVERSITY

Potential effects of climate change on durability of timber and wood based building materials

Curling, Simon; Ormondroyd, Graham

Timber 2018

Published: 26/06/2018

Peer reviewed version

Cyswllt i'r cyhoeddiad / Link to publication

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):
Curling, S., & Ormondroyd, G. (2018). Potential effects of climate change on durability of timber and wood based building materials. In M. Spear (Ed.), *Timber 2018* (pp. 193-200)

Hawliau Cyffredinol / General rights
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 ?

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.

23. Apr. 2024

POTENTIAL EFFECTS OF CLIMATE CHANGE ON DURABILITY OF TIMBER AND WOOD BASED BUILDING MATERIALS

Simon Curling and Graham Ormondroyd

BioComposites Centre, Bangor University,
Bangor, Gwynedd, UK

SUMMARY

The risk of microbiological attack on wood is determined by both material and climatic factors and indeed the hazard for a component is based on its intrinsic durability and the conditions in which it is used. The use of wood and organic materials in construction is increasing but ultimately all these materials will be susceptible to microbiological attack. The Scheffer Climate index applies climatic variables such as temperature and wetting time to assess hazard zones within geographical areas. A changing and variable climate e.g. an increase in heavy but short duration rain events, may have an effect on the incidence or severity of microbiological attack and with the increase in the use of timber this could have significant impact on buildings and construction. This paper shows a significant increase in the Scheffer climate indices for various locations of the UK from 1990 to 2017 and shows projections of continuing increases in the index until at least 2055.

KEYWORDS: (Durability, Climate Change, Timber, Climate index)

INTRODUCTION

If the conditions are favourable, biological materials will inevitably be at risk of decay and deterioration from the action of other organism. Timber is obviously no exception and the wood preservation and wood modification industries attest to this. Timber can be attacked by a variety of organisms such as fungi, bacteria and insects with decay causing fungi a major source of economic loss. Decay fungi require certain conditions- an adequate temperature and a moisture source – to enable them to decay wood. Inside structures, these aspects can be controlled but for exterior timber out of ground contact, these factors are determined by the climatic conditions the wood is exposed to. A number of models have been used to determine climate risk and service life (Van de Kuilen 2007, Viitanen et al. 2009, Gobakken and Lebow 2009, Thelandersson et al. 2009, Brischke and Rapp 2010, Brischke et al 2011) but one of the earliest and simplest is the climate index developed by Theodore Scheffer in 1971 (Scheffer 1971) and termed the Scheffer Index.. The Scheffer Climate Index (SCI) determines regional risk for decay based on mean temperature and the number of days where rain is greater than a prescribed value. This index was originally determined for the contiguous states of the USA but has since been used in other regions e.g. Canada (Wang and Morris 2008), Europe (Brischke et al 2011, Ferdandez-Golfin 2016) and Korea (Kim and Ra 2014). The modelling performed has shown that the UK (particularly western areas) and Ireland lie in zones that have some of the highest Decay Climate Indices in Europe (Brischke et al 2011, Fruhwald et al 2012). Whilst there has been some good correlation between the Scheffer index and decay occurrence (Wang and Morris, 2008) it is not a perfect measure of decay likelihood due to local climate variables (DeGroot 1982). However, in terms of general regional trends and hazard mapping the Scheffer index is a useful tool. As decay requires optimum temperature and moisture it is likely that it will be affected by climate change, with predictions stating that temperature and precipitation will rise in the UK in the future. The Scheffer index is a good toll for tracking this change and previous work has shown that the index is rising in the US and Canada (Wang and Morris 2008, Carll 2009, Lebow and Carll 2010) and in Korea (Kim and Ra 2014). In the UK modelling of the central region data in 2006 (Brimblecombe et al 2006) shows an expected rise in the Scheffer Index in the future.

This paper uses historic data from the UK meteorological office to determine the Scheffer index for different regions of the UK; how they may have changed between 1960 to 1990 and 1990 to present (2017); and to estimate future Scheffer indices following climate change scenarios.

METHODS

Scheffer Climate Index equation

The Scheffer index calculation is based on mean temperature and moisture content and uses the following equation

$$SCI = \frac{\sum_{Jan}^{Dec}[(T-2)(D-3)]}{16.7}$$

Where
SCI = Scheffer Climate Index
T = mean monthly temperature
D = mean number of days in the month with 0.25mm or more of rain.
$\sum_{Jan}^{Dec}$ = the sum of the products for each month of the year.

The temperature and rain days have attached constants to accommodate minimum temperature requirements and to estimate wetting times. The divisor (16.7) is an arbitrary number designed to accommodate the index value approximately in a value range of 0-100, although values of 100+ are easily possible.

A general hazard risk has been assigned depending on SCI values as shown in table 1

Table 1. Decay hazard associated with given Scheffer Climate index value

SCI	Hazard
< 35	Low hazard
35 to 65	Moderate hazard
> 65	High hazard
> 100	Very high hazard

Historic and current Scheffer index determination

Determination of the historic and current Scheffer index was calculated using data from the UK Metrological office. For temperature data was obtained from a number of weather stations around the UK that has publically available data , some of which goes back to the 1800's. Data was obtained from 1931 from at least 1 station in each region, with further stations used where possible for more complete data. The data was obtained from the UK historic station data (https://www.metoffice.gov.uk/public/weather/climate-historic/#?tab=climateHistoric). The station locations used are shown in table 2.

Table 2. Weather stations used for historic data

Station	Region	Station	Region
Cambridge	Central	Bradford	North East
Lowestoft	Central	Durham	North East
Sutton Bonnington	Central	Whitby	North East
Eastbourne	South East	Leuchars	East Scotland
Hurn	South East	Nairn	East Scotland
Manston	South East	Dunstaffnage	North Scotland
Oxford	South East	Wick	North Scotland
Aberporth	South West	Paisley	South Scotland
Camborne	South West	Lerwick	Shetland
Ross-on-Wye	South West	Stornaway	Western Isles
Newton Rigg	North West	Tiree	Western Isles
Shawbury	North West	Armagh	Northern Ireland
Valley	North West	Ballypatrick Forest	Northern Ireland

Figure 1. HadUKP climate data regions

Mean monthly temperatures were calculated as the mean of the mean high and mean low monthly temperatures. The numbers of days of rain greater than 0.25mm was extracted from the regional HadUKP data set (Alexander and Jones 2001) (Figure 1). The annual SCI was then calculated for each station, with means calculated for regions where possible (South Scotland and Shetland are single station data points only). Mean SCI was then determined for ranges of 30 years – data from the 1960's 1970s' and 1980 were used to determine the mean

30 year SCI for 1990 and data from the 1990's 2000's and 2010's (up to 2017) were used to determine the mean 30 (27) year SCI for 2017.

Future Scheffer Climate Index projections

Predictions of the future SCI were made for two time periods – the mid 2020's and the mid 2050's. The data for temperature change was calculated using projections detailed in The UK Climate Projections (UKCP09) with the low and high emission projections at 90% probability uti8lised. The data for the change in rain days was determined from linear trend data for the period 1961 to 2006 as shown in the UKCP09 data. These temperature and rain projections were applied to the mean of the data for each station for the range of 2007 to 2017 and the projected SCI determined at both low and high emission scenarios for the mid 2020's and the mid 2050's.

RESULTS AND DISCUSSION

Historic and current data

The SCI for 1990 and 2017 based on 30 years data is shown in Table 3. In all stations there was an increase in the index (shown as the percentage change) from 1990 to 2017. In all cases this change was found to be significant at the p=0.05 (95% probability) level using standard t-test statistical analysis. In line with previous work (Wang and Morris2008, Lebow and Carll 2010) the data shows a significant change in the Scheffer Climate index and the associated decay hazard over the past 30 years. This implies that the decay hazard for exterior above ground wood exposure has also increased although when using the SCI it must be remembered that localised conditions ultimately determine the decay hazard. Mean values of the current (2017) data for each region are shown in figure 2

Table 3. SCI index for 1990 and 2017 based on mean 30 year data.

Station	1990 30 Year SCI	2017 30 Year SCI	Change (%)
Central			
Cambridge	75	87	15.82
Lowestoft	74	85	15.41
Sutton Bonnington	70	83	18.18
East Scotland			
Leuchars	76	87	15.21
Nairn	72	84	16.18
North Scotland			
Dunstaffnage	87	102	16.52
Wick	83	97	16.86
North East			
Bradford	74	87	16.55
Durham	71	83	16.36
Whitby	73	89	21.11

Northern Ireland			
Armagh	92	101	10.24
Ballypatrick Forest	76	87	13.64
North West			
Newton Rigg	73	83	15.34
Shawbury	82	95	16.81
Valley	93	106	13.98
South Scotland			
Paisley	91	113	24.77
South East			
Eastbourne	74	86	16.89
Hurn	66	77	16.46
Manston	67	79	18.13
Oxford	78	90	15.38
Shetland			
Lerwick	74	90	21.12
South West			
Aberporth	84	95	13.43
Camborne	96	107	11.28
Ross-on-Wye	87	101	15.74
Western Isles			
Stornaway	90	108	19.49
Tiree	104	120	15.34

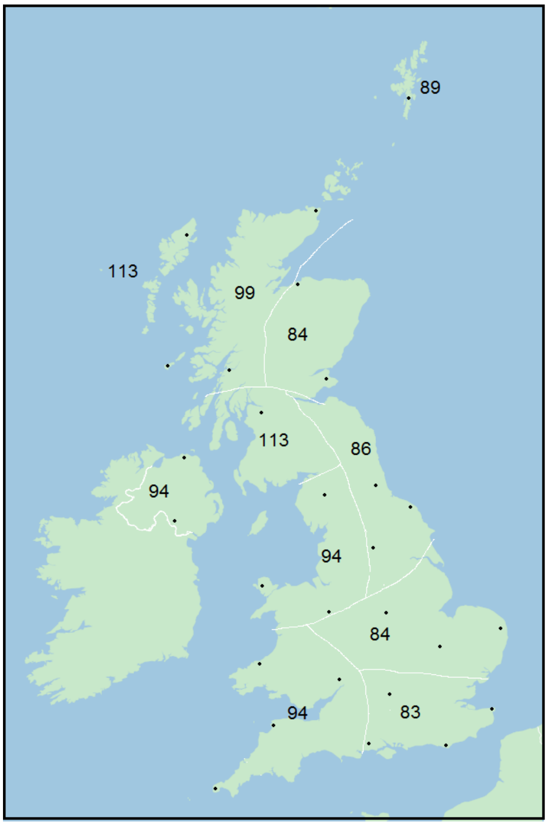

Figure 2. Current (2017) mean SCI values of UK regions

Future Scheffer Climate Index projections

The future SCI projections are shown on figures 3 as the percentage increase over the 2017 figures. In each case two values are given – the first is based on the low emission scenario and the second (in brackets) on the high emission scenario. These projections suggest a significant increase in the SCI and the associated decay hazard although again it must be remembered that localised conditions ultimately determine the decay hazard. These are simple projections only and are based on current climate models applied to current data. Whilst other climate and location data must certainly be taken into account for a more complete picture it is clear that there is a trend for a greater climate induced decay hazard over the next 30-40 year in the UK.

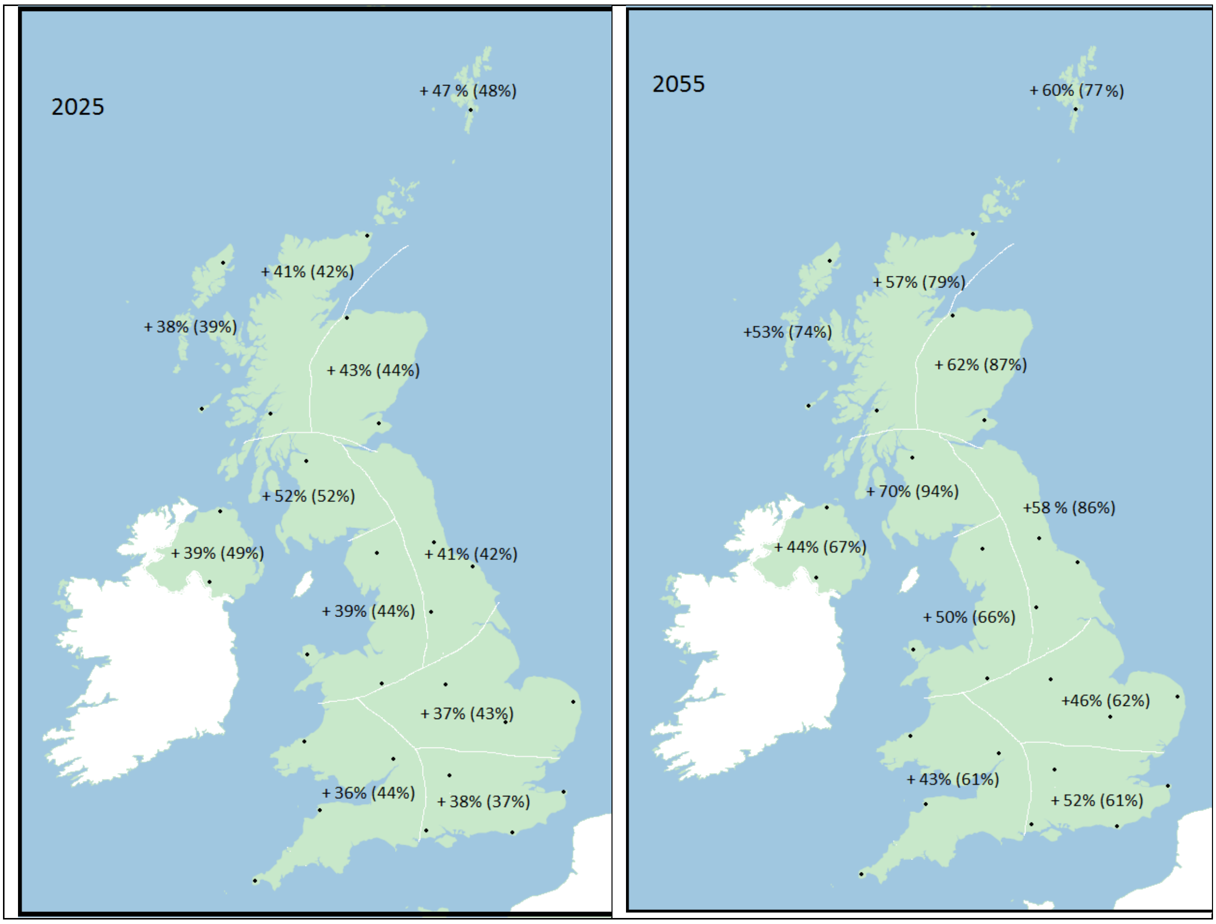

Figure 3. SCI projections for mid 2020's and mid 2050's based on low and (high) emission climate projections

CONCLUSIONS

The climate index for decay in the UK has increased from 1990 to 2017 and this implies an associated rise in decay hazard. Based on climate projections a large increase in the Scheffer Climate Index for decay is projected by the mid 2050's in the UK.

ACKNOWLEDGEMENT

© Crown Copyright 2009. The UK Climate Projections (UKCP09) have been made available by the Department for Environment, Food and Rural Affairs (Defra) and the Department of

Energy and Climate Change (DECC) under licence from the Met Office, UKCIP, British Atmospheric Data Centre, Newcastle University, University of East Anglia, Environment Agency, Tyndall Centre and Proudman Oceanographic Laboratory. These organisations give no warranties, express or implied, as to the accuracy of the UKCP09 and do not accept any liability for loss or damage, which may arise from reliance upon the UKCP09 and any use of the UKCP09 is undertaken entirely at the users risk.

Financial support provided by the Welsh Government and Higher Education Funding Council for Wales through the Sêr Cymru National Research Network for Low Carbon, Energy and Environment (NRN-LCEE). This work forms part of the "Plants and Architecture" cluster.

REFERENCES

ALEXANDER, L.V. and JONES, P.D. (2001) Updated precipitation series for the U.K. and discussion of recent extremes, *Atmospheric Science Letters* Volume 1.

BRIMBLECOMBE P, GROSSI C,M. HARRIS I (2006) The effect of long-term trends in dampness on historic buildings. *Weather* 61 (10)

BRISCHKE C.and RAPP A. O (2010) Potential impacts of climate change on wood deterioration, *International Wood Products Journal*, 1:2, 85-92.

BRISCHKE C, FRÜHWALD HANSSON E, KAVURMACI D, THELANDERSSON S (2011) Decay Hazard Mapping for Europe. Document IRG/WP 11-20463. International Research Group on Wood Protection, Stockholm,

CARLL, C G. (2009). Decay hazard (Scheffer) index values calculated from 1971–2000 climate normal data. General Technical Report FPL-GTR-179. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 17 p.

DEGROOT RC (1982) An assessment of climate index in predicting wood decay in houses. Durability of Building Materials 1 (1982). Elsevier, Amsterdam.

FERNANDEZ-GOLFIN, J LARRUMBIDE E, RUANO A, GALVAN J, CONDE M (2016). Wood decay hazard in Spain using the Scheffer index: proposal for an improvement. *European. Journal of Wood Products*. 74:591–599

GOBAKKEN LR, LEBOW, PK (2009): Modelling mould growth on coated modified and unmodified wood substrates exposed outdoors. *Wood Science and Technology* **44**:315-333.

KIM T, and RA J,B (2014). Change of Decay Hazard Index (Scheffer Index) for Exterior Above-Ground Wood in Korea. *Journal of Korean Wood Science and Technology*. 42(6): 732~739,

KUILEN VAN DE, J-WG (2007): Service life modelling of timber structures. *Materials and Structures* 40, 151-161

LEBOW P and CARLL (2010). Investigation of Shift in Decay Hazard (Scheffer) Index Values over the Period 1969-2008 in the Conterminous United States. *Proceedings of the American Wood Protection Society* 106 118-125

SCHEFFER, TC (1971): A climate index for estimating potential for decay in wood structures above ground. *Forest Products Journal* **21**:25-31.

THELANDERSSON, S, ISAKSON, T, EKSTRAND-TOBIN, A, JOHANSSON, P (2009): Modelling of onset of mould growth for wood exposed to varying climate conditions. Document IRG/WP 09-20414. International Research Group on Wood Protection, Stockholm,

VIITANEN, H, TORATTI, T, PEUHKURI, R, OJANEN, T, MAKKONEN, L (2009): Evaluation of exposure conditions for wooden facades and decking. Document IRG/WP 09-20408. International Research Group on Wood Protection, Stockholm.

VIITANEN H., TORATTI T. MAKKONEN L, PEUHKURI R, OJANEN T. RUOKOLAINEN L, RÄISÄNEN J. (2010) Towards modelling of decay risk of wooden materials. *European Journal of Wood and Wood Products*, 68 (3), pp.303-313.

WANG J and MORRIS P (2008). Effect of Climate change on above ground decay hazard for wood products according to the Scheffer index. CWPA Proceedings, 2008, pp 92-103