BELGIAN WEATHER DATA FOR 21TH CENTURY …

Climatic data for simulation and energy calculations and IEC technology.

22-04-2021

Jc. MARBAIX
ATIC member

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Belgian climate data

- As part of estimating the energy demand and the comfort conditions of a project, we have to do modeling and simulations.
- The power of current IT tools allows us to carry out a detailed study over a full year or a specific period with a calculation time step of less than one hour.
- To carry out this study, one of the important inputs is « climate data »

- This presentation proposes an exploration of the necessary and available data.

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- The weather data is a multivariate data :
  - the dry bulb temperature,
  - humidity (in one of its values),
  - solar irradiation (generally on a horizontal surface, global and diffuse level),
  - the wind (speed, direction),
  - atmospheric pressure
  - [precipitation, cloud cover …]
- From these values one can « easily » determine useful derived values :
  - enthalpy, wet bulb temperature, dew point, irradiation received on any orientation … and also frequency curves

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- Classically, « historical » TMY « Typical mean year » data is used, defined as statistically representative of the average behavior over a given period of time.
- Files of the typical year are constructed in accordance with the standard EN ISO 15927-4
  « ***Performance hygrothermique des bâtiments. Calcul et présentation des données climatiques ; Données horaires pour l'évaluation du besoin énergétique annuel de chauffage et de refroidissement*** »
  … is a collection of 12 months of « real data » but from different years.

	Period	Length (years)	Age (years)	
IRM/UCL	1958 - 1975	18	45/63	MBDSA
TMY2	1961 - 1990	30	30/60	TRNSYS
IWEC	1982 - 1999	18	21/39	ASHRAE, CARRIER, ENERGYplus

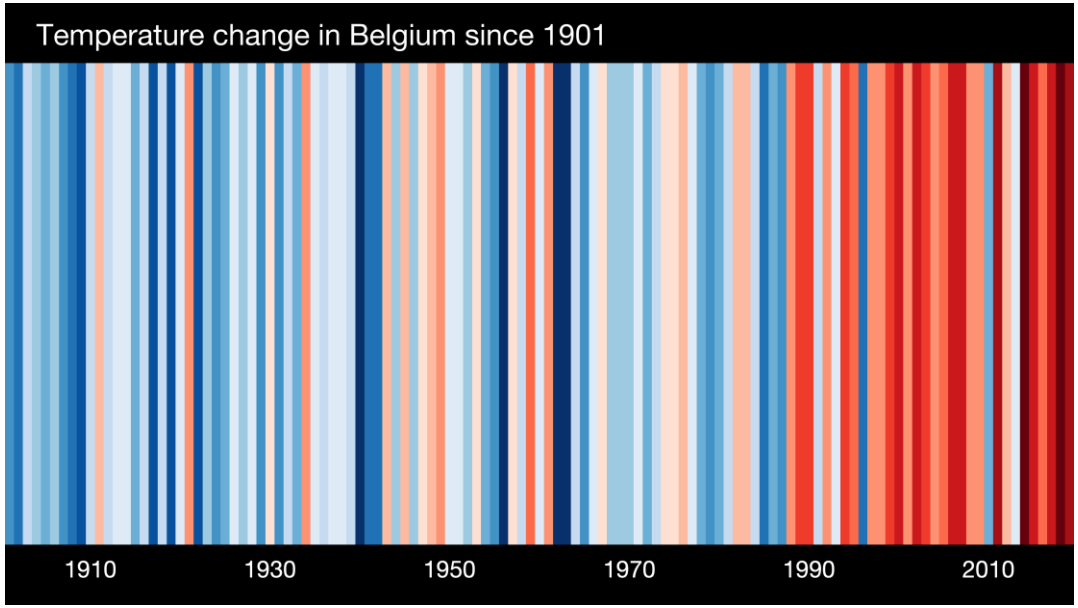
IWEC International Weather for Energy Calculation https://energyplus.net/weather/sources

Belgian climate data

HOWEVER

- We’are talking about one, and we’re experiencing obvious global warming !

annual mean temperature (with color code)



From :
https://showyourstripes.info/

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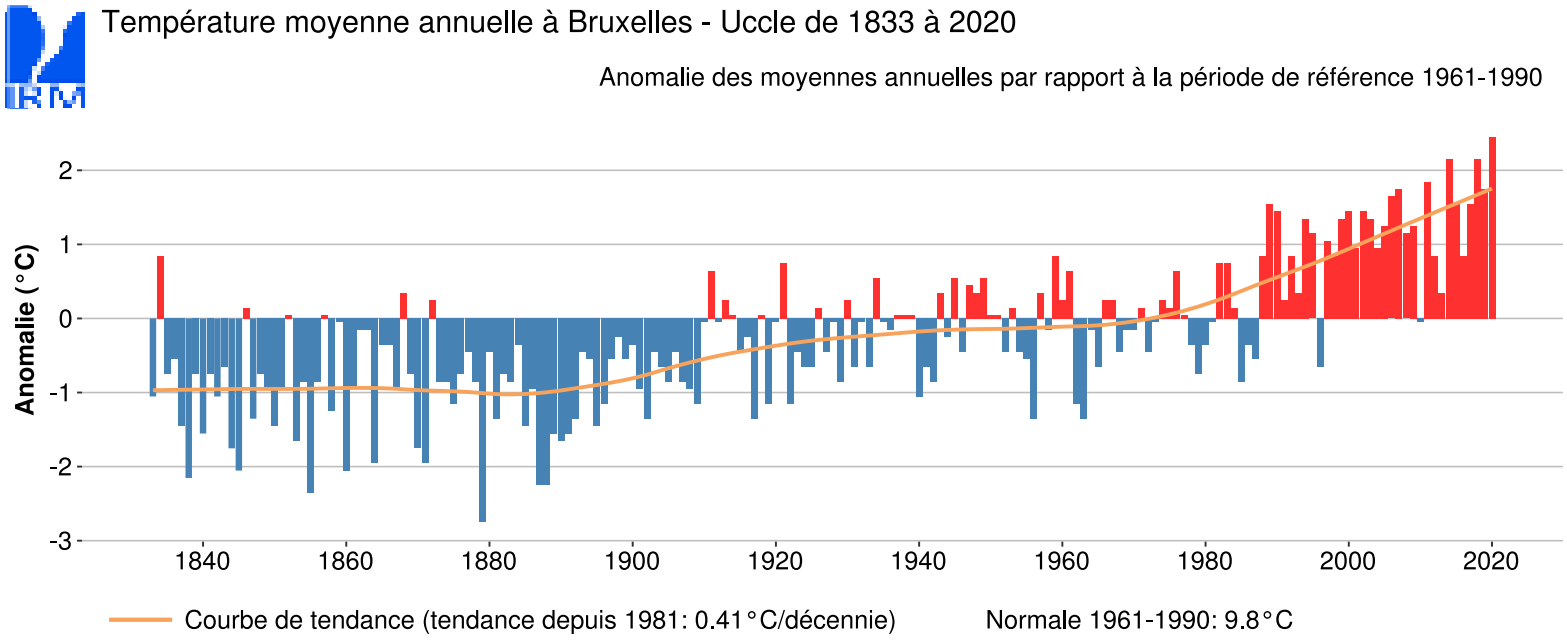
Belgian climate data



© www.meteo.be

From : https://www.meteo.be/fr/climat/changement-climatique-en-belgique/a-uccle/temperature-de-lair/moyenne/annuel

Belgian climate data

UPDATE NEEDED - REQUESTED

- Typical years … recent data from 21st century !
  - Of course they exist … paying
    - IWEC2 (ASHRAE), TMY3 (Meteonorm)
  - ! raw climate data is in the public domain (‘publication obligation’)

- Waves of heat (and cold) …
  - Are they more constraigning, more frequent ?
  - a study of the behavior of systems and installations with these more extreme constraints is necessary

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Most current and « free sources » of TMY :

- **JRC / PVGIS**

  The European Joint Research Center (JRC) makes the Photovoltaic Geographical Information System (PVGIS) available free … in particular a tool to generate TMY files for any location in Europe for periods of 10 years.

Most recent data is from 2016.

https://re.jrc.ec.europa.eu/pvg_tools/fr/#TMY

- files available for : 2005-2014, 2006-2015, 2007-2016
- The location is selectable precisely (latitude/longitude) on a map so there are extrapolations and approximations ...

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Most current and « free sources » of TMY :

- **Onebuilding.org**
  http://climate.onebuilding.org/WMO_Region_6_Europe/BEL_Belgium/index.html

  Fully compliant with EN ISO 15927-4 2005 for determination of typical year
  TMY files contain file in .epw format (like IWEC). [2004-2018]

  – A tool for converting epw files to csv is available in EneryPlusV9-3-0> PreProcess> WeatherConverter> Weather.exe… [to download EnergyPlus https://energyplus.net/downloads]

  – TMY2, EPW files viewers are available :
  - BEOPT at https://beopt.nrel.gov/downloadDView
  - Climate Consultant : http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php

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34 meteorological stations available on « climate.onebuilding.org »

BRU_Brussels_Region					
BEL_BRU_Brussels.Natl.AP.064510_TMYx.2004-2018.zip	331 K	BEL_BRU_Brussels.Natl.AP.064510_TMYx.zip	319 K		
VLG_Flanders_Region					
BEL_VLG_Antwerp.Intl.AP.064500_TMYx.2004-2018.zip	332 K	BEL_VLG_Kleine.Brogel.AFB.064790_TMYx.2004-2018.zip	334 K	BEL_VLG_Retie.064640_TMYx.zip	315 K
BEL_VLG_Antwerp.Intl.AP.064500_TMYx.zip	328 K	BEL_VLG_Kleine.Brogel.AFB.064790_TMYx.zip	329 K	BEL_VLG_Schaffen.064650_TMYx.2004-2018.zip	333 K
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BEL_WAL_Chievres.AFB.064320_TMYx.zip	326 K	BEL_WAL_Humain.064720_TMYx.2004-2018.zip	303 K	BEL_WAL_St.Hubert.AFB.064760_TMYx.2004-2018.zip	289 K
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TMY some comparisons : average

	Annual average				15 th April - 15th Sept. average			
	tdry [C]	tdp [C]	twb [C]	Ig H [W/m²]	tdry [C]	tdp [C]	twb [C]	Ig H [W/m²]
IRM [1958-75]	9,89	6,08	7,87	107,6	14,60	9,60	11,75	174,4
TMY2 [1961-90]	9,73	6,42	7,96		14,68	10,45	12,23	
IWEC [1982-99]	10,29	6,82	8,43		15,08	10,56	12,45	
JRC [2007-16]	10,60	6,77	8,54		15,89	10,45	12,78	
OneBuilding [2004-18]	11,05	6,40	8,59	153,0	16,30	9,96	12,68	251,5

In 40th years => average tdry : + 1,16 K over year and + 1,7 K in « summer »
dp dewpoint / wb wetbulb

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TMY some comparisons : maximum

T_max	tdry [C]	tdp [C]	twb [C]
IRM [1958-75]	30	19,75	22,03
TMY2 [1961-90]	30	21,3	22,76
IWEC [1982-99]	34,9 !	20,7	23,71
JRC [2007-16]	31,01	22,08	23,68
OneBuilding [2004-18]	32,4	21,9	23,77

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TMY, analyzes in IEC perspective : nb. hours

tdry vs twb [wetbulb]

Very old Belgian 1958-1975 IRM/UCL

Hours	tdry>=23	tdry>=24	tdry>=25
Max	147	100	57
twb<=16	23	4	2
twb<=17	59	29	7
twb<=18	81	64	13

New Belgian 2004-2018 UCL weather files,

Hours	tdry>=23	tdry>=24	tdry>=25
max	363	248	174
twb<=16	93	51	19
twb<=17	143	72	32
twb<=18	205	113	65

tdry>=24 [C] et twb <=17 [C] => 72h / 248h in new file vs. 29h /100h in old file

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TMY, analyzes in IEC perspective : nb. hours

tdry vs tdp [dewpoint]

Very old Belgian 1958-1975 IRM/UCL

Hours	tdry>=23	tdry>=24	tdry>=25
max	147	100	57
tdp<=16	106	65	27
tdp<=17	128	83	42
tdp<=18	136	90	48

New Belgian 2004-2018 UCL weather files,

Hours	tdry>=23	tdry>=24	tdry>=25
max	363	248	174
tdp<=16	295	197	138
tdp<=17	321	213	148
tdp<=18	337	226	155

tdry>=24 [C] et tdp <=17 [C] => 83h/100h = +- 10 days average of 8h/day in old file

tdry>=24 [C] et tdp <=17 [C] => 213h/248h = +- 26 days ave. 8h/day

=> 5h to 12h/day in new file

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HOT (COLD) WAVES :

For many years, via the MBDSA program, we have extreme waves for Uccle (Ostende and Saint-Hubert) : cold and hot wave

[hot wave : 5 days with tmax > 25 C at least 3 days >30 C]

for Uccle :

- [cold wave from December 27, 1984 → January 20, 1985 or 25 days, 600h]
  - dry hot wave from **June 24, 1976** → **July 18, 1976** i.e. 25 days, 600h

Again relatively old ! 36 and 44 years old

… according to the 'meteobelgique.be' analysis :

https://www.meteobelgique.be/article/nouvelles/la-suite/2418-bilan-de-la-vague-de-chaleur-d-aout-2020

https://www.meteobelgique.be/article/articles-et-dossier/le-climat/2084-les-vagues-de-chaleur-en-belgique-depuis-1901

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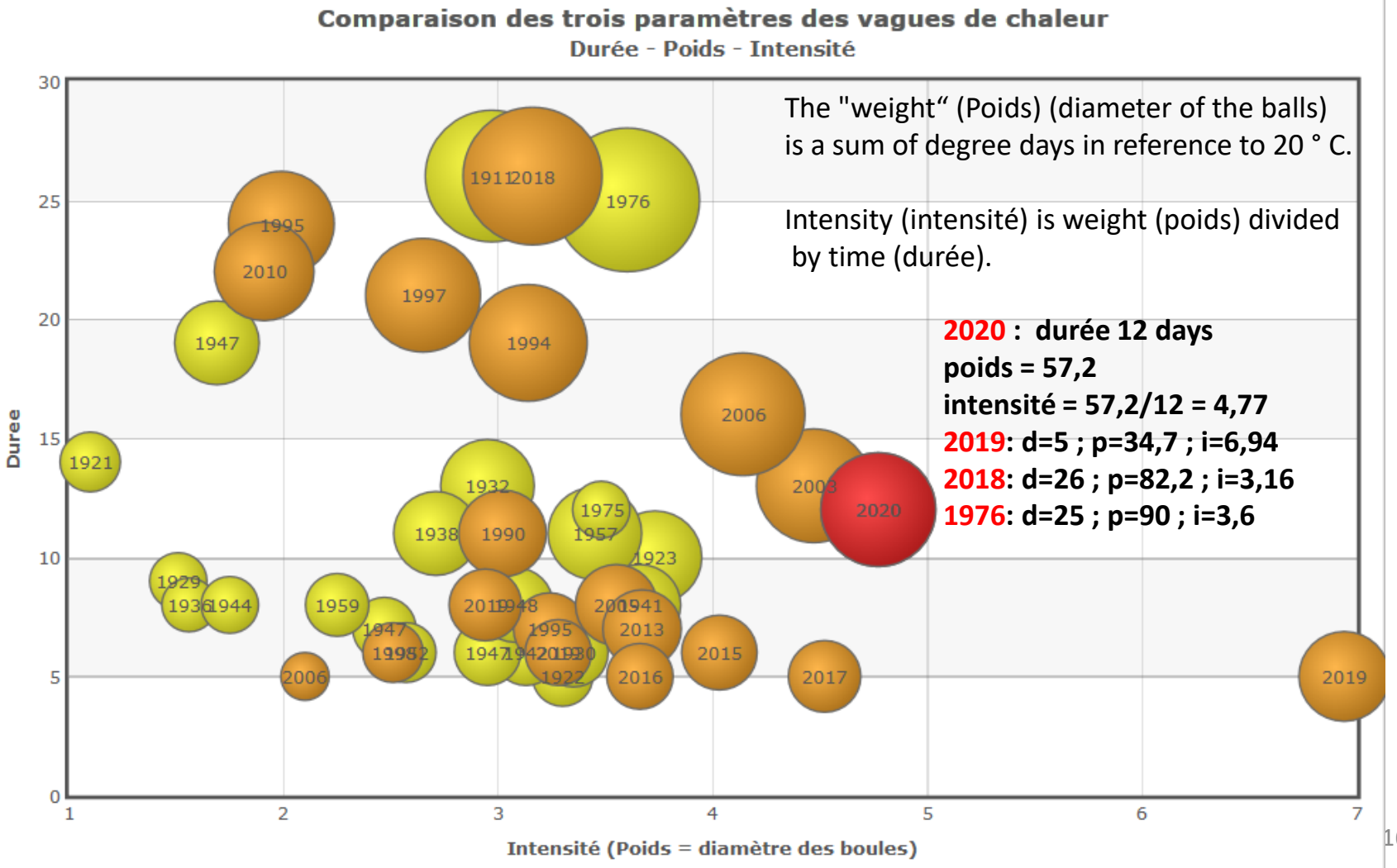
HOT WAVES at Uccle :

© www.meteobelgique.be



The "weight“ (Poids) (diameter of the balls) is a sum of degree days in reference to 20 ° C.

Intensity (intensité) is weight (poids) divided by time (durée).

2020 : durée 12 days
poids = 57,2
intensité = 57,2/12 = 4,77
2019: d=5 ; p=34,7 ; i=6,94
2018: d=26 ; p=82,2 ; i=3,16
1976: d=25 ; p=90 ; i=3,6

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HOT WAVES at Uccle :

The hot wave of 1976 undoubtedly remains a good reference.
Having files from 2018, 2003, 2006 would probably be interesting.
The recent 2020 wave of great intensity but of only 12 days would also be interesting.
The year 2019 was also quite special with 3 mini waves.

Ete (summer)	**Période (date)**	**Durée** (nb. days)	**Poids (weight)**	**Intensité (Intensity)**	**J>30°** (days >30°)	**T° max**
1976	du 22 JUN au 16 JUL	25	90.0	3.60	17	34.6
1995	du 20 JUL au 12 AUG	24	47.8	1.99	8	34.0
2006	du 15 JUL au 30 JUL	16	66.3	4.14	7	36.2
2010	du 23 JUN au 14 JUL	22	42.0	1.91	6	33.9
2010	du 23 JUN au 14 JUL	22	42.0	1.91	6	33.9
2018	du 13 JUL au 7 AUG	26	82.2	3.16	9	35.4
2019	du 23 JUN au 30 JUN	8	23.5	2.94	3	32.6
2019	du 22 JUL au 26 JUL	5	34.7	6.94	4	39.7
2019	du 23 AUG au 28 AUG	6	19.7	3.28	3	33.3
2020	du 5 AUG au 16 AUG	12	57.2	4.77	8	35.9

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HOT WAVES & Co. : Source of data NOOA ...

Data « year by year » – « hours by hours » … for World and so Belgian stations. ***Since 2005, free since 2012 !***
On the American site of NOAA « National Centers for Environmental Information - National Oceanic and Atmospheric Administration »

https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00532#
> Integrated Surface Dataset (Global) dans Download data > NCEI direct download

Hourly values: https://www.ncei.noaa.gov/data/global-hourly/ in directory « access » files **by year, by Station number**; ex: Uccle 064470 ; **23 belgian stations**.
Via ftp ftp://ftp.ncei.noaa.gov/pub/data/noaa/

Lite version (light !) https://www.ncei.noaa.gov/pub/data/noaa/isd-lite/
ftp://ftp.ncei.noaa.gov/pub/data/noaa/isd-lite files **by year, by Station number**

! If missing data ? - Lack of the irradiation !

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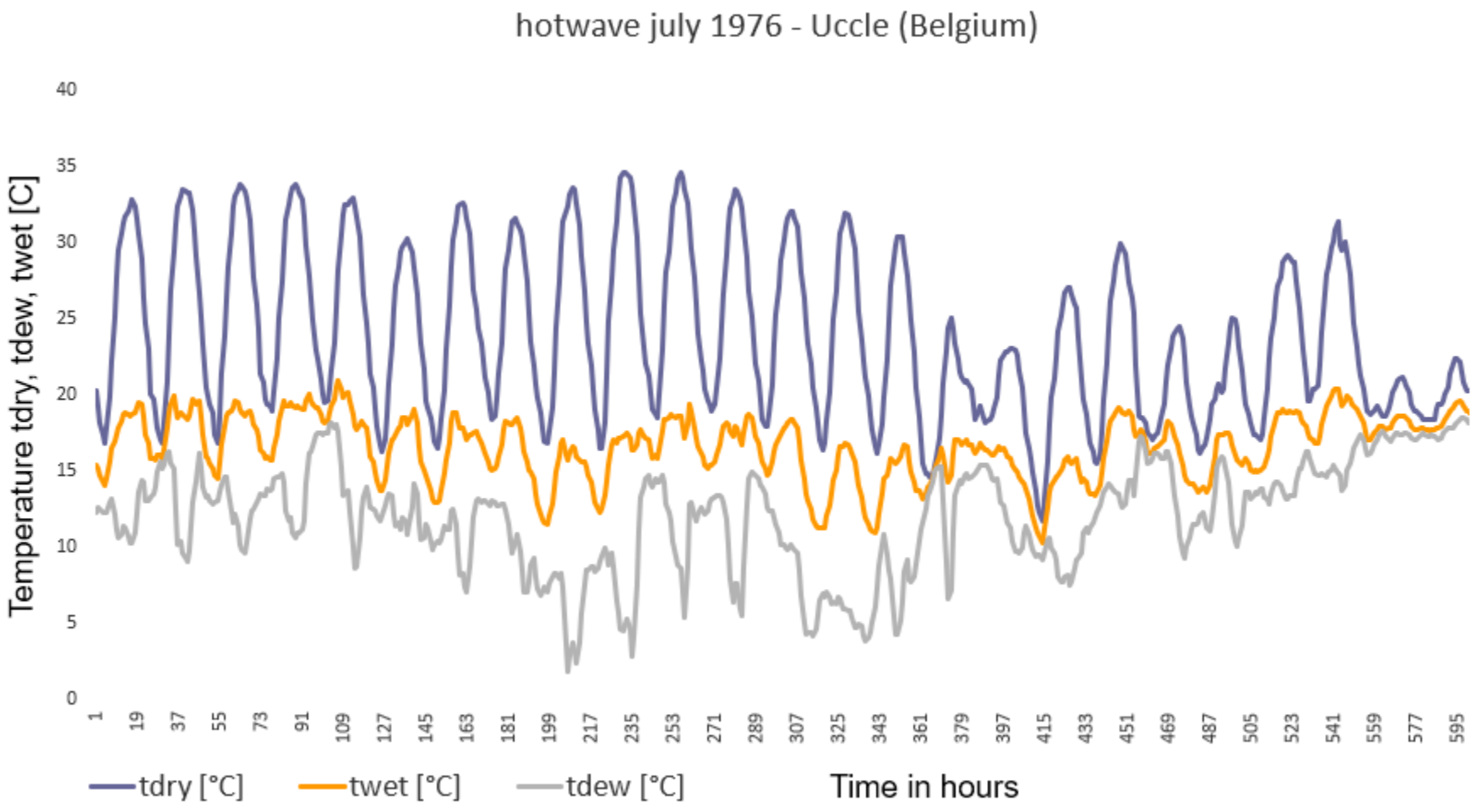
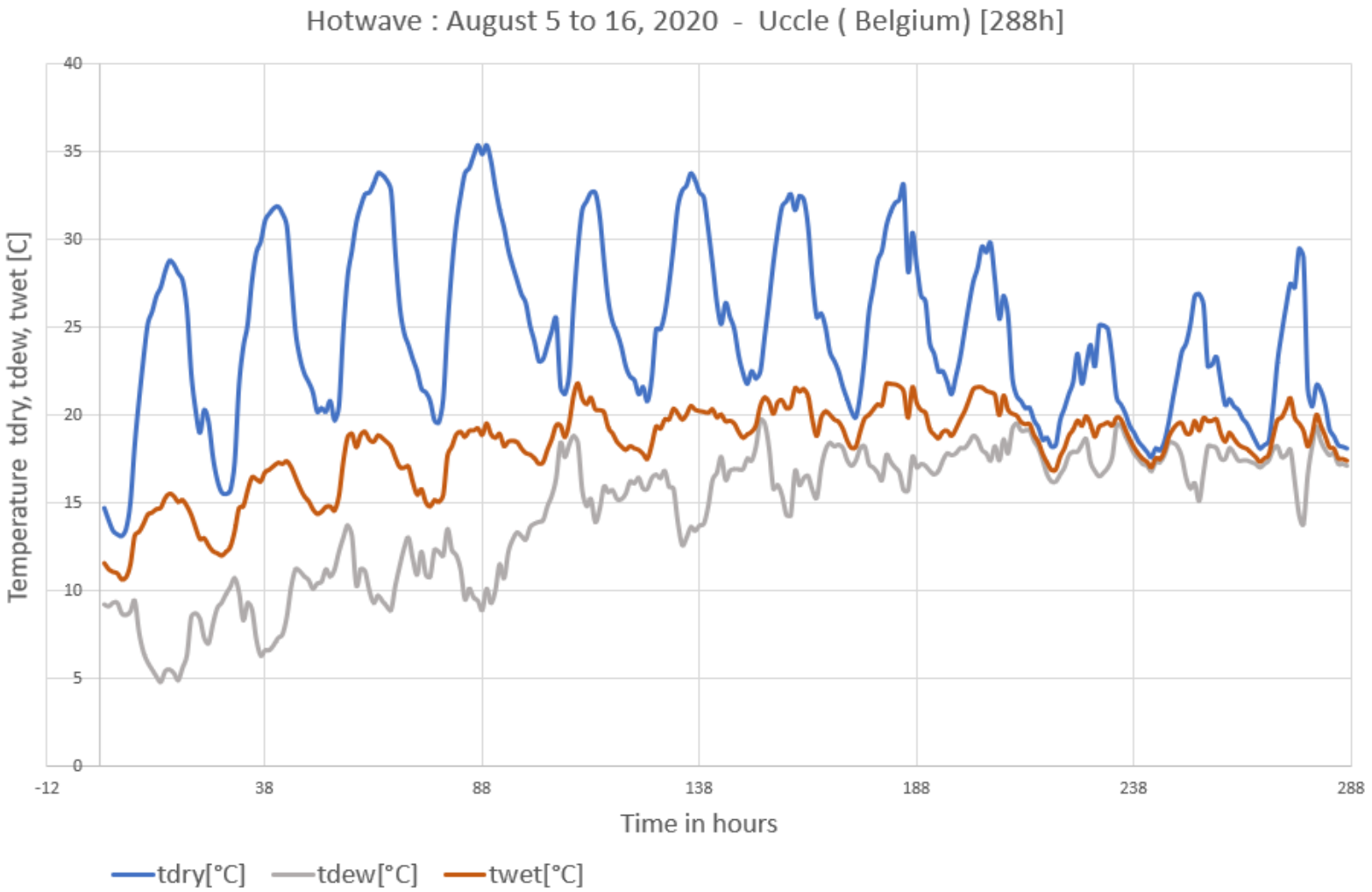
HOT WAVES : t_dry, tdew [dewpoint], twet [wet bulb] [C]



Belgian climate data

HOT WAVES :



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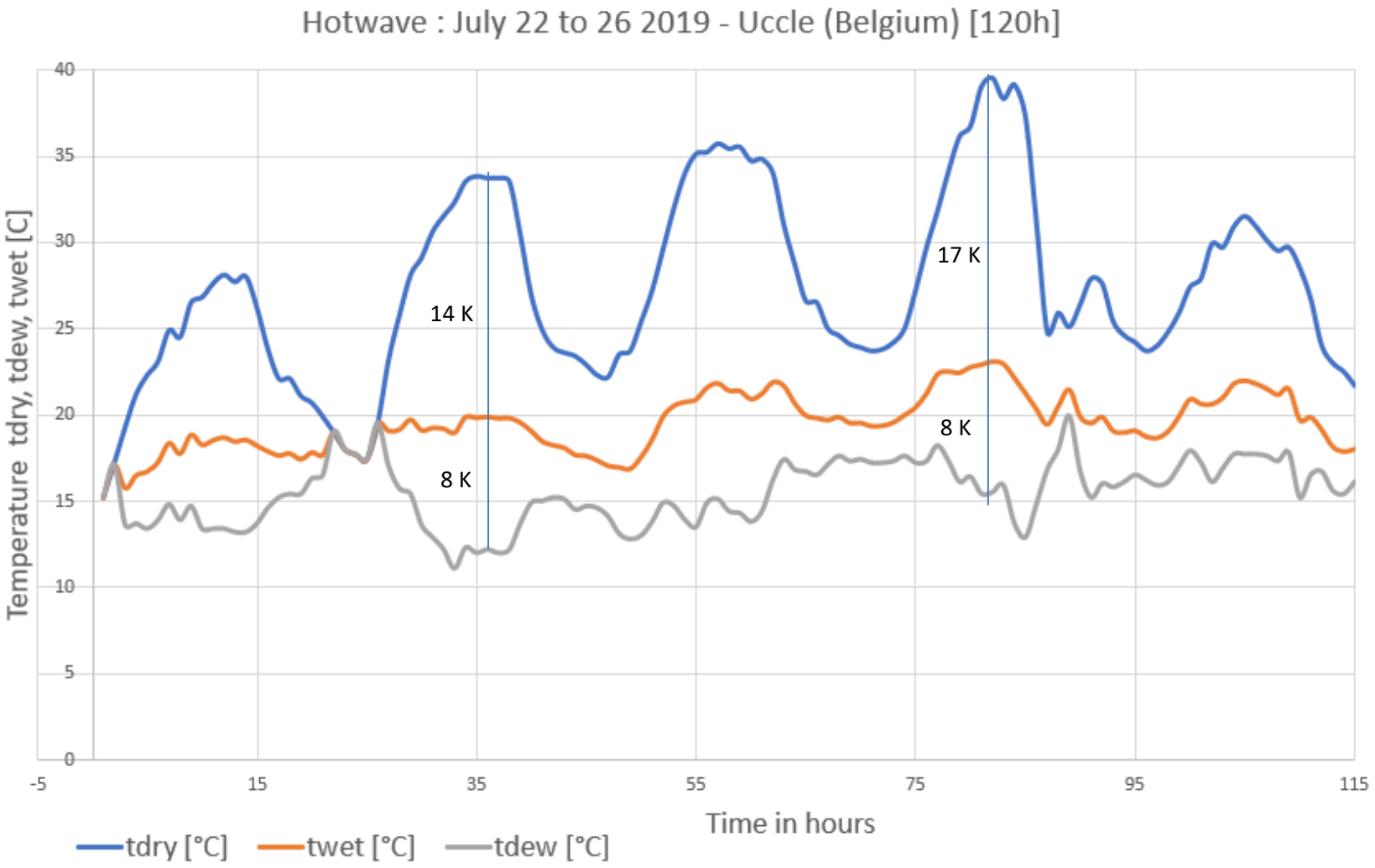
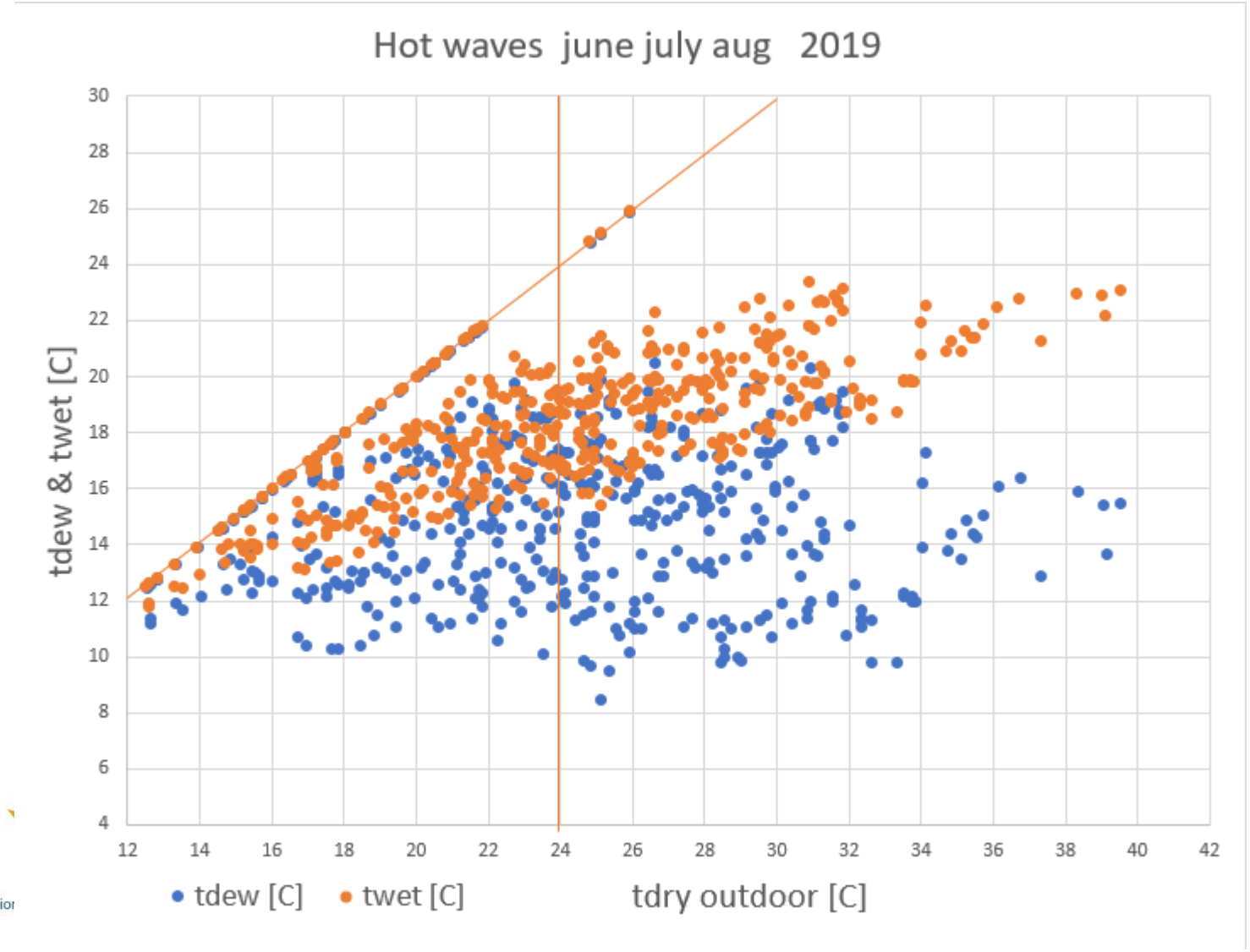
HOT WAVES :



Belgian climate data

HOT WAVES : t_dry, tdew, twet [C]



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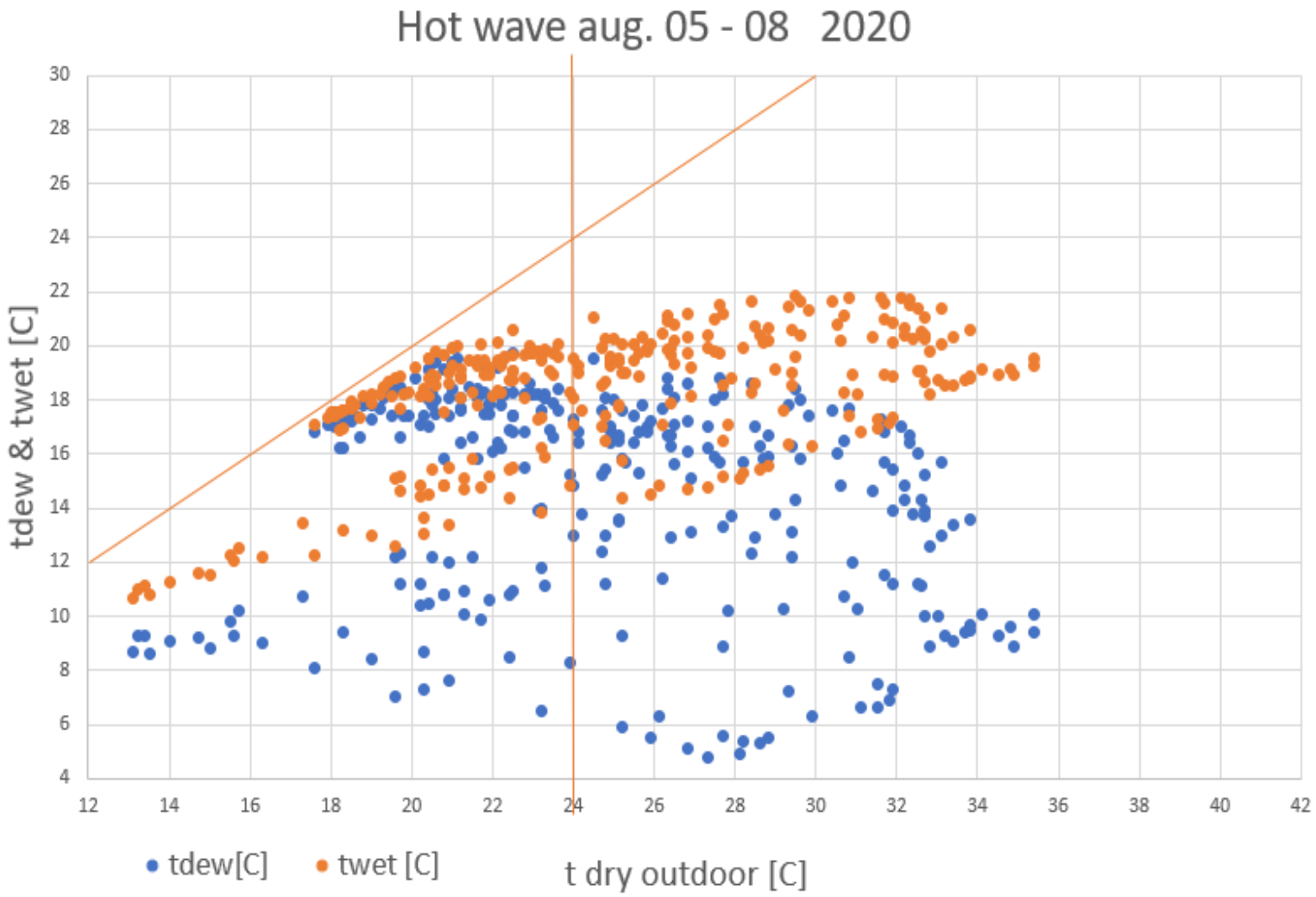
HOT WAVES : t_dry, tdew, twet [C]



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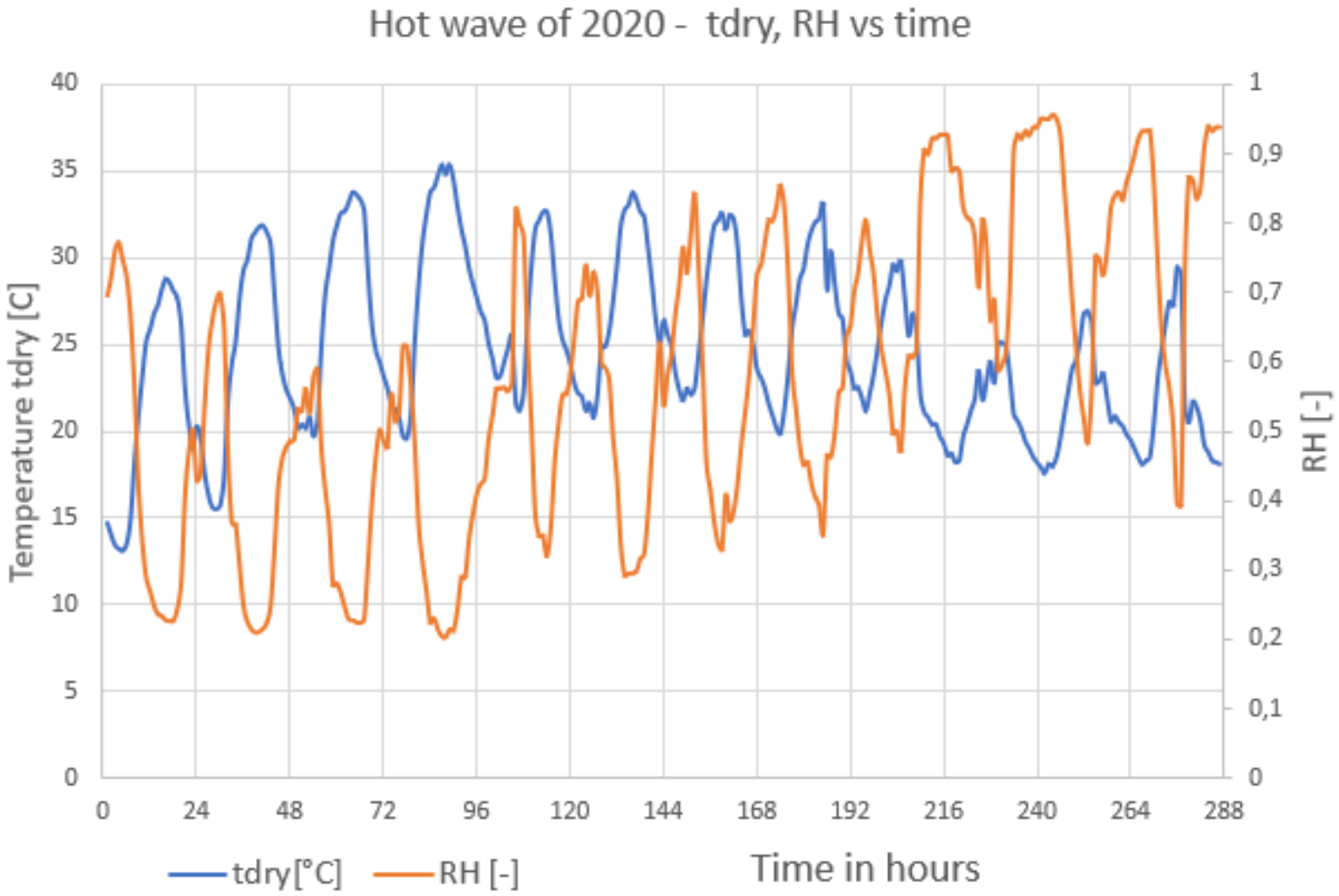
Hot wave of 2020 - tdry, RH vs time
Temperature tdry [C]
RH [-]
Time in hours
tdry[°C]
RH [-]
0
5
10
15
20
25
30
35
40
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
0
24
48
72
96
120
144
168
192
216
240
264
288

Belgian climate data

XMS > extreme year :

Not just TMY files … why a limitation of '1 typical year hourly' ?

It is interesting and increasingly essential to take into account the extreme conditions !

> Drury B. Crawley, Linda K. Lawrie at *14th Conference of International Building Performance Simulation Association, Hyderabad, India, Dec. 7-9, 2015*.

RETHINKING THE TMY: IS THE 'TYPICAL' METEOROLOGICAL YEAR BEST FOR BUILDING PERFORMANCE SIMULATION?

http://climate.onebuilding.org/papers/2015_12_Crawley_Lawrie_Rethinking_the_TMY.pdf

> Introduce the idea of XMY eXtreme Meteorological Year files

> Drury B. Crawley, Linda K. Lawrie **in** *Proceedings of the 16th IBPSA Conference Rome, Italy, Sept. 2-4, 2019*

Should We Be Using Just 'Typical' Weather Data in Building Performance Simulation?
http://www.ibpsa.org/proceedings/BS2019/BS2019_210594.pdf or
http://climate.onebuilding.org/papers/2019_09%20ShouldWeBeUsingTypicalWeatherData-BS2019_210594.pdf

> Introduce a new approach in data/month selection …

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Why not Data in the futur ?

We construct now for the 50th futur years, equipment are selected for 20 next year !

Considering the GIEC different scenario … and meteorological model … the goal is to generate a « T or XMY » in the futur … !

- **IEA Annexe 80** - Resilient Cooling of Buildings -Task Force Weather Data
  - ***Anaïs MACHARD*** from University of 'La Rochelle' France
    - With data from the CORDEX Project construct Typical Year in the futur and predicte hot wave.
    - The Methodology is describe in ref : https://www.mdpi.com/1996-1073/13/13/3424
    - See also https://www.sciencedirect.com/science/article/pii/S0306261916307127

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Why not Data in the futur ?

- ***Xavier FETTWEIS, Sébastien DOUTRELOUP*** Ulg Laboratory of Climatology www.climato.be

  some study and recent work [provide data for OCCuPANt project]
  - RCM : regional climate model [MAR] applied to belgium
  - TMY/XMY futur weather files for belgian cities -> 2100

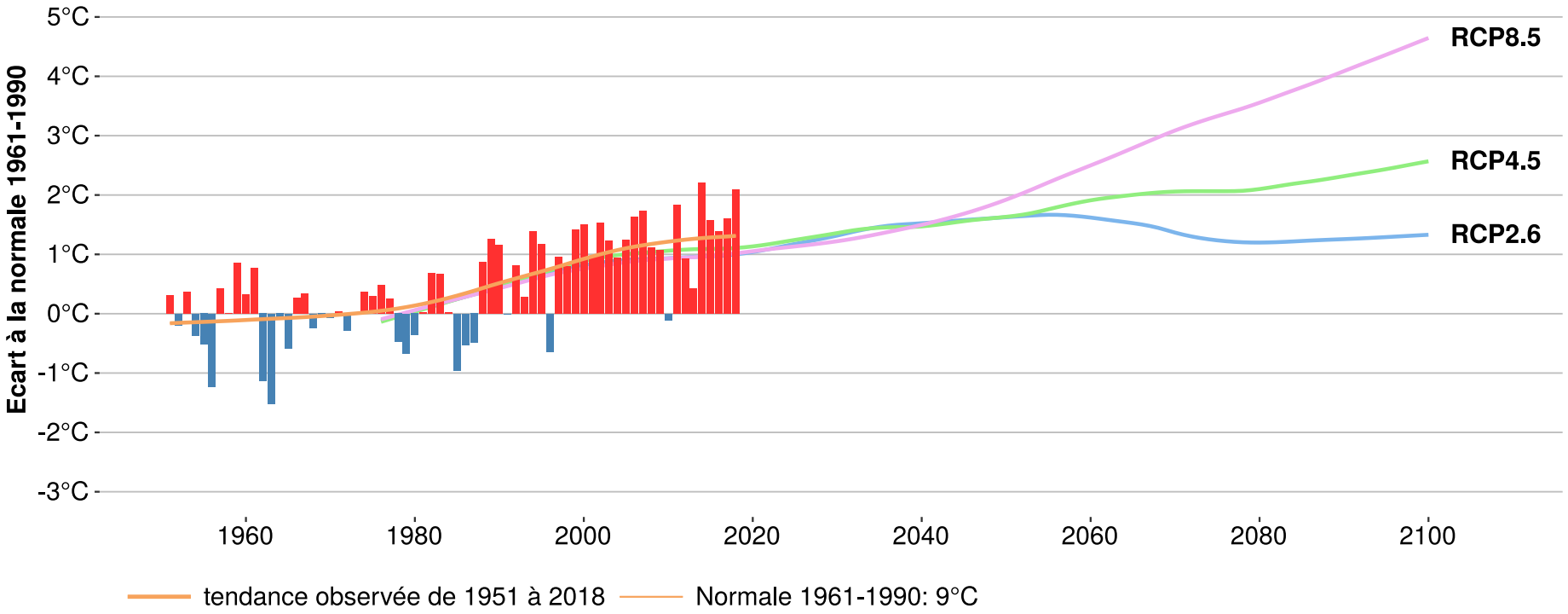
- « Two » choices :
  - The « socio-economic development scenario (choice of **one** of the scenarios selected by the IPCC RCP/SPP …)
  - The climate/meteorological evolution model choice of **one** !

This is the great game of assumptions and uncertainties but it has undoubtedly become essential !

Belgian climate data

Evolution de la température annuelle moyenne en Belgique

Projections climatiques jusqu'à 2100 selon 3 scénarios d'émission de GES (RCP2.6, RCP4.5 et RCP8.5).
Observations de 1951 à 2018 (moyenne de 8 stations historiques)



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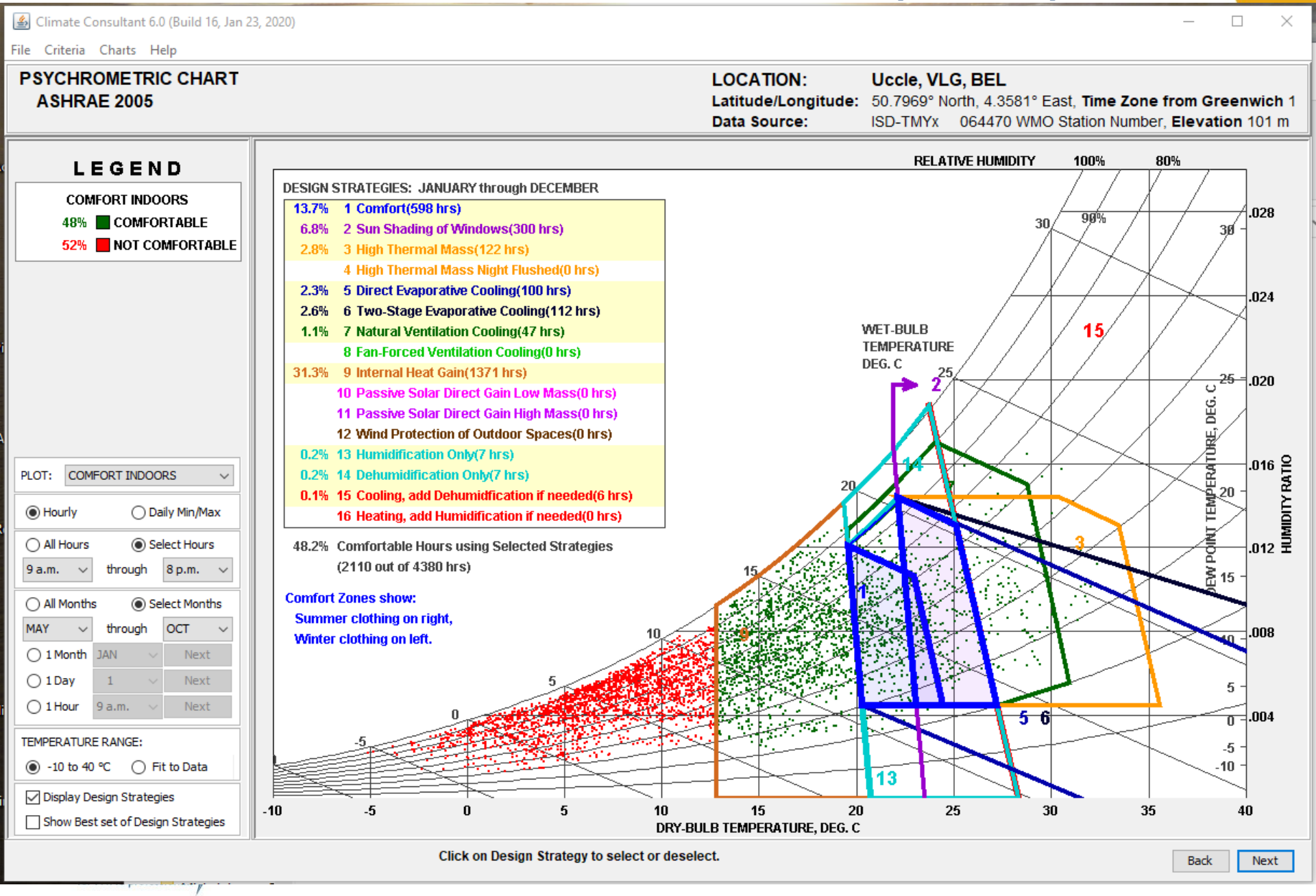
Climate consultant visualization of the Uccle [2004-2018] TMY file



Belgian climate data

Conclusions

After the observation of the “advanced age” of our climate data and the research to recent data for the 21st century,

a new observation has imposed itself on us - research is already a step further. Beyond the energy balances, we must focus on the extreme situations, more frequent in the recent past and “also” in the future.

We have up-to-date climate data.
It remains to continue to explore and use the data. Clarify what are the measured and calculated data … How they are measured or calculated …

Keywords for “Cooling” are : adaptation, resilience, sustainability

... IEC is certainly part of the answer.

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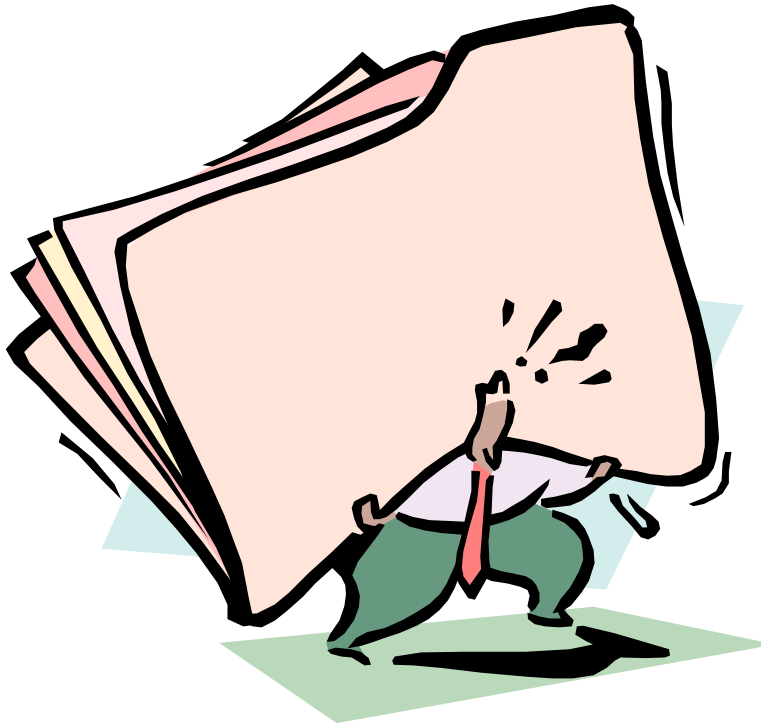
Thank you for your attention



what feels like
the End
is often
the Beginning

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Real-time weather reports …
https://www.meteoblue.com/fr/meteo/archive/yearcomparison/uccle_belgique_2785124

Graphical weather forecasts from climato.be
https://www.climato.uliege.be/cms/c_5652758/fr/climato-meteogrammes

About weather stations in Belgium
https://www.meteo.be/fr/a-propos-irm/reseau-d-observation/stations-automatiques
(we can read that: The collection and dissemination of these observations is an international obligation of national meteorological services.)

IWEC (old) : https://energyplus.net/weather-region/europe_wmo_region_6/BEL%20%20

IWEC2 http://weather.whiteboxtechnologies.com/IWEC2
one station 40$ [+-34€] - pack 21 belgian stations 110$ [+-92€]

TMY3 https://meteonorm.com/en/buy#licences 1 year subscription full world access
675 CHF/an [+-615€/an]

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Year of the month in de TMY file.

	Jan.	Fev.	Mar.	Avr.	mai	juin	juil	aout	sept	oct	nov	dec
IRM/UCL	1967	1972	1967	1962	1960	1960	1958	1962	1958	1967	1968	1975
TMY2	-	u	n	k	n	o	w	-	un	kn	ow	-
IWEC	1986	1999	1983	1985	1997	1990	1991	1998	1983	1983	1983	1998
JRC 05-14	2009	2012	2014	2010	2011	2013	2011	2011	2013	2013	2013	2011
JRC 07-16	2013	2008	2011	2016	2011	2014	2014	2015	2010	2015	2009	2009
OneBuilding 04-18	2005	2016	2010	2010	2014	2006	2017	2016	2004	2004	2012	2016

	Data available in the files
IRM/UCL	Tdry, x, relhum, tdew, twet, wind speed, Ibeam, Ihdiff, Ihglob ! [No patm.]
TMY2	Tdry, Tdew, relhum, patm., Ibeam, Ihdiff, Ihglob, wind speed, wind dir., precip. ++
IWEC	Tdry, Tdew, relhum, patm., Ibeam, Ihdiff, Ihglob, wind speed, wind dir., ++
JRC 07-16	Tdry, relhum, Ibeam, Ihdiff, Ihglob, wind speed, wind dir., patm., LWinfra
OneBuilding	Tdry, Tdew, relhum, patm., Ibeam, Ihdiff, Ihglob, wind speed, wind dir., ++

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Belgian climate data

TMY, analyzes in IEC perspective :

Number of hours in the **very old** **Belgian IRM/UCL** weather file, **tdry vs twb [wetbulb]**

Hours	**tdry>=23**	**tdry>=24**	**tdry>=25**	**tdry>=26**	**tdry>=27**	**tdry>=28**	**tdry>=29**
max	147	100	57	30	22	11	5
twb<=14	0	0	0	0	0	0	0
twb<=15	5	1	1	0	0	0	0
twb<=16	23	4	2	0	0	0	0
twb<=17	59	29	7	0	0	0	0
twb<=18	81	64	13	3	1	0	0
twb<=19	109	77	24	6	3	0	0

tdry>=24 [C] and twb <=17 [C] => 29h /100h in old file !

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Belgian climate data

TMY, analyzes in IEC perspective :

Number of hours in the **New Belgian 2004-2018 UCL** weather file, **tdry vs twb [wetbulb]**

Hours	**tdry>=23**	**tdry>=24**	**tdry>=25**	**tdry>=26**	**tdry>=27**	**tdry>=28**	**tdry>=29**	**tdry>=30**
max	363	248	174	123	90	57	32	17
twb<=14	12	2	0	0	0	0	0	0
twb<=15	40	22	7	0	0	0	0	0
twb<=16	93	51	19	6	5	0	0	0
twb<=17	143	72	32	16	11	5	3	0
twb<=18	205	113	65	39	22	13	7	0
twb<=19	272	167	17	68	45	28	13	4

tdry>=24 [C] et twb <=17 [C] **=>** 72h / 248h in new file vs. 29h /100h in old file

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Belgian climate data

TMY, analyzes in IEC perspective :

Number of hours in the **very old** **Belgian IRM/UCL** weather file, **tdry vs tdp [dewpoint]**

Hours	**tdry>=23**	**tdry>=24**	**tdry>=25**	**tdry>=26**	**tdry>=27**	**tdry>=28**	**tdry>=29**
max	147	100	57	30	22	11	5
tdp<=14	81	47	17	5	2	0	0
tdp<=15	92	55	23	6	3	0	0
tdp<=16	106	65	27	9	4	1	0
tdp<=17	128	83	42	18	12	5	3
tdp<=18	136	90	48	23	15	7	5
tdp<=19	145	98	55	28	20	10	5

tdry>=24 [C] et tdp <=17 [C] => 83h/100h = +- 10 days average of 8h/day

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Belgian climate data

TMY, analyzes in IEC perspective :

Number of hours in the **New Belgian 2004-2018 UCL** weather file, **tdry vs tdp [dewpoint]**

Hours	tdry>=23	tdry>=24	tdry>=25	tdry>=26	tdry>=27	tdry>=28	tdry>=29	tdry>=30
max	363	248	174	123	90	57	32	17
tdp<=14	227	142	96	69	50	33	18	8
tdp<=15	265	173	121	87	63	41	23	12
tdp<=16	295	197	138	97	72	47	26	14
tdp<=17	321	213	148	103	75	49	28	15
tdp<=18	337	226	155	109	79	50	28	15
tdp<=19	351	237	163	114	82	52	30	16

tdry>=24 [C] et tdp <=17 [C] => 213h/248h = +- 26 days ave. 8h/day => 5h to 12h/day

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Belgian climate data

DEGREE-HOURS DH :

Setting and reference temperature : 23 to 26°C
***n** new file [2004-2018] , **o** old file [1958-1975] , **dp** dewpoint, **wet** wet bulb*

	Degree_hours tdry	
Set [C]	DH_n	DH_o
23	909	286
24	614	164
25	407	91
26	264	53

Cooling if t>24 C	« Degree_hours » new file		« Degree_hours » old file	
T_{H2O} set [C]	DHdp	DHwet	DHdp	DHwet
24	2705	1470	959	558
20	1720	527	559	180
17	1030	106	281	17

Ex: **tref setting** = 24 C **tdry** = 30 C ϕ=0.4 **t dewpoint** = 14.94 C **t wetbulb** = 20.06
tdry >= tref setting OK **T_{H2O} set** = 17 C
DH=30-24=6 **DHdp** = 17-14.94=2.06 **Dhwet** = 17-20.06=0 (<0!)

DH ~ charge Dhwet et DHdp ~ max available for Cooling IEC

Cooling if t >24 C	« Degree_hours » new file		« Degree_hours » old file	
T_{H2O} set [C]	DHdp	DHwet	DHdp	DHwet
24	2705	1470	959	558
20	1720	527	559	180
17	1030	106	281	17

Cooling if t>20 C	« Degree_hours » new file		« Degree_hours » old file	
T_{H2O} set [C]	DHdp	DHwet	DHdp	DHwet
24	10228	6285	5798	3869
20	6715	3115	3810	1903
17	4155	990	2361	640