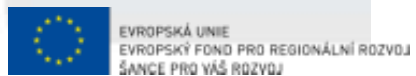


Physics and Health

February 2025

Jan Hollan,
Public Health Department
Faculty of Medicine, Masaryk
University



film **Wake up, Freak out** (12 min)

- The ever increasing (and huge already) influence on public health: **climate change**
- caused by **global warming**
- which is caused by the fact that **greenhouse effect** became stronger
- and that mainly due to **CO₂ from fossil fuels**

1. Climate change

Why is our Earth warming?

The **greenhouse effect** became stronger...

Greenhouse effect: *A process in which*

the planet **surface is irradiated** not just by the Sun, but **by the radiation emitted by the planetary atmosphere as well**

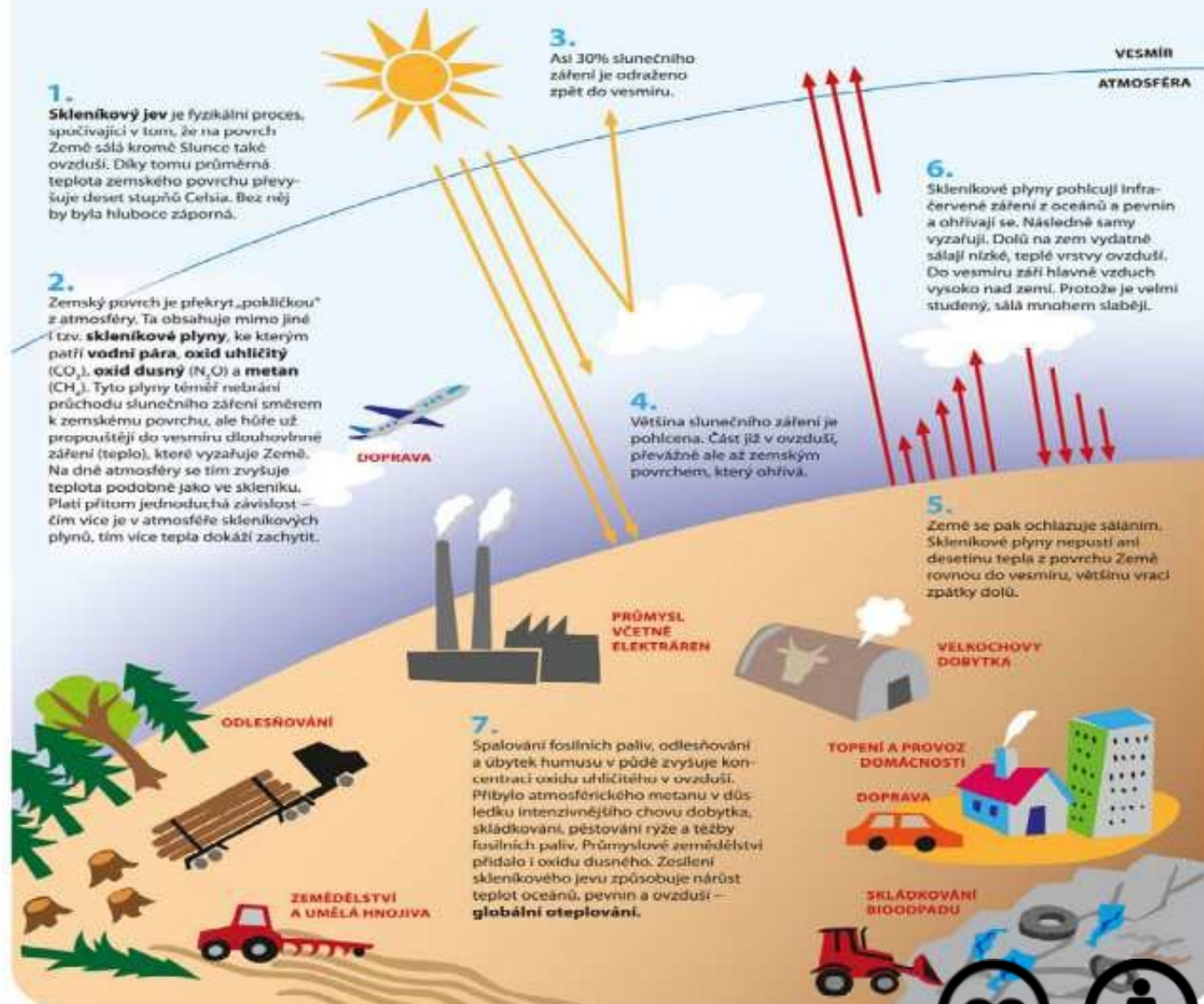
The essence of greenhouse effect is the **higher transmissivity of the air for solar radiation** (of wavelengths mostly below 3 μm) **than for the radiation of Earth surface and of the air itself** (mostly over 3 μm , i.e., longwave infrared).

In case of a greenhouse, the additional downward radiation is emitted by the glass or plastics transparent to solar radiation. In case of the atmosphere, the emitting substances are just such gases, whose molecules are composed by more than 2 atoms – the greenhouse gases.

The process can be viewed from the opposite direction as well: **radiation escaping to the space comes mostly not from the warm surface, but from the very cold air at large heights.**

(Radiation of the Sun, as well as that of the parts of the Earth – of the air, soil or sea is caused by their temperatures. As all radiation, it is a heat transport.)

Schéma skleníkového efektu a zdroje skleníkových plynů z lidské činnosti



source: Veronica, designer Olga Pluháčková;



please study the [fully readable czech/english pdf file](#)
version of the poster

How strong is the downward radiation of the atmosphere?

A square metre of the surface gets, in average, **third of a kilowatt** of this (longwave) infrared radiation

Absorbed **Solar radiation** per metre square of Earth surface is **twice lower!**

The natural greenhouse effect is very strong indeed:

twice stronger than sunshine absorbed by Earth surface

and so its, actually rather small, one-per-cent **increase**, caused by us adding greenhouse gases (carbon dioxide from fossil fuels mainly) to the atmosphere,

causes a never-seen warming of the planet

More information on physics of that warming, its man-made causes, impacts of climate change and the mitigation of the warming see at: <http://amper.ped.muni.cz/gw/activities/>

Here we limit ourselves to its *health effects*.

Drought

- in Czechia, just the profits in agriculture are affected, and some discomfort for inhabitants may happen
- ***in regions which were always rather dry***, but still quite productive in recent past, thanks to winter precipitation, **the decline of precipitation together with temperature increase results in disruption**
- In Syria due to dry winters 2007-2009? Maybe not. But see an overview www.worldwater.org/water-conflict/
- disruption due to drought affected Somalia, Sudan, Afghanistan, drought expels people from Mexican countryside

Loss of livelihood leads to

- conflicts, up to a civil war
- disassembly of state structures
- migration inside the region
- emigration of the strongest ones or those who are subsidised by relatives in a hope that they might be able to send back enough money in future, so that the families remaining in their original countries may be able to live there decently

Another deterioration or loss of livelihoods

- deluges and floods (long-lasting, uncommonly strong monsoon precipitation, short and extremely intense ones from hurricanes-typhoons-cyclones)
- devastation by extreme wind
- *in both cases, loss of access to potable water, health care and resulting morbidity and mortality*
- *(The Conversation, 2018-01-25 and The Lancet 2018-10-11, Feb 2025 article on Portorico); Mortality caused by tropical cyclones in the United States: average over 7000 per event, within 15 years after (Nature 2024)*
- “merely” altered weather patterns, making food production (common for many preceding generations) more complicated up to impossible
- less food from sea (warming, acidification, [anoxia](#))
- and [sea level rise](#)
- [Climate-induced stressors to peace: a review of recent literature](#) (2021)

Stable climate – the most important natural source

- functioning the whole Holocene (>10 000 a)
- enabled the developement of civilisation in various Earth regions
- but we have lost it already, due to our emissions
- further loss can – should – has to be slowed down
- we are not doing that, just wishing:
[Paris Agreement](#)...: keep global warming well below 2 K, as close to 1,5 K as possible
- but we have warmed the Earth by 1.5 K already

Any consumption,
if fed by fossil fuels
and not being indispensable,
is immoral

- This concerns almost all **heating, travel, electricity**
- and also **production** of anything (how much fossil carbon has been consumed for it is reflected by the product price).
- Production depends on **discarding and repeated buying of new products.**

Addendum:

we did not speak about **emissions of methane** and nitrous oxide. To lower them, a **grand reduction of milk products and meat is needed**, implying a **much larger proportion of vegetable-based food**. This would be beneficial to health directly as well. *Anybody who is not a vegan can contribute to such transition...*

From an encyclical letter *Laudato si'* of Pope Francis *on Care for our Common Home*

14. I urgently appeal, then, for a new dialogue about how we are shaping the future of our planet. We need a conversation which includes everyone, since the environmental challenge we are undergoing, and its human roots, concern and affect us all. ...

(see [its full text](#) on the Vatican site – *if you did not study it yet, please do it now*; it is the most thorough view of the problems of our world, available in many languages)

51. ...There is a pressing need to calculate the use of environmental space throughout the world for depositing **gas residues** which have been accumulating for two centuries and have created a situation which currently affects all the countries of the world. The **warming caused by huge consumption on the part of some rich countries has repercussions on the poorest areas of the world**, especially Africa, where a rise in temperature, together with drought, has proved devastating for farming. ...

and a quote by Prince Charles:

„The efforts to lower the amount of greenhouse gases through international agreements is welcome, but they come, unfortunately, ten years too late.“

and a quote by Prince Charles:

„The efforts to lower the amount of greenhouse gases through international agreements is welcome, but they come, unfortunately, ten years too late.“

- the quote is from a leaflet on Greenhouse Effect issued by the Okologie-Institut in Austria in...

1991

A concrete problem: Heat waves

- Czech etc. problem is, we are not accustomed to them (they are dangerous for old people mainly)
- in hot, rich countries an evident rise of mortality (see [an article from 2014 on Arizona](#))
- Incredible [heat wave in Canada 2021](#)
- in very hot and humid regions, an emergence of situations when people die from overheating even when avoiding any physical activity (their basal metabolism produces more heat than evaporative cooling can carry away)
- (basal metabolism: ~ 100 W)
- „wet bulb temperature“ - what is it? (*preparation and observation*)

A thorough overview: The Lancet

The Lancet Countdown on health and climate change:

from 25 years of inaction to a global transformation for public health

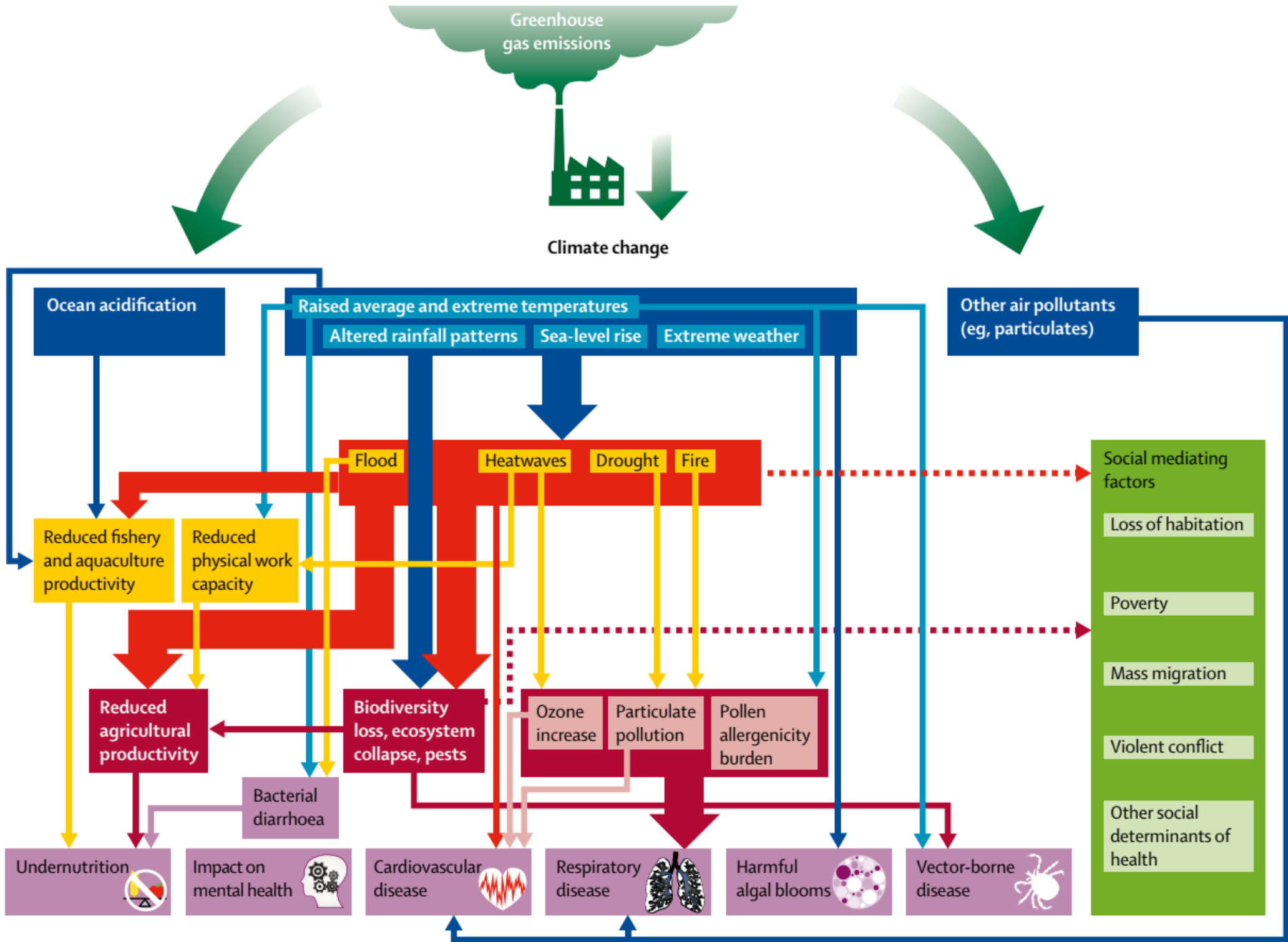
- [a 2017-10-30 article](#)
- Each autumn there is a new
- <https://www.lancetcountdown.org/>

2018: The Lancet

The 2018 report of the Lancet Countdown on health and climate change:

shaping the health of nations for centuries to come

- From [2018-11-28](#). Including the scheme:



The [2019 report of The Lancet Countdown](#) on health and climate change:

ensuring that the health of a child born today is not defined by a changing climate (the best, detailed and fully up-to-date source on climate crisis and health – please, read it)

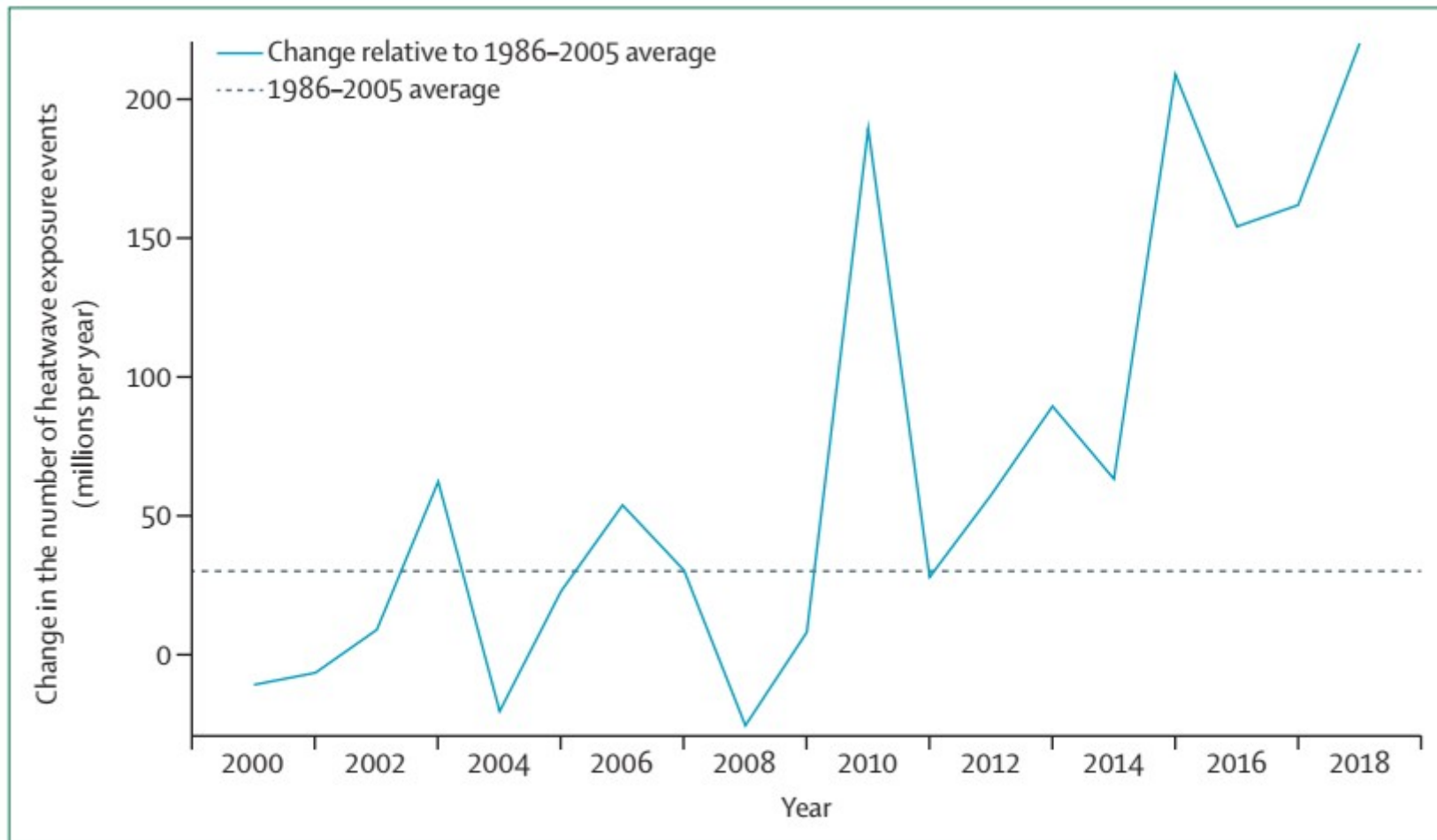
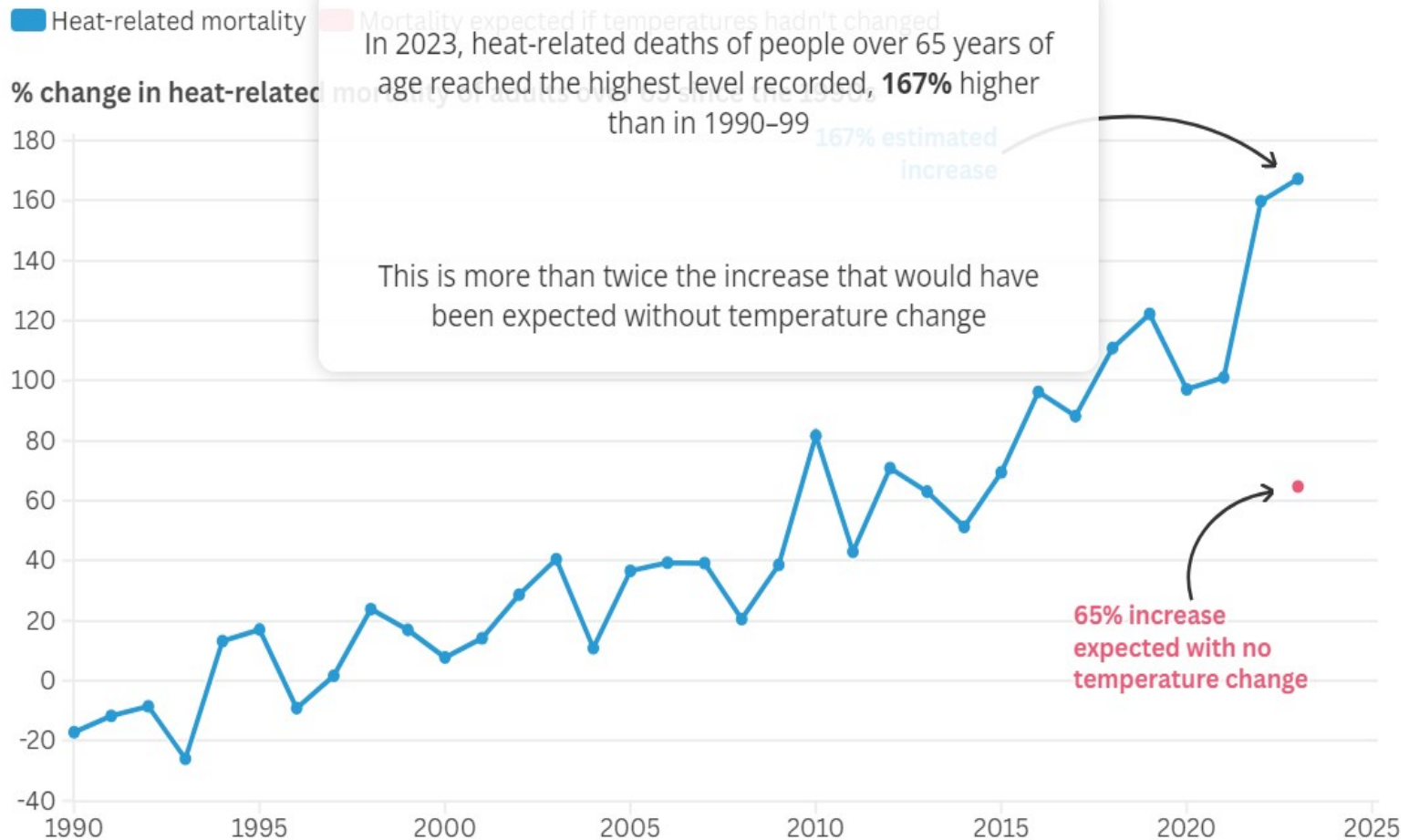


Figure 1: Change in the number of heatwave exposure events in people aged 65 years and older, compared with the historical 1986–2005 average number of events

A figure from
<https://lancetcountdown.org/2024-visual-summary/>

Health-Threatening High Temperatures

Annual deaths of adults over 65 years of age attributable to health-threatening high temperatures attributable to human-induced climate change compared to counterfactual without human-induced climate change



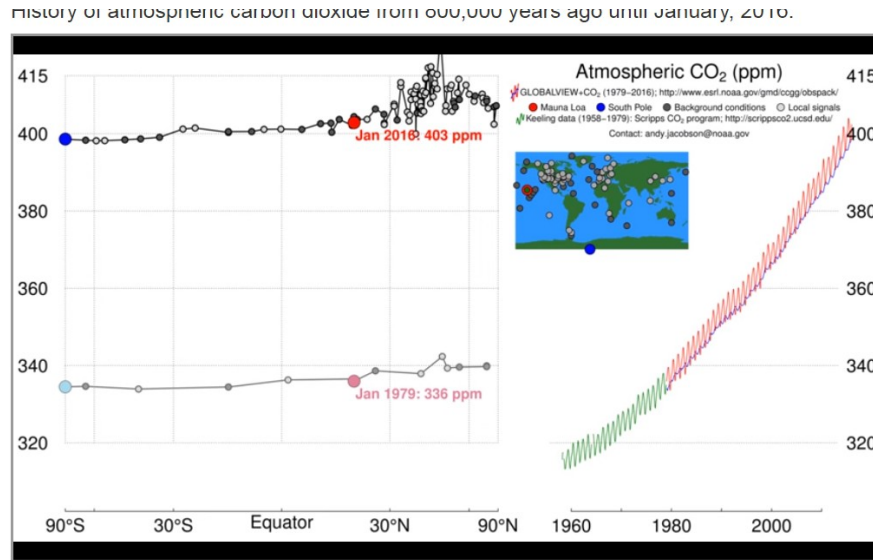
Please reference the 2024 Report of the Lancet Countdown if using this data •
For a full description of the indicator, see the 2024 report of the Lancet Countdown at lancetcountdown.org



2. CO_2 as *an indicator of air purity indoors*

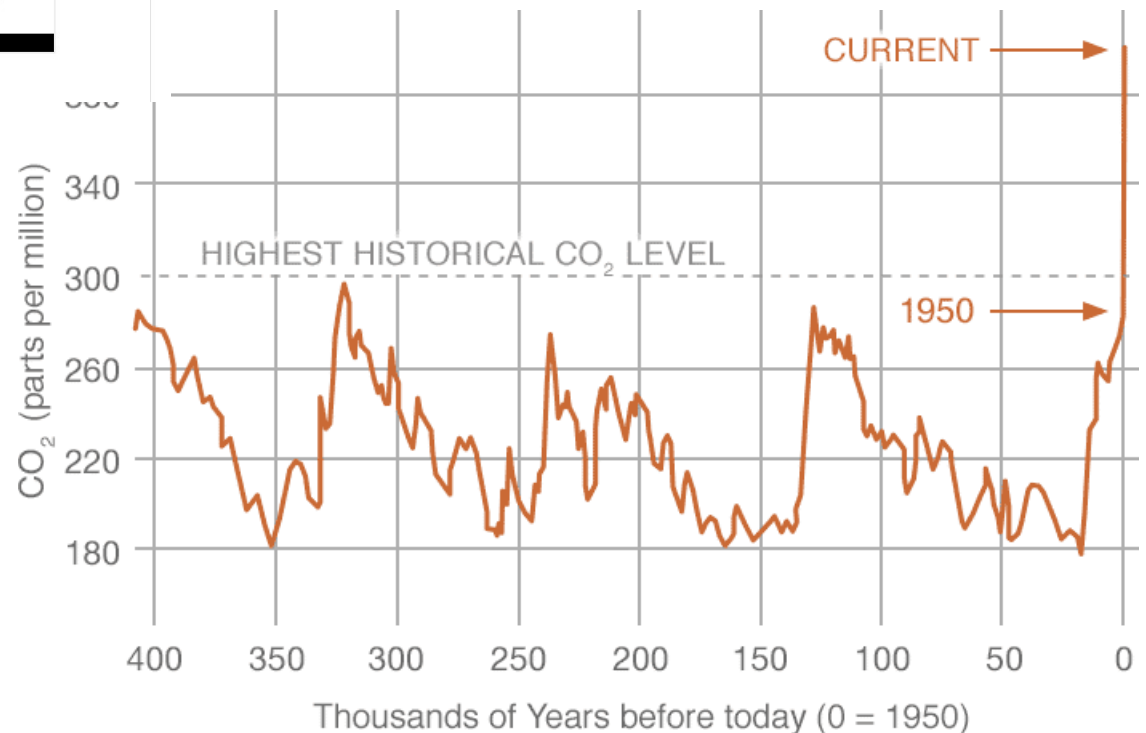
- Metabolism: oxidation of ingested sugars, fats, proteins
- Its main products: CO_2 and H_2O in exhaust air
- - both about 40 g/h
- water vapour goes away together with odours and salt by skin too (perspiratio invisibile)
- another stuff is expelled as a part of urine

Keeling curve



Download full-resolution version of this animation (warning: large file, ~50 MB)

CO₂ concentration was
0.28 ‰ centuries ago,
now it went over 0.4 ‰.
It was always below
0.30 ‰ during
Quaternary



an animated graph of CO₂ - see www.esrl.noaa.gov/gmd/ccgg/trends/history.html

Has $>1 \text{ ‰}$ of CO_2 a health effect in itself?

- is that possible?
- if we breath out...

how many per cent of carbon dioxide?

Has $>1 \text{ ‰}$ of CO_2 a health effect in itself?

- is that possible?
- if we breath out **5 % of carbon dioxide?**
- sometimes we hear that “the oxygen is consumed” – but its amount in the exhaled air is whole 16 % (from the original 21, minus 5 from carbon oxidation), so its partial pressure is like in 2500 m height in mountains (Alps etc.)
- (see ev. <https://en.wikipedia.org/wiki/Breathing>)
- on oxygen in the Earth atmospehre see a chapter 7.2, *A question to contemplate: Do we need trees to produce oxygen?* – in a book [Climate and Flows of Substances](#) (2015)

No, < 2 ‰ of CO₂ has no health effect in itself!

- Some old experiments claimed that even such a very low concentration in the inhaled air affects cognitive performance
- A [thorough study](#) (2023) showed no effect
- So, CO₂ is but a [proxy for odours](#) which cause sleepiness and decline of attention
- and a proxy for possible pathogens from infectious persons
- relative humidity is less suitable as a proxy, as building materials and furniture buffer its variation

3. *What to do during heatwaves*

- Don't go outside in the afternoon
- Take siesta as people in southern countries
- Minimalise physical activity
- (Announce heat holidays)
- Drink generously (be aware that old people have no lust to do so – *how should we help?*)
- Avoid heat intrusion indoors – ***how?***
- Cool the interior by intense ventilation late at night and early morning

Protecting indoors against heat

- Let just that much sun in, what is needed for illumination (blue sky is preferred)
- That needs movable shades at window exteriors
- Sky-lights, when high enough (so that direct sunlight remains there together with heated air) are very good for that
- Afternoon ventilation just through „Komfortlüftung“, a device shifting the heat from inlet air stream to outlet one (so-called heat recovery, better known from its winter use)
- Just fans agitating the air instead of open windows draught (*know the ceiling ones? And the „computer“ ones at <12 V?*)

What hinders a generous nighttime ventilation?

- Institute rules
- Draught is difficult to achieve in appartement houses at windstill weather
- Fears that something or somebody will com through open doors or windows (*how to avoid it without compromising ventilation?*)
- Lack of being used to do that
- We have „air conditon“, so what? (*what it is in fact, what harm it does*)

4. *The notion of „room temperature“*

- Having a constant temperature may suite a laboratory (together with humidity, eventually).
- Is it a reasonable target for living rooms and so on?
- Is it practical, comfortable and healthy to maintain the same indoor temperature both during frosts and heat waves?
- What temperatures used to be at home and in offices 100 years ago in the course of the day and year?
- What are the „temperatures in various directions“ in common rooms during frosts?
- Temperatures of what? Of the „bulb“... affected by what?

Passive standard for buildings

- means winter interiors without significant temperature gradients
- without cold air draughts
- and so without a need of very warm surfaces (radiators, stoves) – let's realise that in warmer periods, when even sub-standard buildings have no cold windows and corners, we don't need such heating surfaces, even if the indoor air is cooler than it is commonly in winter

What are the thermometer readings in the rooms used by you?

- *(discussion, reports on leaflets)*
- animals in our latitudes adapt seasonally to differing temperatures
- people did so too, in the past
- the advantage of that was a larger basal metabolism in cold periods
- (mediated by a shortening daylight length, too, probably)
- most of us don't have this seasonal adaptation now

~18 °C is enough

Heating homes to at least 18 °C in winter poses minimal risk to the health of a sedentary person, wearing suitable clothing.

Daytime recommendations

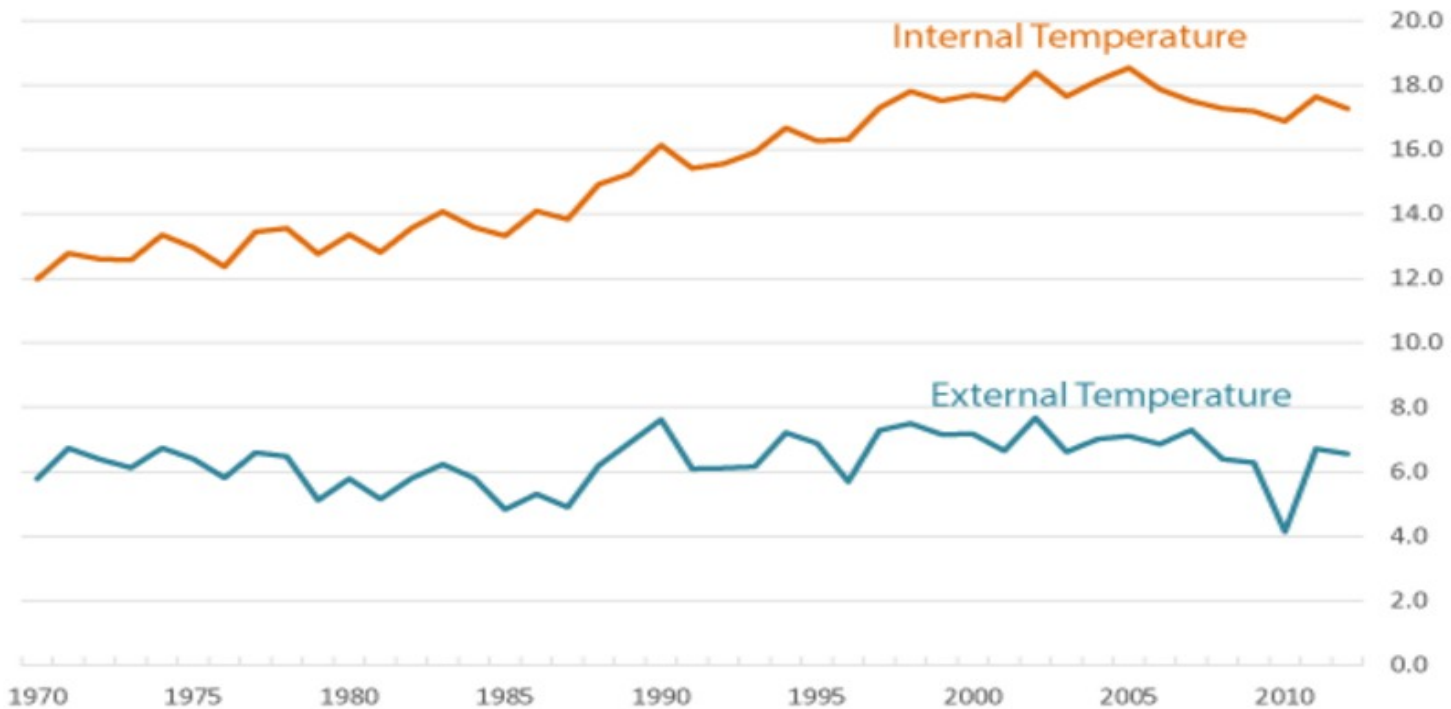
- The 18 °C threshold is particularly important for people **over 65yrs or with preexisting medical conditions**. Having temperatures *slightly above this threshold may be beneficial* for health. But even lower ones are often no problem: “[Winter thermal comfort and health in the elderly](#)”, Hughes et al., 2019

- The 18 °C threshold also applies to **healthy people (1 – 64)***. *If they are wearing appropriate clothing and are active, they may wish to heat their homes to slightly less than 18 °C*

Evolution of average temperatures of British interiors

Average internal and external winter temperature (°C)

Figures based on the average modelled temperature from October to March



Source: Energy Consumption in the UK (ECUK), 2015 data tables

Staying in (common long ago) cool environments increases the amount of Brown Adipose Tissue and so the ability to heat oneself when appropriate

- Not only is the life more comfortable during winter (cold is often not perceived as unpleasant)
- see *Human whole body cold adaptation*, ([Temperature, 2016-02-22](#))
- but it can be **a way to counter overweight and obesity**
- See a collection of references on temperatures <https://www.zotero.org/jenikholan/collections/5SU2KAUH>

5. What relative humidities do we encounter; which ones are harmful

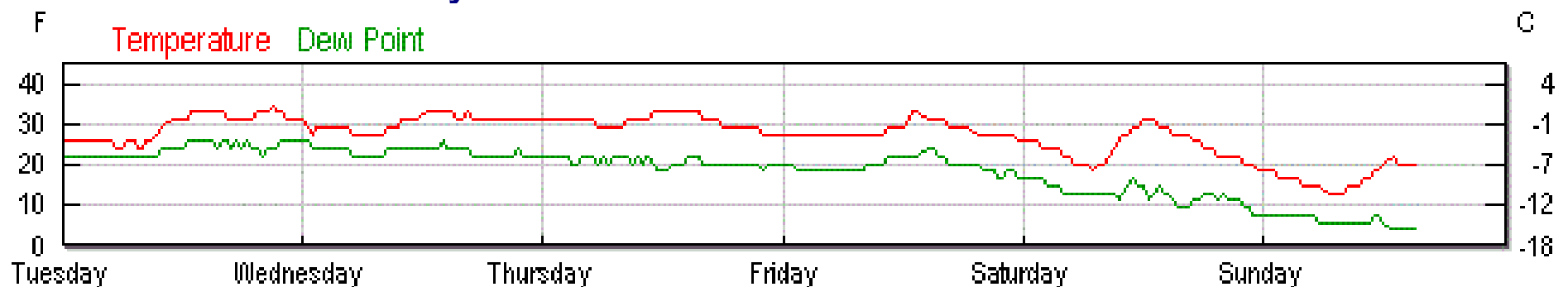
- relative humidity: ratio of water vapour content to that one, when the air would be saturated
- absolute humidity: grammes of vapour in one cubic metre of air
- during frosts, the abs. humidity is very low, during hot days it can be high
- when a very cold air comes indoors and is heated, its relative humidity plummets
- *a reliable measurement of rel. humidity: a pair of thermometres, one of them being wet*

When the high relative humidity harms

- **during heat waves (sultriness)** – it is preferable to dehumidify it before letting it indoors
 - how? cooling it low enough
 - the humidity won't be really low, like below 65 %, but that's OK already
- in bad (*that is, those not obeying the **passive standard***) intensely inhabited buildings **during frosts**: dampness of cold areas of walls, mainly in corners and behind furniture; mold grow
 - easy symptomatic (non-causal) help - ventilation

Low winter humidity is always bad

- how it comes to existence indoors? - *discussion*
- an unequivocal factor promoting flu incidence, see *Flu Weather: It's Not the Cold, It's the Humidity*, www.wunderground.com/cat6/flu-weather-its-not-cold-its-humidity (2018-02-09)
- For COVID-19, see [November 2022 article](#)
- history of temperature and dew point from Feb 20. to 25, 2018, Brno-Tuřany (airport); other periods see www.wunderground.com/cat6 and its [history link](#)



Prevention of dry air indoors in winter

- *let not ventilation be the more vigorous the stronger the frost*
- that is: **having the building envelope tight enough**
- in passive houses: the blower-door test (by pressure difference of 50 Pa just 0,6 of air volume can be exchanged with the exterior; practice shows, that the air-tightness can be even several times better)
- making existing building enough air-tight is not difficult, the comfort gain is wonderful (*discuss*)

6. *What should be considered a pollutant?*

- Pollutant – an ugly word...
- Pollution – a religious notion only, long ago
- Now (starting with [Silent Spring](#) - 1962 book) – anything we add to the natural environment
- chemicals, radiation, heat
- need not be just stuff not existing there before, or additions which we are aware of as harming somebody/something
- enough, if the state of environment is changed from the natural one
- as that is the proper one – paradigm of Eden

7. *What is PM, which component of it acts most toxically?*

- PM – *Particulate Matter*. That is, non-gaseous particles in the air, aerosol other than fog (other than pure water droplets).
- An index is added, meaning what amount of the pollutant is smaller than so many micrometres
- Legal limits and common measurement concerns PM₁₀; PM_{2,5} is beginning to be monitored. Both are given as microgrammes per cubic metre
- But PM₁ a PM_{0,1} are more important – a preferred way is to report numbers per cm³.

Particles around 10 μm

- agitated dust from fields and roads
- causes respiratory problems
- sediments quickly again
- A Czech example [from the CHMI](#):

Koncentrace PM v neděli 25. února 2018

25.02.2018 18:00 -
19:00 SEČ

PM₁₀

PM₁₀

PM_{2,5}

Název

Klasifikace

Kvalita ovzduší

1h
 $\mu\text{g}/\text{m}^3$

24h
 $\mu\text{g}/\text{m}^3$

1h
 $\mu\text{g}/\text{m}^3$

Název	Klasifikace	<u>Kvalita ovzduší</u>	1h $\mu\text{g}/\text{m}^3$	24h $\mu\text{g}/\text{m}^3$	1h $\mu\text{g}/\text{m}^3$
Ostrava-Českobratrská (hot spot)	dopravní	4 - vyhovující	78,0	50,9	61,0
Ostrava-Hrabová	průmyslová	2 - dobrá	24,0	37,5	
Ostrava-Kunčičky	průmyslová	2 - dobrá	34,0	30,0	
Ostrava-Mariánské Hory	průmyslová	3 - uspokojivá	43,0	28,5	
Ostrava-Poruba, DD	dopravní	3 - uspokojivá	44,0	32,2	
Ostrava-Poruba/ČHMÚ	předměstská				
Ostrava-Přívoz	průmyslová	3 - uspokojivá	61,0	51,3	52
Ostrava-Radvanice ZÚ	průmyslová	4 - vyhovující	86,0	62,0	79,0

Particles below 1 μm

- staying long time in the air
- forming also from gaseous emissions of nitrous and sulphur oxides
- the worst ones are from noncomplete burning – nanoparticles: carbon graphitic cores with giant relative surface, to which cancerogenic toxins like PAH (polyaromatic hydrocarbons) are adsorbed; so-called Black Carbon
- **they travel down to** alveolae and from them to the blood and **inside cells**
- main producer: **diesel engines** and solid fuels in small devices (households)

Measures against them

- at least, get rid of diesels whose particle filters don't work as well as they did when new
- European towns announced end of personal diesel cars within their territories in a few years
- see also the 2012 WHO European Office study

[Health Effects of Black Carbon](#)

8. *Harmful electromagnetic radiation*

- ionising (from nuclides, mainly from radon – not just gamma, beta and alpha too)
- solar (UV, but also macular degeneration of retina due to blue component after a long-year exposure) – how much sun is enough for D-vitamine production?
- man-made: **Light at Night**
(in extenso: see the slides for the 5th grade)

Light themes

- *discussion: do you have enough darkness for sleep? How do you protect yourselves from light if it disturbs you?*
- *How long do you sleep in various situations (response on leaflets)*
- Why the sleep is so important, even for studying...
- light measurement below the table, by the wall, by the window, outside, to the eyes
- yellow glasses influence

Light as a pollutant

- Light pollution – no heavy issue?
- Outdoors: **any light added artificially**
(at night) alters its natural state
- Indoors? It has no natural state, being artificial itself. As long as we light it on purpose:
 - light which could harm our health...

Darkness: a basic attribute of night

- Darkness, what's that?
- Less light than short ago
or in adjacent area.
- Common in daytime too...
- There is light outdoors in nature at night,
• but less of it below a roof or in a forest.
- No light: just totally enclosed spaces.

Day and night alteration: the basic rhythm of our world

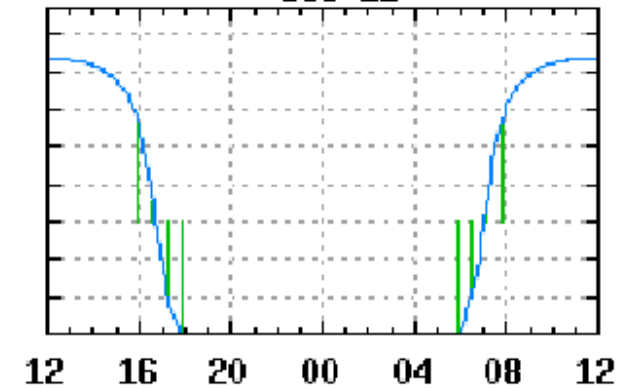
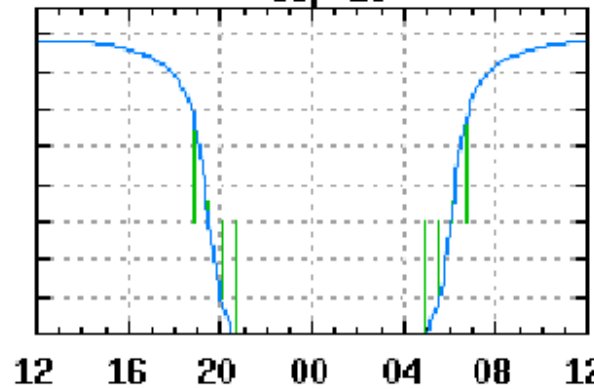
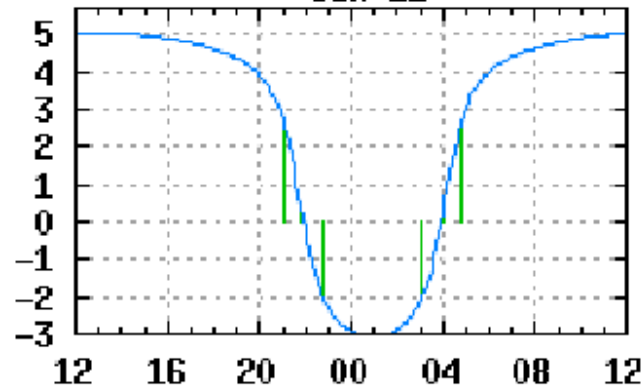
- sunny day, winter to summer, flat terrain:
30 thousand to 100 thousand lux
- 1/1000 lx at night
- overcast: 3x to 30x less
- day/night ratio: 3 millions to 1000 millions
- full moon night – 1/10 lx
(the ratio day/night diminishes 100x)

log (horizontal illuminance / 1 lx) clear sky, with/out Moon

- Jun 22

- Sep 23

- Dec 22



letní slunovrat

(6,3 h, astron. nenastává)

- 2006-09-02

rovnodennost

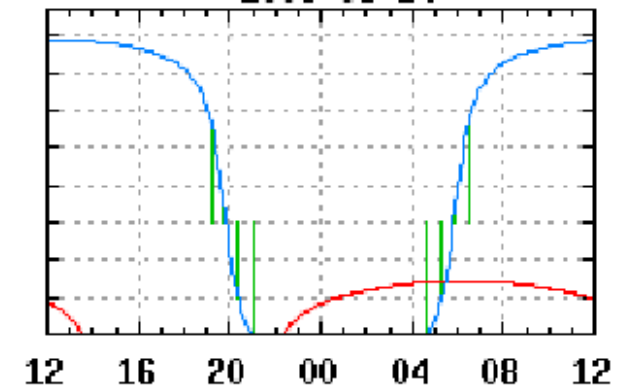
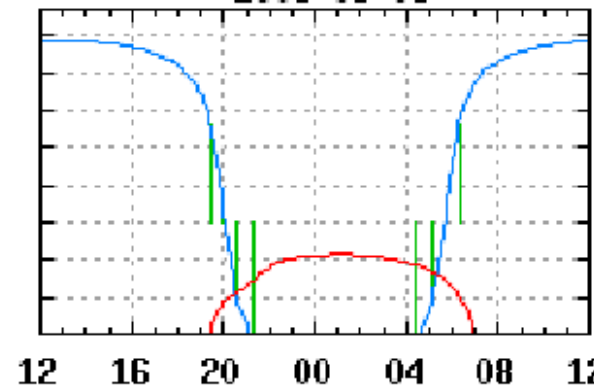
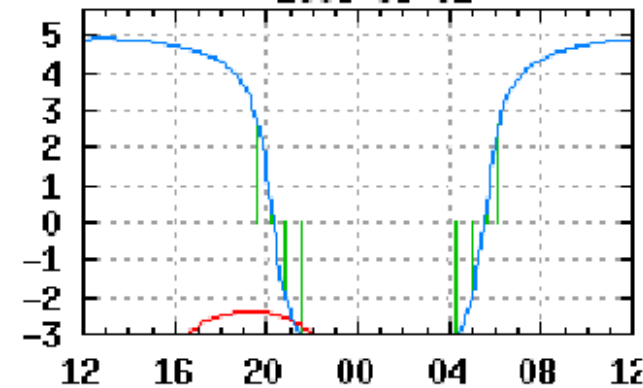
(10,7 h, 8,2 h)

- 2006-09-08

zimní slunovrat

(14,5 h, 11,9 h)

- 2006-09-14



půl dne po první čtvrti
(max. 0.004 lx, ve dne...)

úplněk
(téměř 0,2 lx)

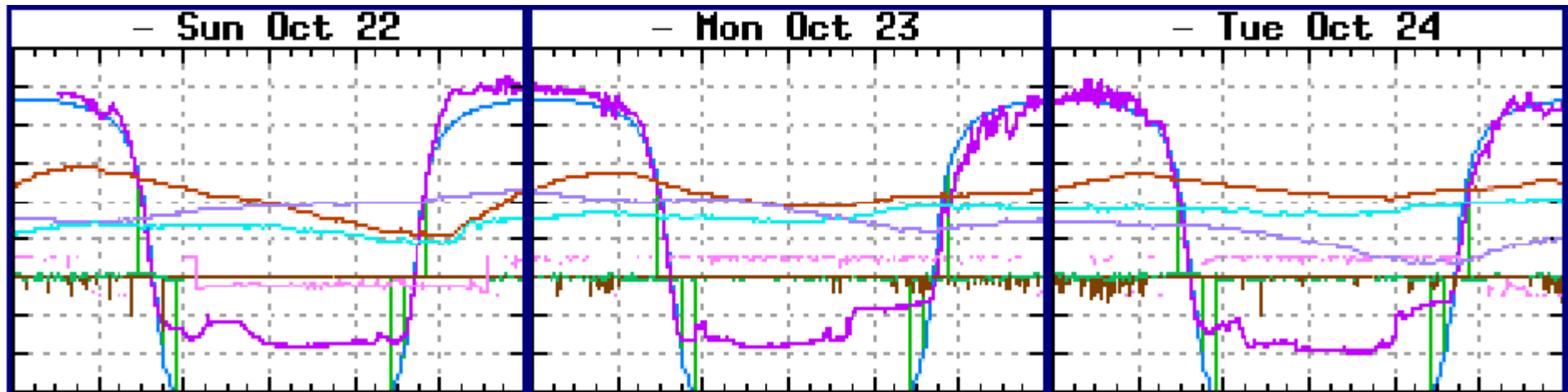
0,5 d před poslední čtvrtí
(až 0,03 lx)

And indoors?

- Orders of magnitude less light than outdoors – *originally*
- Now, tens to hundreds lux at night
- Often more than during daylight...
- *24/7*

Brno, Kuhberg

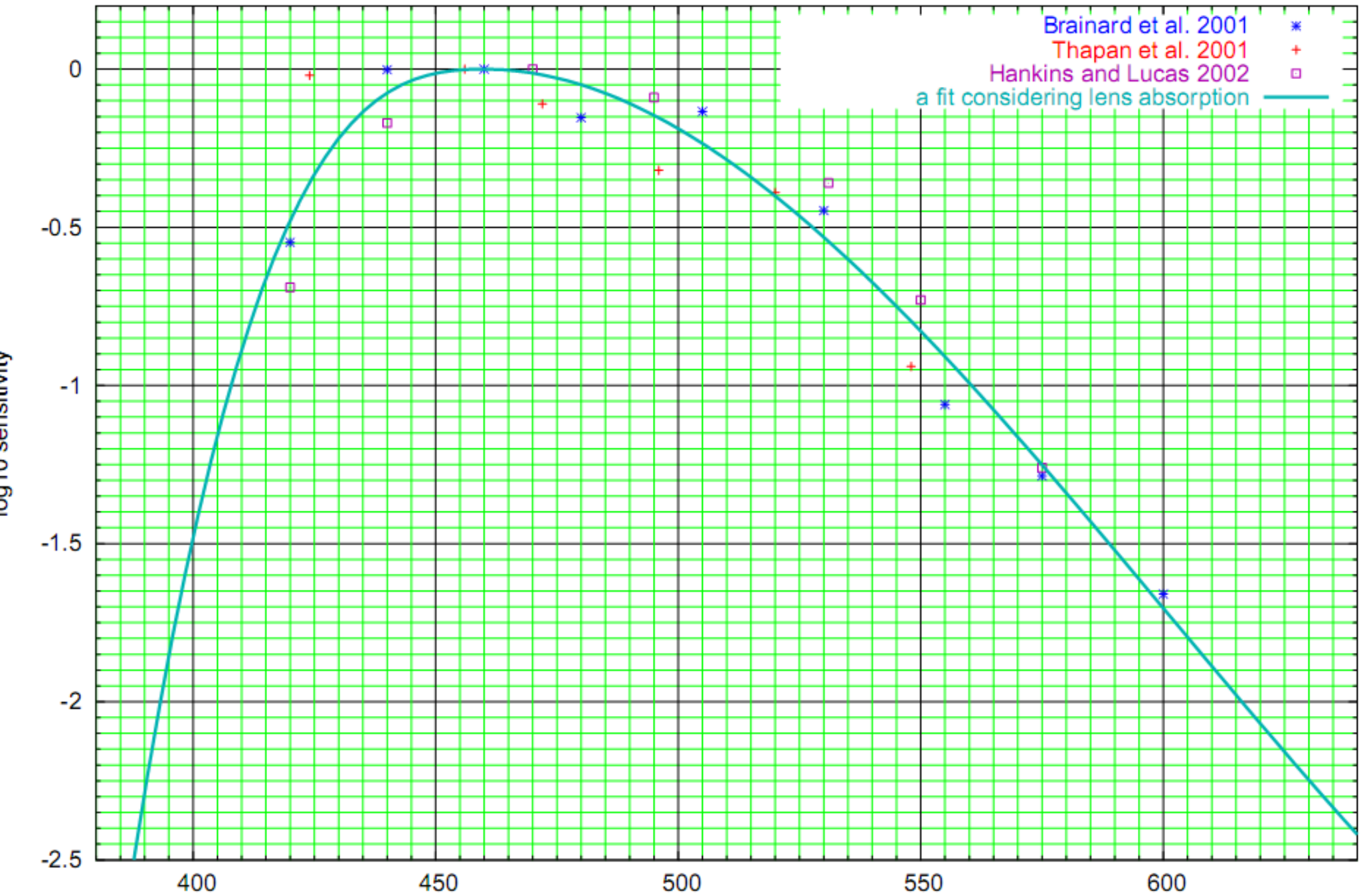
- Clear sky: 1 to 2 centilux
instead of 1 millilux
- Overcast: decilux levels



Circadian rhythm, melatonin

- natural night and melatonin production is 11 h in average (more in winter, less in summer)
- our electric culture shortened it to the sleeptime
- breast and prostate cancer, obesity, diabetes

Action spectrum of melanonin suppression by light



Stevens, R.G. Electric power use and breast cancer: a hypothesis. *Am. J. Epidemiol.* **125**, 556 (1987).

[Stevens, R.G.](#) Light-at-night, circadian disruption and breast cancer: assessment of existing evidence. *International Journal of Epidemiology* **38**, 963-970 (2009):

Background Breast cancer incidence is increasing globally for largely unknown reasons. The possibility that a portion of the breast cancer burden might be explained by the introduction and increasing use of electricity to light the night was suggested >20 years ago.

Methods The theory is based on nocturnal light-induced disruption of circadian rhythms, notably reduction of melatonin synthesis. It has formed the basis for a series of predictions including that non-day shift work would increase risk, blind women would be at lower risk, long sleep duration would lower risk and community nighttime light level would co-distribute with breast cancer incidence on the population level.

Results Accumulation of epidemiological evidence has accelerated in recent years, reflected in an International Agency for Research on Cancer (IARC) classification of shift work as a probable human carcinogen (2A). There is also a strong rodent model in support of the light-at-night (LAN) idea.

Conclusion

If a consensus eventually emerges that LAN does increase risk, then the mechanisms for the effect are important to elucidate for intervention and mitigation. The basic understanding of phototransduction for the circadian system, and of the molecular genetics of circadian rhythm generation are both advancing rapidly, and will provide for the development of lighting technologies at home and at work that minimize circadian disruption, while maintaining visual efficiency and aesthetics. In the interim, there are strategies now available to reduce the potential for circadian disruption, which include

- extending the daily dark period,
- appreciate nocturnal awakening in the dark,
- using dim red light for nighttime necessities,
- and unless recommended by a physician, not taking melatonin tablets.

- Kloog, I., Haim, A., Stevens, R.G., Barchana, M. & Portnov, B.A.

Light at Night Co-distributes with Incident Breast but not Lung Cancer in the Female Population of Israel.

Chronobiology International **25**, 65-81 (2008).

- Kloog, I., Haim, A., Stevens, R.G. & Portnov, B.A.

Global Co-Distribution of Light at Night (LAN) and Cancers of Prostate, Colon, and Lung in Men.

Chronobiology International **26**, 108-125 (2009).

- Kloog, I., Portnov, B.A., Rennert, H.S. & Haim, A.

Does the Modern Urbanized Sleeping Habitat Pose a Breast Cancer Risk?

Chronobiol Int **28**, 76-80 (2011)

Newer papers see collection [LightAtNight](https://www.zotero.org/jenikholan/library) in my public bibliograpy <https://www.zotero.org/jenikholan/library> - mainly the 2023 large article:

[Artificial light at night: a global disruptor of the night-time environment](#)

Basic rules for outdoor lighting (like in Slovenia and most of Italy)

No emissions horizontally and upwards

Using just that much light, what's necessary
for the task, no more than 1 cd/m^2 or 10 lx

Ads max. 10 x more luminance than
surroundings (3 x is enough)



Yellow, faint light (lux to dekalux)
for night work

and just centilux/millilux levels

for moving during sleeptime

should become a norm

Technical measures

- replace old lights by new, fainter, better aimed ones
- dimming,
- filtering,
- shading (*help yourself to sleep well – i.e., employ protective aids*)

Can you spoil your eyes by *faint* light?

- Did you ever hear „*light up! don't damage your vision*“?
- What physiology mechanism could do that?
- All creatures, do they have their vision spoiled? Do just the happy people supplied with electricity see really well when old?
- Faint light does not contract eye pupils, so the vision is to be properly in focus. People over 50 have to use various glasses, cheap ones are OK, but more than 1 or 2 are needed
- Very faint light implies more effort for the brain only, so we are tired and go to sleep sooner – OK!

Light: Good Servant, but a Bad Lord!

<http://amper.ped.muni.cz/light/declaration/>

9. *Noise toxicity*

- <http://www.cochlea.org/en/noise>
- <http://www.cochlea.eu/en/pathology/presbycusis>
- (on hair cells: <http://www.cochlea.eu/en/hair-cells>)
- (*on noise in detail, see the slides 5. grade*)

Noise then and now

- how to get back to harmless levels?

Noise - various meanings

- strong sound
- sound with no recognizable tones, no melody
- any sound we don't want to hear
- antipode of silence
- Noise – the same root as Nausea

Noise / Sound

- Sound pollution?
- (sound: OK, good, healthy, reasonable...)
- Therefore: Noise pollution
- or, better, Acoustic pollution

More noise targeting us

- Natural phenomena
- Anthropogenic sources, preindustrial
- Its new sources in the 20-th century
- ... and in the 21-st one...

Weber-Fechner law

- what we perceive, is the ratio of inputs
- - i. e., the increment of the
 - logarithm

Quantification

- $L_p = 10 \text{ dB} \cdot \log(p^2/p_0^2)$

$$p_0 = 2 \cdot 10^{-5} \text{ Pa}$$

- $L_I = 10 \text{ dB} \cdot \log(I / I_0)$

$$I_0 = 10^{-12} \text{ W/m}^2$$

- That's for 1000 Hz...

What's 1000 Hz?

- and what spectral composition the real sounds have,
- like speech?

Some loudness levels

- pneumatic chipper at 1 metre 115
- hand-held circular saw at 1 metre 115
- power lawn mower at 1 metre 92
- diesel truck 50 km/h at 20 metres 85
- passenger car 60 km/h at 20 metres 65
- conversation at 1 metre 55
- quiet room 40
- ... and what about less?

Ten times, two times, three times..

-
- How many decibels it amounts to?

5 dB, that is some ratio of energy fluxes

- and further 5 dB the same ratio
- together, it is 10 dB, that is 10x more
- so, 5 dB is a square root of that, or roughly
3:1 ratio:
- 5 dB more means (just a bit more than) 3x more

Health effects

- en.wikipedia.org/wiki/Noise_health_effects
- hearing impairment – over the aging-dependent one
(high frequencies most affected, loss of speech recognition)
- tinnitus
- hypertension
- cardiovascular
- discomfort, anger
- sleep disturbance

Sleep well?

- Darkness
and silence
are *a must*

Technical measures against noise

- barriers to its propagation
- emission reduction
- protect yourself!