«Развитие представлений и моделирование условий термического комфорта населения на фоне современных климатических изменений».

Константинов Павел [1,2]

К.Г.Н.

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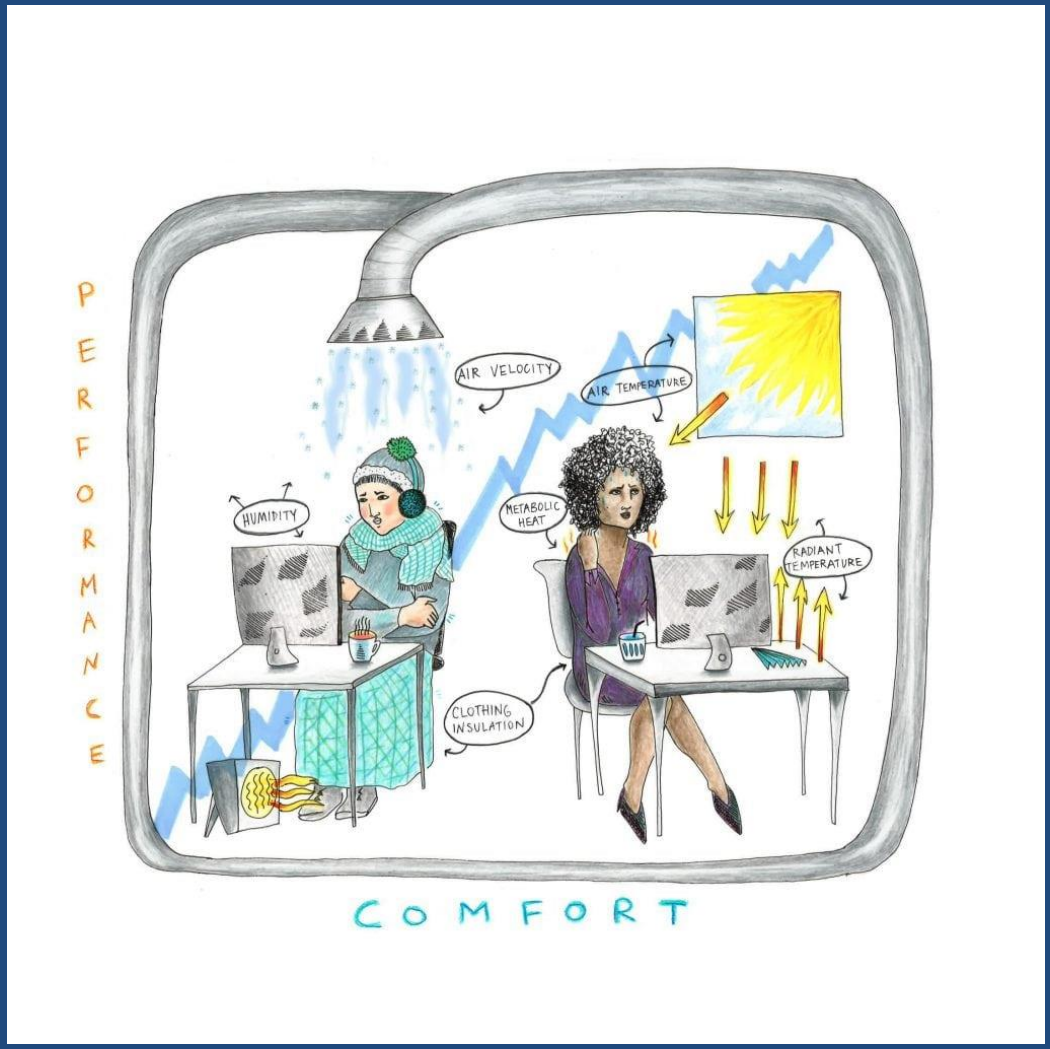
кафедра метеорологии и климатологии,

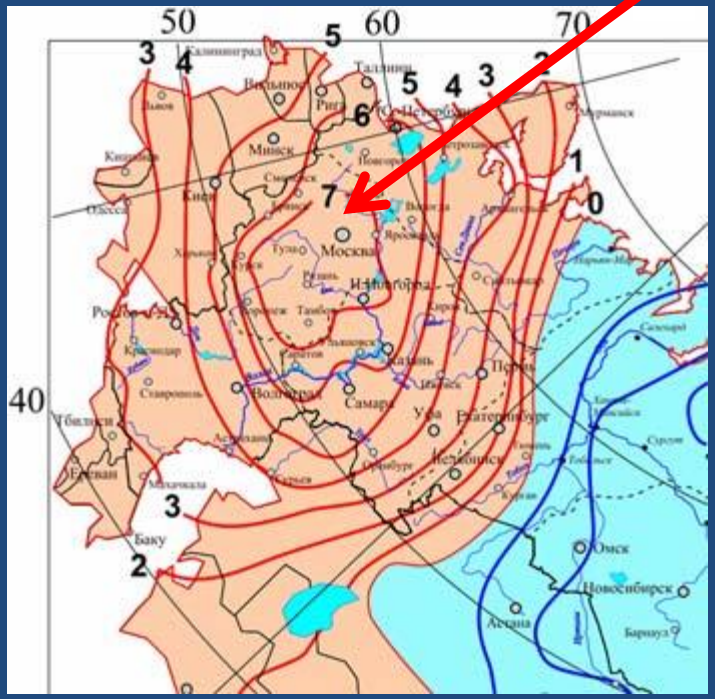
[2] **Научный центр «Смарт технологии устойчивого развития городской среды в условиях глобальных изменений» РУДН**

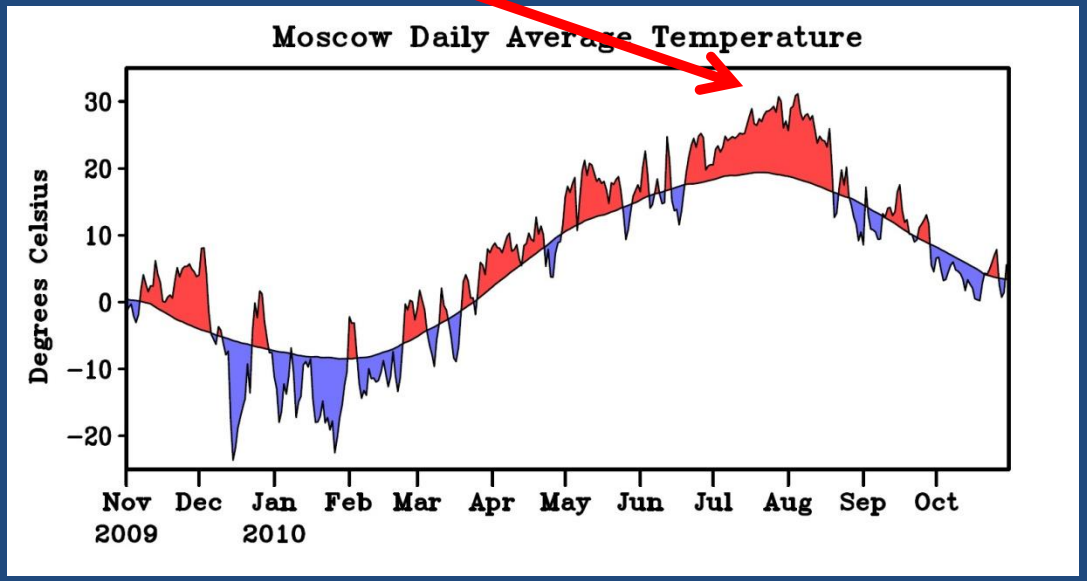
Когда мы вспоминаем о термическом комфорте?



Moscow's 2010 heat wave

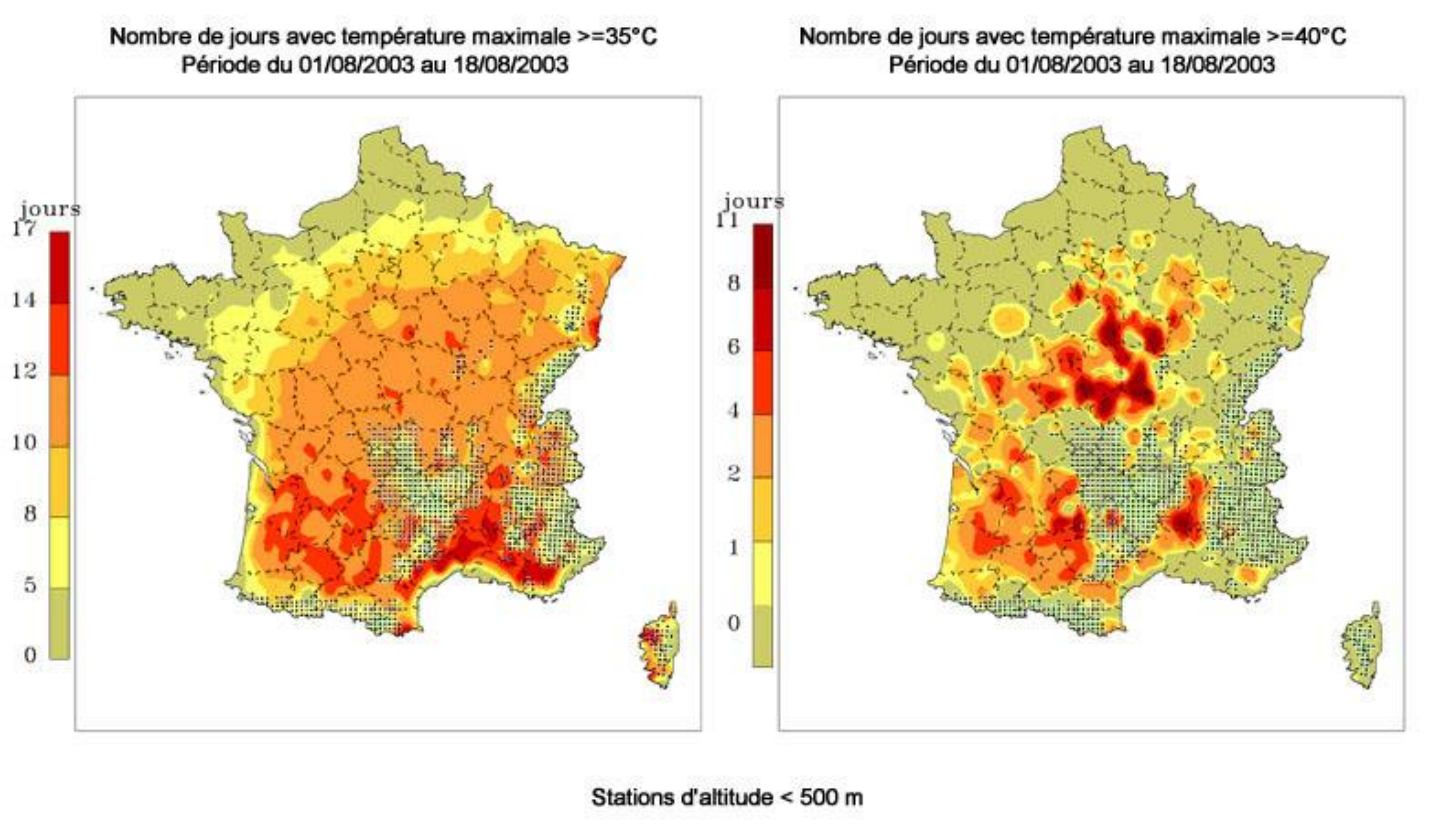
Tmax=38,1 C





The exceptional heat over such a long duration, combined with poor air quality from wildfires increased deaths by at least 11,000 in Moscow (NOAA,2010)

European Heat Wave



During August, 2003 much of Europe experienced unusually high temperatures. The extent of the extremes and their effect was greatest in France. The maps below show the number of days where air temperature exceeded 35C and 40C, respectively. The impact was greatest in cities where the temperature was raised and the population was vulnerable.

By G.Mills, 2010 WMO, Pune

Холод ничуть не лучше

e-Paper |Sunday Chronicle

DECCAN Chronicle

Auto Refresh | Corp

IN INDIA

91,723

69,624

Maharashtra 907212 644400 26604

Andhra Pradesh 498125 394

» Nation » Current Affairs » 11 Jan 2018 » 143 deaths due to se ...

NATION, CURRENT AFFAIRS

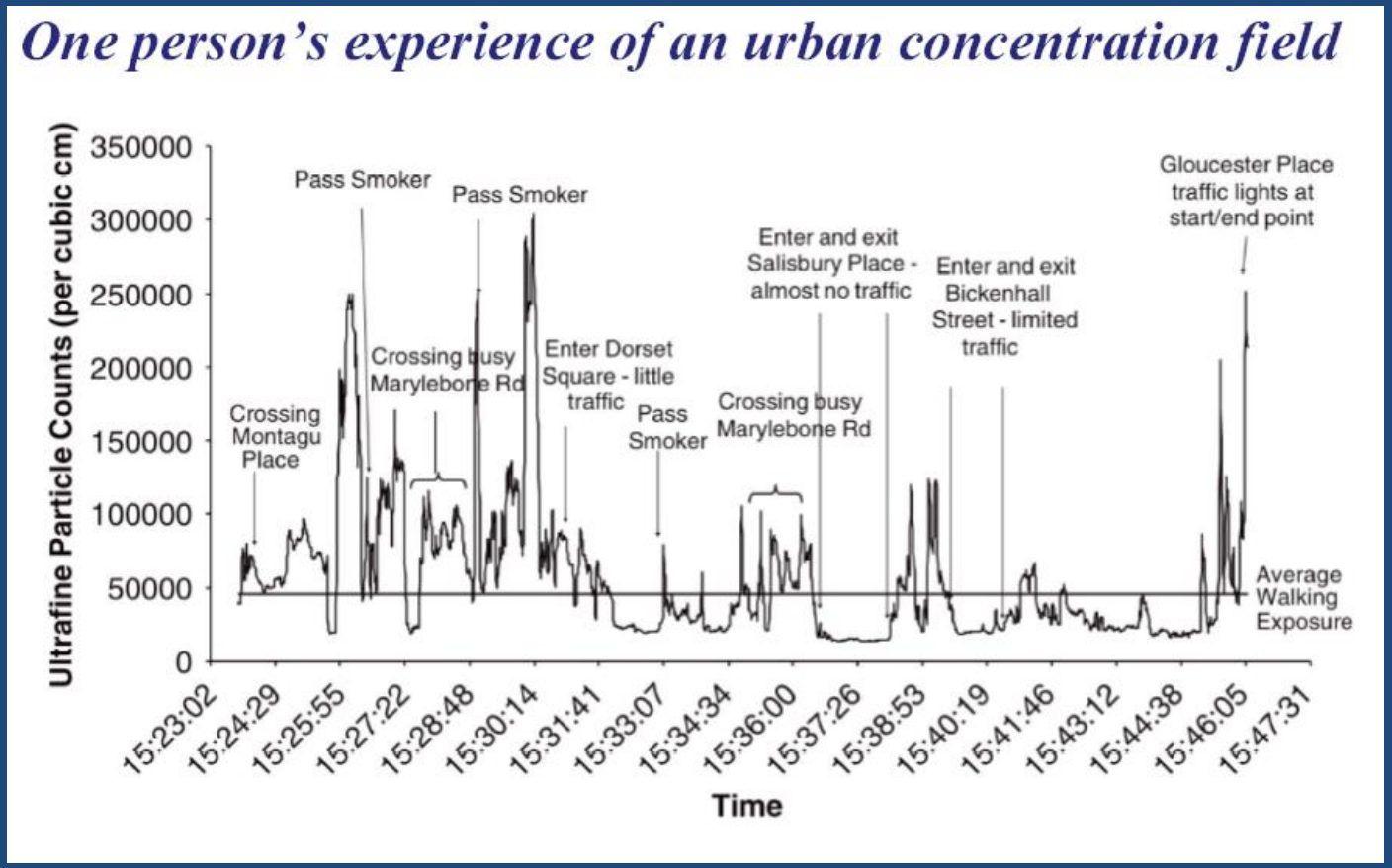
143 deaths due to severe cold wave in Uttar Pradesh

DECCAN CHRONICLE.

Published Jan 11, 2018, 2:09 am IST **Updated** Jan 11, 2018, 2:39 am IST

A six-year-old boy Satyam, who had gone to school in Barabanki, started shivering and died, due to cold, said sources.

Персональный комфорт



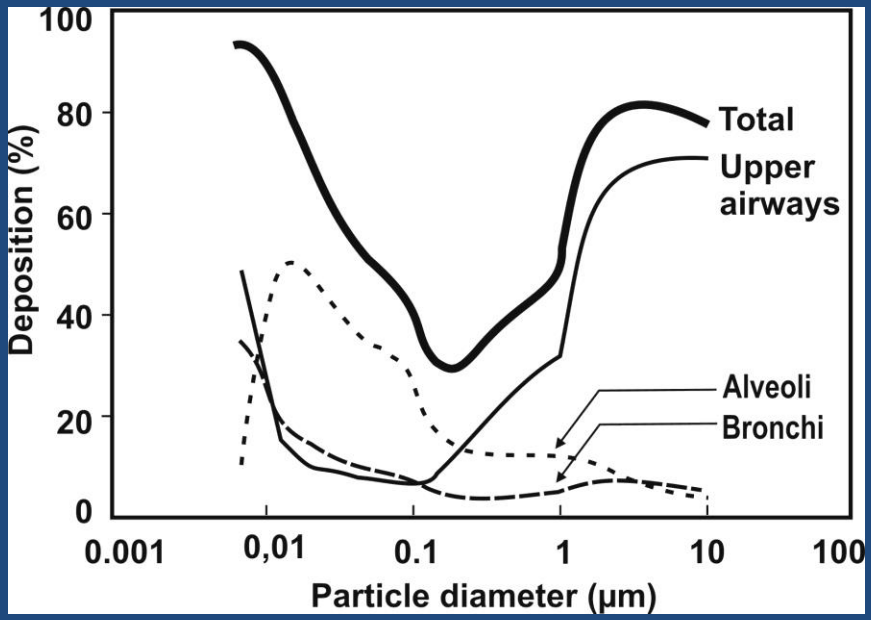
The urban effect modifies the environment to which humans are exposed, often worsening natural stresses by reducing wind-speed, raising temperature and diminishing air quality.

By G.Mills, 2010 WMO, Pune

Air quality

Air quality is a very large subject about which there is a substantial literature. Here we will just identify issues that are related to the nature of the urban surface, rather than chemistry of the atmosphere.

The dispersion of pollutants depends upon One of the features of the urban surface is its

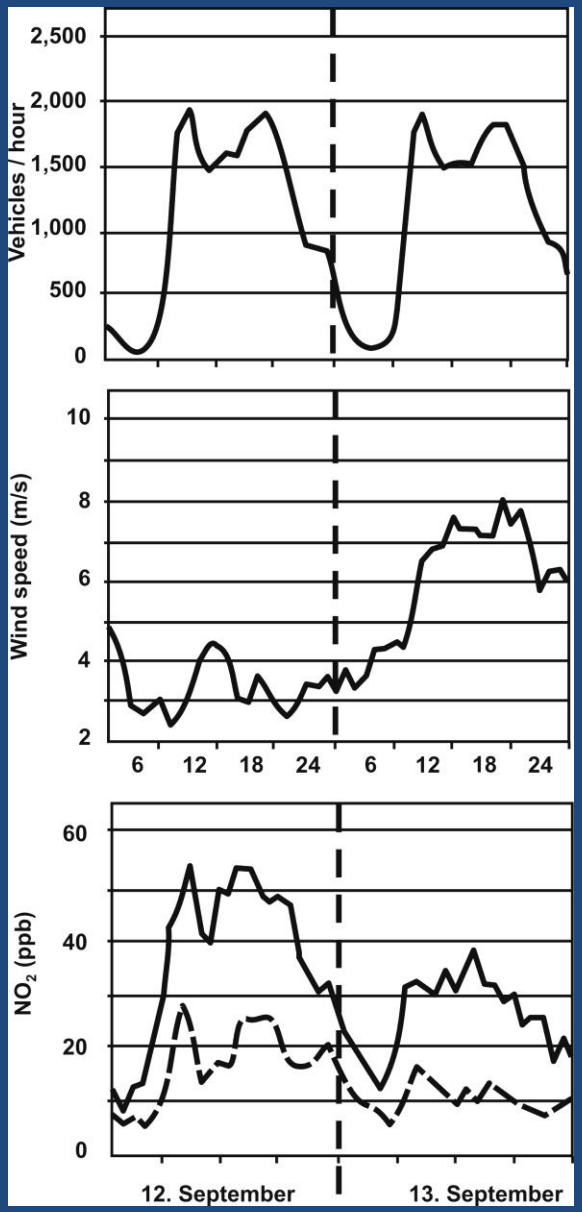


The impact of pollutants depends very much on their composition and their size.

Emissions

Emissions have distinct patterns in space and time. Urban areas are characterised by the density of pollutant sources. For many places, air quality is closely tied to vehicle emissions that have diurnal patterns.

These emissions occur within city streets that inhibit air motion and may generate re-circulating flows, thus trapping vehicular emissions and limiting their dispersion.



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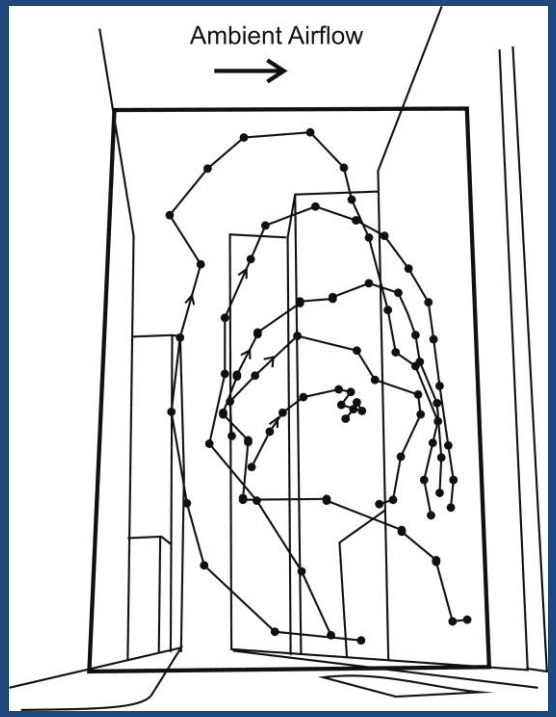
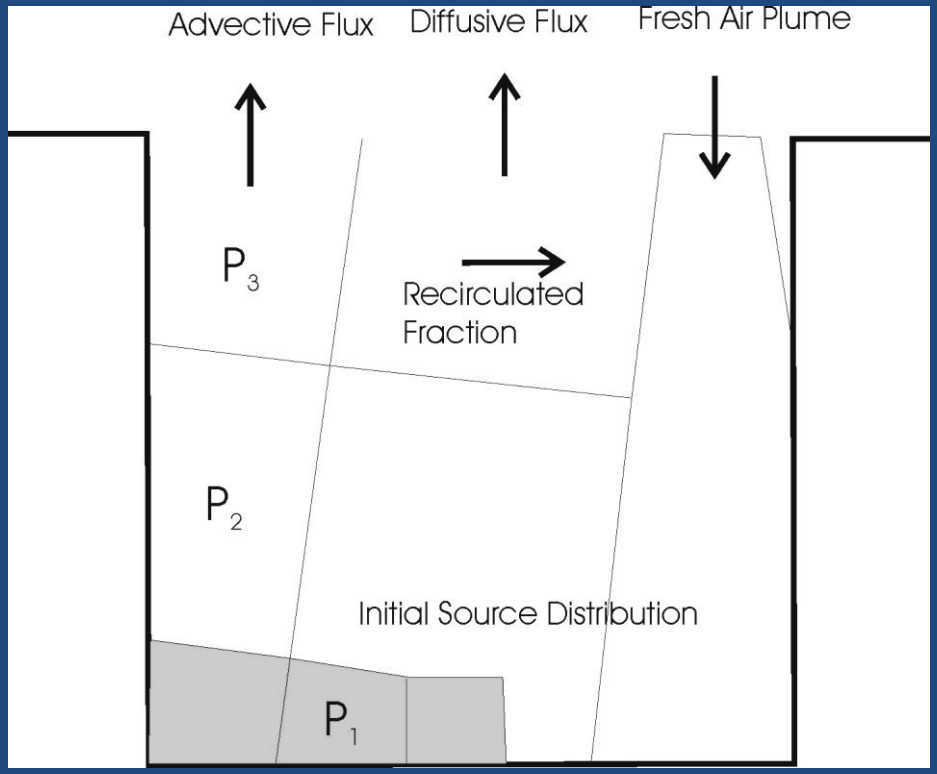
Dispersion





DePaul, F.T., Sheih, C.M., 1986. Measurements of wind velocities in a street canyon. Atmospheric Environment 20, 45-459

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Немного определений

Humans are homeotherms with a deep body temperature (T_B) of 37°C. This temperature must be maintained at a near constant value to maintain health. This is accomplished by regulating exchanges at the outer envelope of the body (the skin and/or clothing surface) to achieve a net energy exchange of zero.

TERMS

Comfort refers to conditions where this balance can be achieved with the least effort.

Discomfort is a measure of the degree of departure from comfort.

Уравнение энергетического баланса человека

$$Q^* + Q_M - (Q_H + Q_E + Q_G) = \Delta Q_S$$

Q^*	Net radiation. Intercepted and reflected short-wave and absorbed and emitted long-wave radiation.
Q_M	Metabolic heat generated internally by the body
Q_H	Turbulent sensible heat exchange at the outer surface
Q_E	QE is turbulent latent heat exchange at the outer surface
Q_G	QG is sensible heat transfer by conduction
ΔQ_S	Heat stored in the body volume.

As homeotherms (warm-blooded creatures), with a near-constant deep body temperature of 37°C, ΔQ_S should be close to zero. All of actions (whether conscious or unconscious) of the body attempts to minimise ΔQ_S

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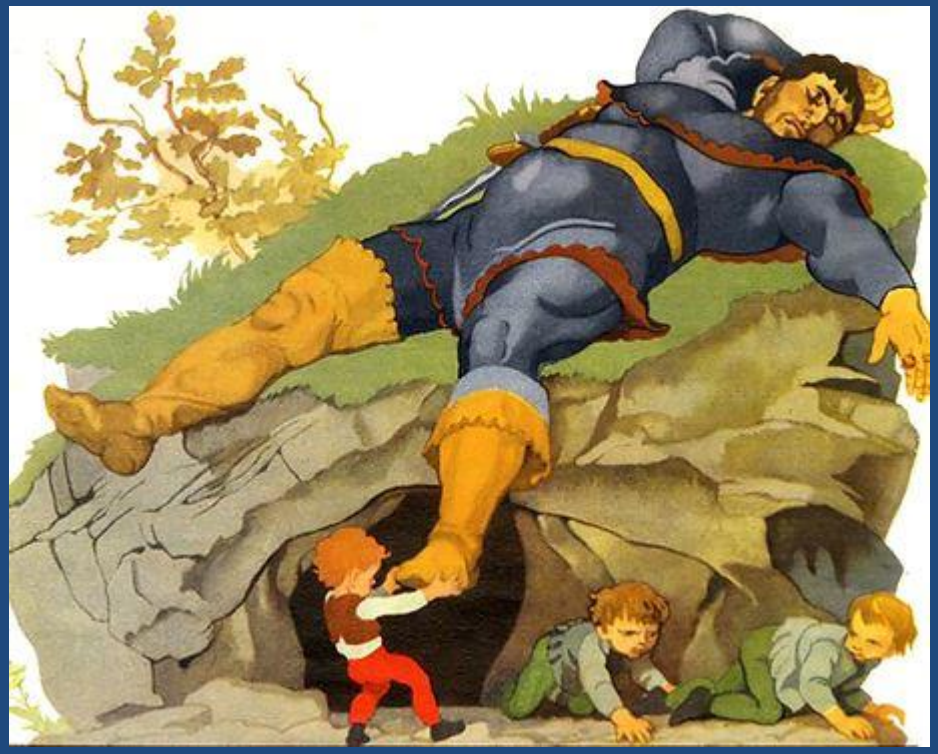
Metabolic Heat Rate (Q_M)

The energy generated by the body is a function of the levels of activity. This level is comprised of a basal rate (70Wm^{-2}) and a work rate.

The amount of energy the body needs to dispose of depends upon the internal heat generated, which can be regulated.

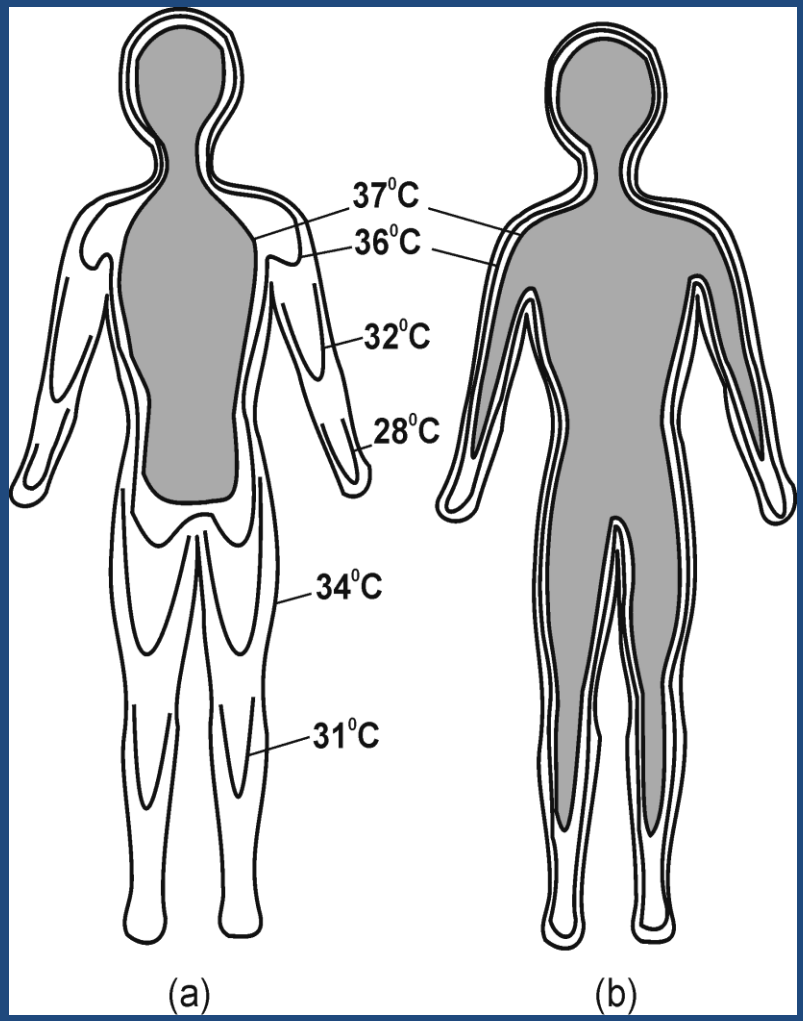
Activity	Wm^{-2}
Resting	
Sleeping	40
Seated, quiet	60
Standing relaxed	70
Walking on a level surface	
$0.9ms^{-1}$	115
$1.8ms^{-1}$	220
Office	
Writing	60
Walking about	100
Lifting/packing	120
Occupational	
Cooking	95 to 115
Housecleaning	115 to 200
Handling 50kg bags	235
Pick and shovel work	235 to 280
Leisure	
Dancing	140 to 255
Tennis	210 to 270
Basketball	290 to 440



возможно ли с точки зрения закона сохранения энергии существование Мальчика-с-пальчика?

Регуляция комфорта

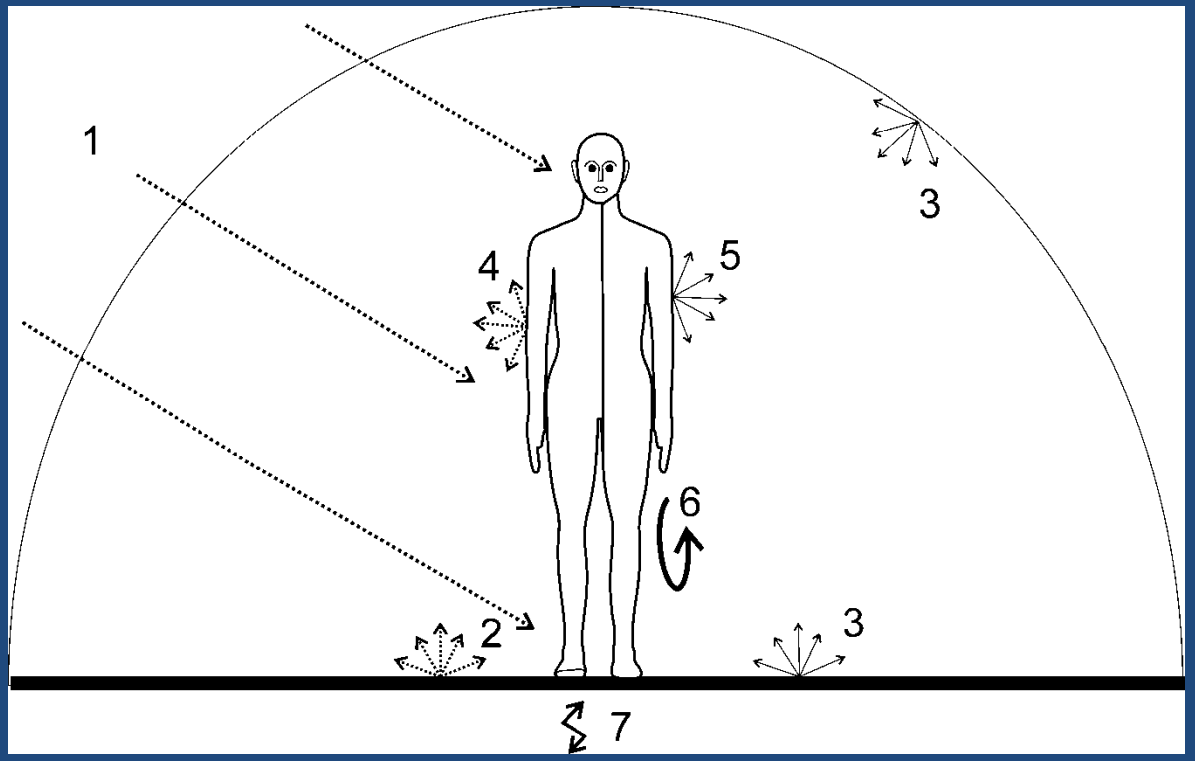
Energy exchanges with the atmosphere occurs primarily at the skin surface. Heat transfer from the transfer within the body occurs from the centre to the skin surface. The exchange is regulated the intervening resistance provided by the tissues close to the skin.



Mount L.E. (1979) Adaptation to thermal environment : man and his productive animals. London : Edward Arnold,

By G.Mills, 2010 WMO, Pune

Моделирование термического климата



The energy budget of a human must account for all the exchanges at the exposed surface. This includes direct solar radiation (1), diffuse short- and long-wave radiation from the sky and ground (2 & 3), reflected short-wave radiation (4) and emitted long-wave (5) radiation, convective sensible and latent heat exchanges that result from surface-air exchanges (6) and the conduction of heat into the substrate (7).

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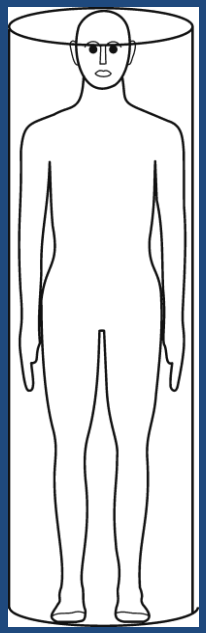
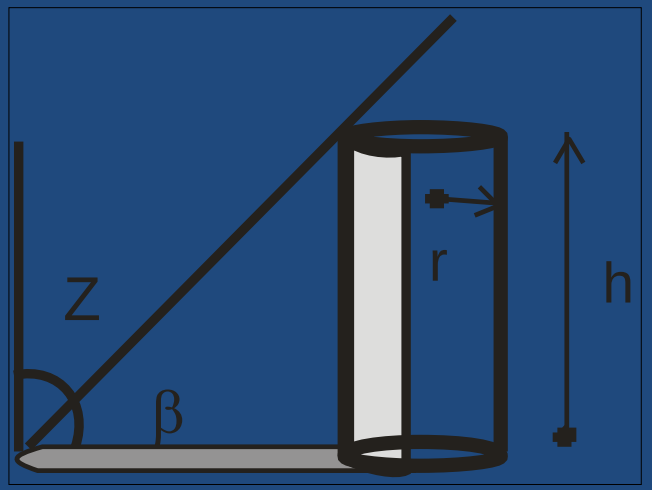
«Огонь, мерцающий в сосуде» ?



The surface area of an upright average man is 1.8m^2 enclosing a mass of 70kg. However the effective area at which exchanges occur can be altered by a change in posture and clothing. A cylinder with a height of 1.65m and a radius of 0.12m may be used to crudely represent this human form.

This simplification can be used effectively to examine radiation and surface-air exchanges. For example, the direct radiation (S) can be determined from that received on a horizontal surface multiplied by the shadow area generated by the beam,

$$2rh\cot(\beta) + \pi r^2$$



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Радиационный обмен

Net radiation consists of both short- (K) and longwave (L) radiation incident on the surface and reflected and emitted from the surface.

$$Q^* = K\downarrow - K\uparrow + L\downarrow - L\uparrow$$

Shortwave radiation receipt (K↓) consists of both direct and diffuse components. Seeking shadow removes the direct component. Reflected radiation (K↑) depends on the albedo of the body, which can be regulated through clothing selection.
Longwave radiation receipt (L↓) depends on the temperatures of the surrounding surfaces and their emissivity. The outgoing longwave radiation consists of a small proportion of reflected L↓ and primarily emitted radiation, which is a function of surface temperature.

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Mean Radiant Temperature

One of the most useful concepts in biometeorology is that of a uniform surface temperature surrounding the body that generates the same radiative load as that experienced in reality – this is the Mean Raditiave Temperature (T_{MRT})

$$T_{MRT} = \sqrt[4]{K^* + L\downarrow}$$

This value is employed in indoor circumstances where surface temperatures may be regulated. Applying it in outdoor circumstances is more difficult and requires that the contributions of all the surfaces 'seen' by the body are accounted for and weighed proportionately. Its advantage is that it aggregates the radiation contributions.

Non-radiative exchanges (1)

The conductive heat flux (Q_G) can usually be ignored for humans. The remaining terms are the convective sensible (Q_H) and latent (Q_E) fluxes.

The sensible heat exchange results from the temperature difference between the outer surface (T_{sk}) and adjacent air temperature (T_a) . Its magnitude is related to the size of the difference and the intervening wind speed through a heat transfer coefficient (h_c in $Wm^{-2}\ K^{-1}$). The inverse of h_c is insulation.

$$Q_H = h_c(T_{sk} - T_a)$$

Skin temperature can be regulated by the body through vasodilation and vasoconstriction. The effect of clothing is to insulate the skin by providing a layer of static air adjacent to the body surface

Теплосберегающие свойства одежды

Garment	Insulation $m^2 K W^{-1}$	Clothing Ensembles	Insulation $m^2 K W^{-1}$
Underpants T-Shirt	0.006 (0.2) 0.012 (0.5)	Walking shorts, short-sleeved shirt	0.056 (2.2)
Long-sleeved shirt Sweat shirt	0.045 (1.8) 0.053 (2.1)	Sweat pants, sweat shirt	0.115 (4.5)
Trousers Overalls	0.031 (1.2) 0.048 (1.9)	Knee-length skirt, short-sleeved shirt, panty hose, sandals	0.084 (3.3)
Single-breasted jacket Long-sleeved sweater	0.063 (2.4) 0.048 (1.9)	Ankle-length skirt, long-sleeved shirt, suit jacket and panty hose	0.172 (6.7)
Skirt Dress	0.029 (1.1) 0.059 (2.3)	Insulated coveralls, thermal underwear	0.213 (8.3)

Information extracted from ASHRAE (2009). Values in parentheses are percentages and represent a comparison between the insulation of the garment with that of still air, which has a value of approximately 3.85×10^{-5} m^2 KW^{-1}.

Non-radiative exchanges (2)

Latent heat exchange (Q_E)between the body and the environment occurs through three mechanisms:

1. Breathing – exhaled air is more humid than that inhaled.
2. Diffusion of water through the skin surface
3. Regulatory sweating.

The latter is most important from the viewpoint of thermoregulation as it can be managed by the body itself. When sensible heat exchange cannot dispose of sufficient heat, the body will sweat as a response. The body will not sweat otherwise.

Non-radiative exchanges (2)

Latent heat exchange is governed by the difference in vapour pressure between the skin and the adjacent air modulated by a transfer coefficient, which depends on airflow

$$Q_E = h_v(e_{sk} - e_a)$$

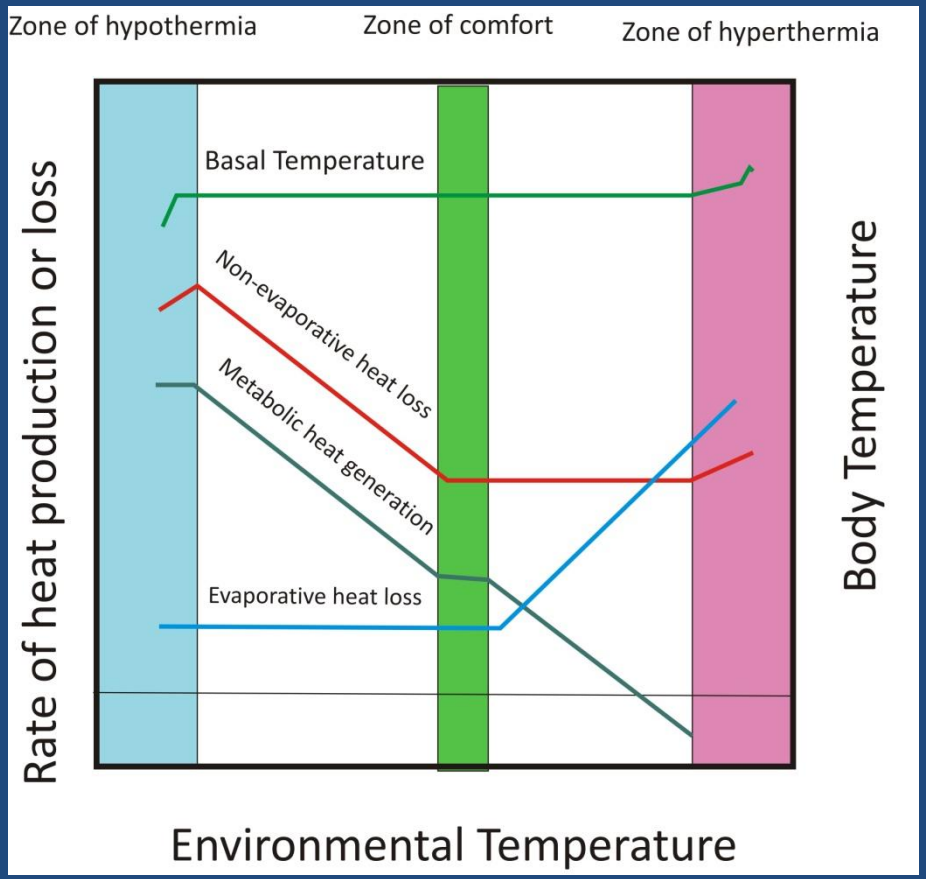
In practice this term is difficult to assess because the body can regulate vapour pressure at the skin surface.

A common practice is to establish the maximum flux based on the assumption that the skin surface is saturated at T_{sk} and determine what proportion of the body's surface needs to be 'wet' to achieve thermal equilibrium.

Thermal Equilibrium

The body can manage equilibrium ($\Delta Q_S=0$) exchanges over a range of environmental temperatures through modifying the magnitudes and nature of heat loss and generation. At the limits the body cannot dispose of sufficient heat (hyperthermia) or generate sufficient heat (hypothermia).

Comfort is a relatively narrow zone where the body has to do least work to maintain equilibrium



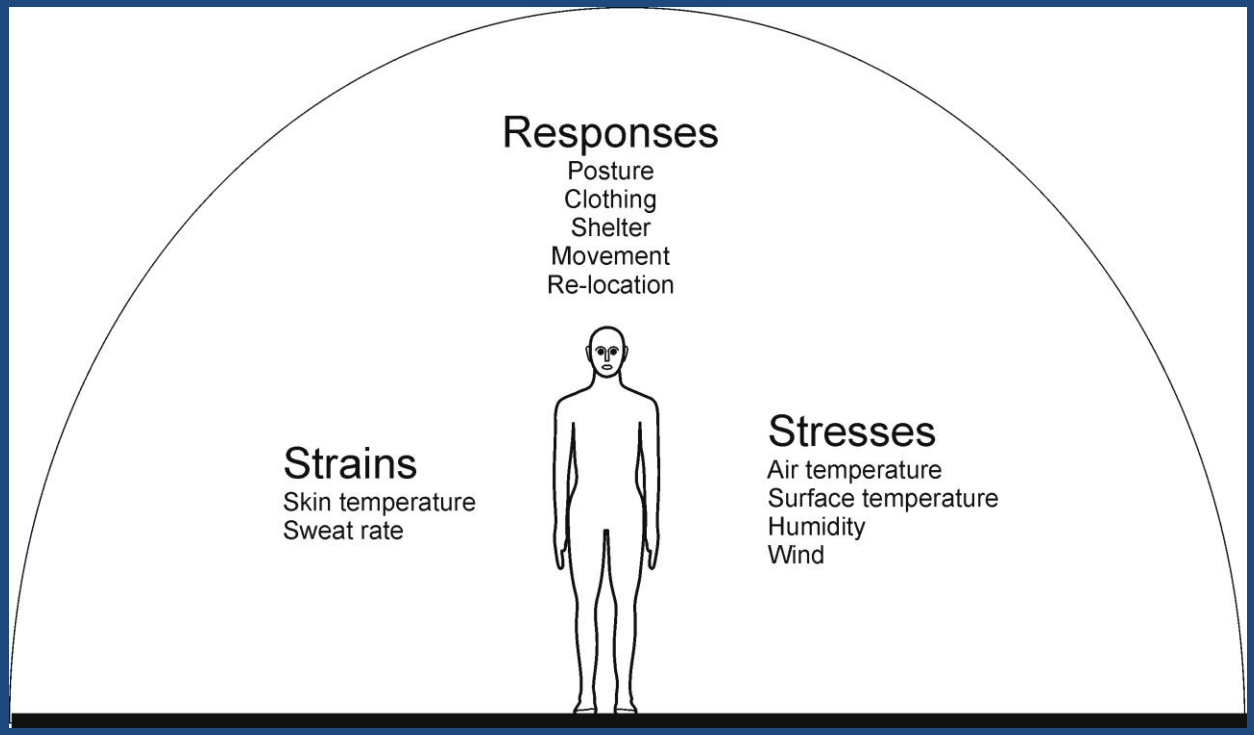
Buildings are designed to achieve comfort.

Термическое воздействие - стресс

Conditions exterior to the body such as temperature or humidity may be referred to as *stresses*. In a given set of circumstances, environmental elements can combine to create either heat or cold stresses. Many simple measures exist that evaluate these stresses for outdoor conditions.

The physical response of the body to these stresses, such as elevated skin temperature or sweating, may be referred to as *strains*.

Достижение термического равновесия



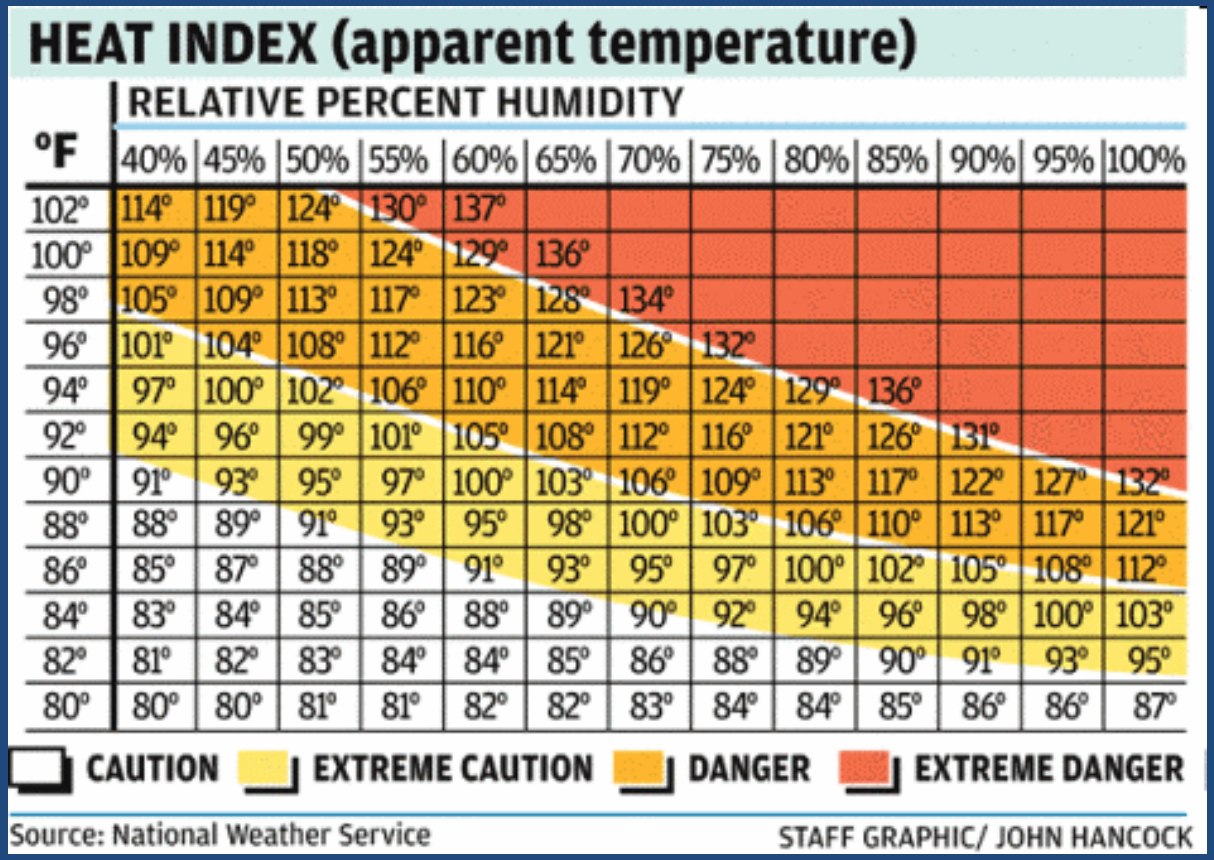
Apart from thermo-physical responses (which can be used as measures of strain, humans can make conscious decisions to deal with the stresses imposed by the environment. Many simple measures exist that employ readily available meteorological data.

«Физик Вальтер Нернст увлекался разведением карпов. Однажды кто-то глубокомысленно заметил: “Странный выбор. Кур разводить и то интереснее”. Нернст невозмутимо ответил: «Я развожу таких животных, которые находятся в тепловом равновесии с окружающей средой. Разводить теплокровных – это значит обогревать на свои деньги мировое пространство”

Индексы термического комфорта.

От простого к сложному

Example: Heat stress



HEAT INDEX (apparent temperature)

°F	RELATIVE PERCENT HUMIDITY												
	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
102°	114°	119°	124°	130°	137°								
100°	109°	114°	118°	124°	129°	136°							
98°	105°	109°	113°	117°	123°	128°	134°						
96°	101°	104°	108°	112°	116°	121°	126°	132°					
94°	97°	100°	102°	106°	110°	114°	119°	124°	129°	136°			
92°	94°	96°	99°	101°	105°	108°	112°	116°	121°	126°	131°		
90°	91°	93°	95°	97°	100°	103°	106°	109°	113°	117°	122°	127°	132°
88°	88°	89°	91°	93°	95°	98°	100°	103°	106°	110°	113°	117°	121°
86°	85°	87°	88°	89°	91°	93°	95°	97°	100°	102°	105°	108°	112°
84°	83°	84°	85°	86°	88°	89°	90°	92°	94°	96°	98°	100°	103°
82°	81°	82°	83°	84°	84°	85°	86°	88°	89°	90°	91°	93°	95°
80°	80°	80°	81°	81°	82°	82°	83°	84°	84°	85°	86°	86°	87°

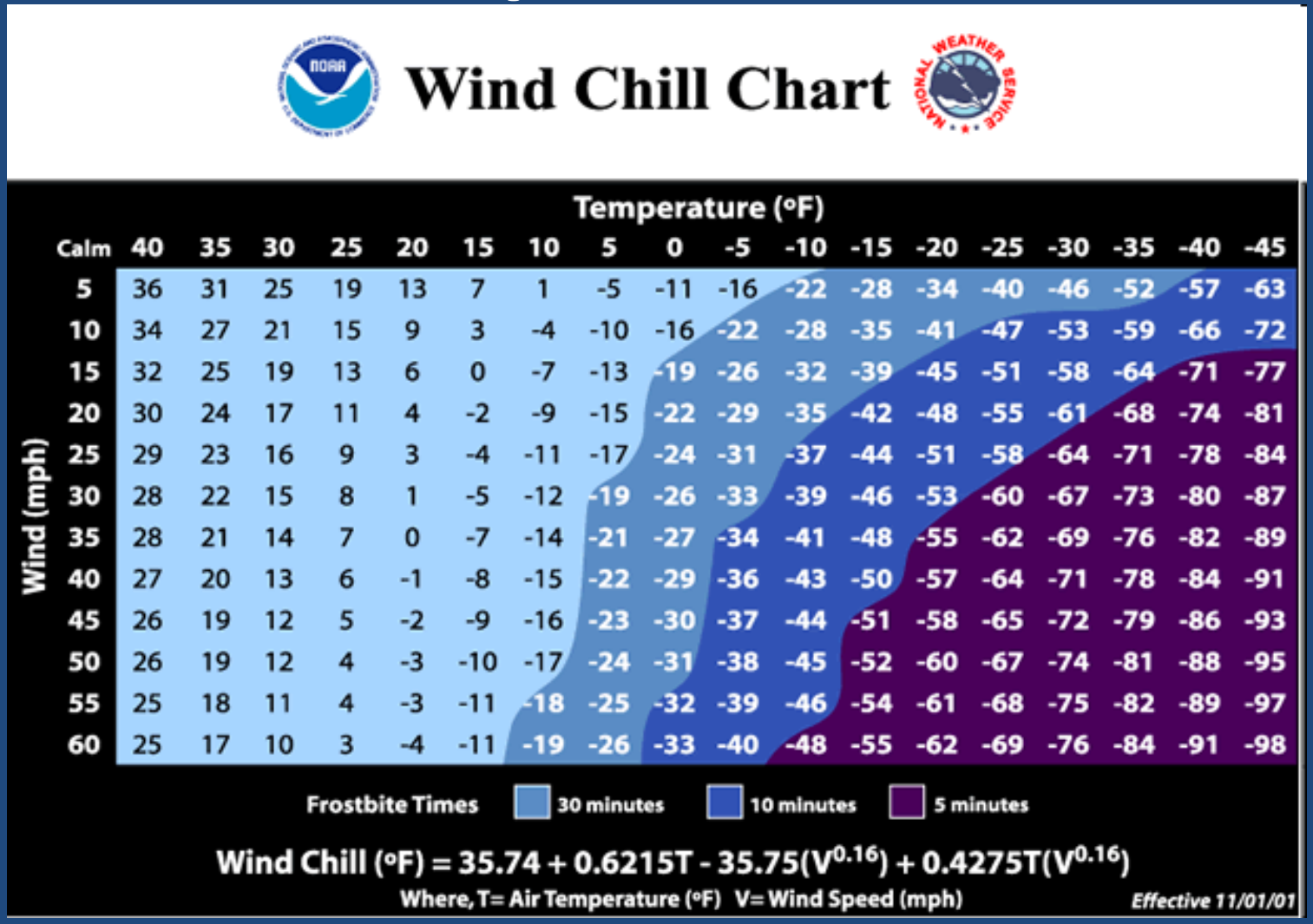
CAUTION EXTREME CAUTION DANGER EXTREME DANGER

Source: National Weather Service STAFF GRAPHIC/ JOHN HANCOCK

This is an example of a heat stress index. Note that it is a derived apparent temperature that accounts for the combined effect of just two variables, air temperature and relative humidity.

Heat Index = $-42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \times 10^{-3}T^2 - 5.481717 \times 10^{-2}R^2 + 1.22874 \times 10^{-3}T^2R + 8.5282 \times 10^{-4}TR^2 - 1.99 \times 10^{-6}T^2R^2$

Example: Cold stress



Wind Chill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times — 30 minutes — 10 minutes — 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

This is a wind chill chart. It presents a ‘wind chill’ temperature that accounts for the joint effect of air temperature (below freezing) and wind, which enhances heat loss.

Эквивалентно-эффективная температура (ЭЭТ °).

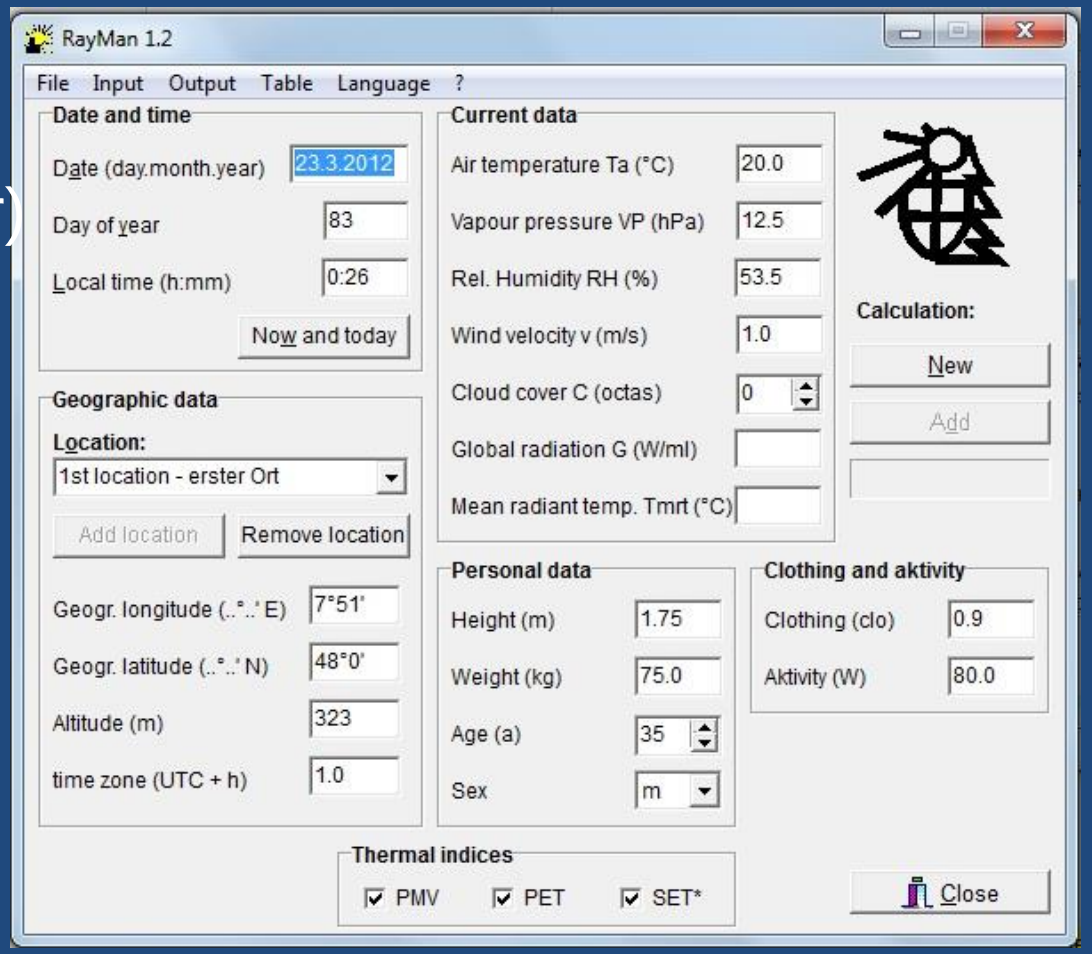
- По А.Миссенарду :

$$ET = 37℃ - \frac{37℃ - T}{0.68 - 0.0014f + \frac{1}{1.76 + 1.4V^{0.75}} - 0.29T(1 - \frac{f}{100})}$$

- По Б.А. Айзенштату:

$$\text{ЭЭТ} = \boldsymbol{T[1 - 0,003(100 - f)]} - \boldsymbol{0,385v^{0'59}[(36,6 - T) + 0,622(V - 1)]} + \boldsymbol{[(0,0015V + 0,008)(36,6 - T) - 0,0167](100 - f)}$$

PET index derived from Rayman model (Matzarakis, Rutz, Mayer)



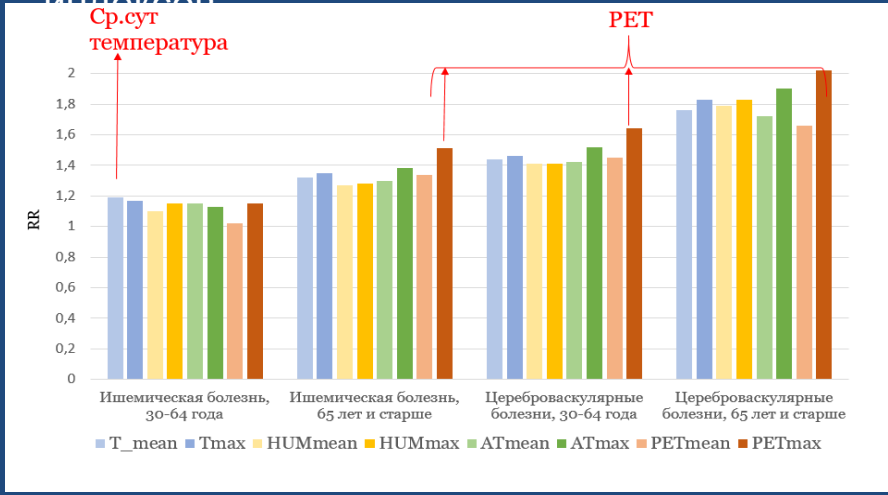
- Matzarakis, A., Rutz, F. (2005) Application of RayMan for tourism and climate investigations. Annalen der Meteorologie 41: Vol. 2, 631-636.
- Matzarakis, A.; Rutz, F.; Mayer, H. (2000) Estimation and calculation of the mean radiant temperature within urban structures. In: Biometeorology and Urban Climatology at the Turn of the Millenium (ed. by R.J. de Dear, J.D. Kalma, T.R. Oke and A. Auliciems): Selected Papers from the Conference ICB-ICUC'99, Sydney. WCASP-50, WMO/TD No. 1026, 273-278.
- Matzarakis, A., Rutz, F., Mayer, H. (2007) Modelling Radiation fluxes in simple and complex environments – Application of the RayMan model. Int. J. Biomet. 51: 323-334.

Помимо простых индексов существуют также более сложные.

(как углеводы)

На основе моделей теплового баланса человека

1) **PET** (Physiologically Equivalent Temperature) (Höppe, 1984) – физиологически эквивалентная температура. Параметр определяется как мера теплоощущения человека, находящегося в состоянии спокойствия. На сегодняшний день PET считается одним из наиболее популярных индексов.



Относительные риски смертности (RR) во время аномально-жаркой погоды, идентифицированной по различным биоклиматическим индексам (Shartova et al., 2018)

PET показывает наибольшие значения по методу максимизации относительных рисков (RR) во время аномально-жаркой погоды, поэтому является основным предиктором смертности (Shartova et al., 2018).

2) **UTCI** (Universal Thermal Climate Index) (Jendritzky et al., 2012) –универсальный тепловой индекс климата. В отличие от PET данный параметр рассчитывается с обязательным учётом воздействия ветра, то есть предполагается, что происходит теплоотдача в окружающую среду за счёт движения человека.

PET

PET – это мера теплового ощущения находящегося в покое человека. Индекс рассчитывается с учётом уравнения теплового баланса человека:

$$M+W+R+C+ED+ERe+ESw+S=0$$, где

M - скорость обмена веществ (внутренняя выработка энергии),

W – теплоотдача при физической работе,

R – радиационный баланс тела,

C - конвективный поток тепла,

ED- скрытый поток тепла, расходуемый на потоотделение,

ERe - сумма тепловых потоков для нагревания и увлажнения вдыхаемого воздуха,

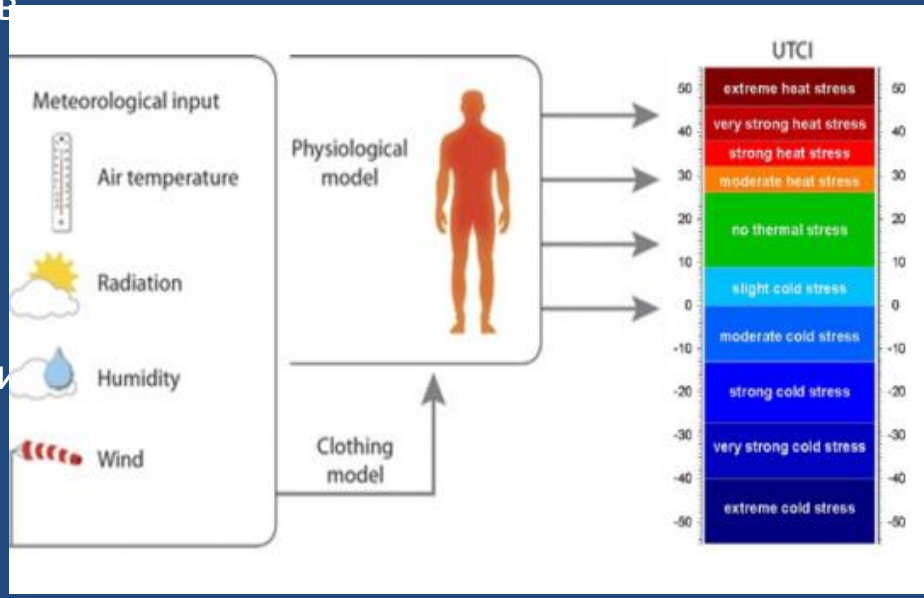
ESw – поток тепла, расходуемый на испарение пота

S - поток тепла, который сохраняется для нагревания или охлаждения масса тела

Индекс PET	Теплоощущение человека	класс физиологического воздействия
	крайне холодно	экстремальный холодовой стресс
4		
	очень холодно	сильный холодовой стресс
8		
	холодно	умеренный холодовой стресс
13		
	прохладно	слабый холодовой стресс
18		
	комфортно	отсутствие теплового воздействия
23		
	умеренно тепло	легкое тепловое воздействие
29		
	тепло	умеренное тепловое воздействие
35		
	жарко	сильное тепловое воздействие
41		
	очень жарко	экстремальное тепловое воздействие

UTCI

- **UTCI** – это универсальный индекс теплового комфорта. Он был разработан в качестве концепции «эквивалентной температуры»: он включает определение базового условия, с которым будут сравниваться все другие климатические условия. Упрощенно говоря, индекс UTCI может быть определен в качестве эквивалентной температуры для данной комбинации ветра, радиации, влажности и температуры воздуха, впоследствии сравниваемый с температурой воздуха в эталонных условиях влажности, радиации и скорости ветра, которая дает одно и то же значение «индекса деформации» или шкалы ощущений

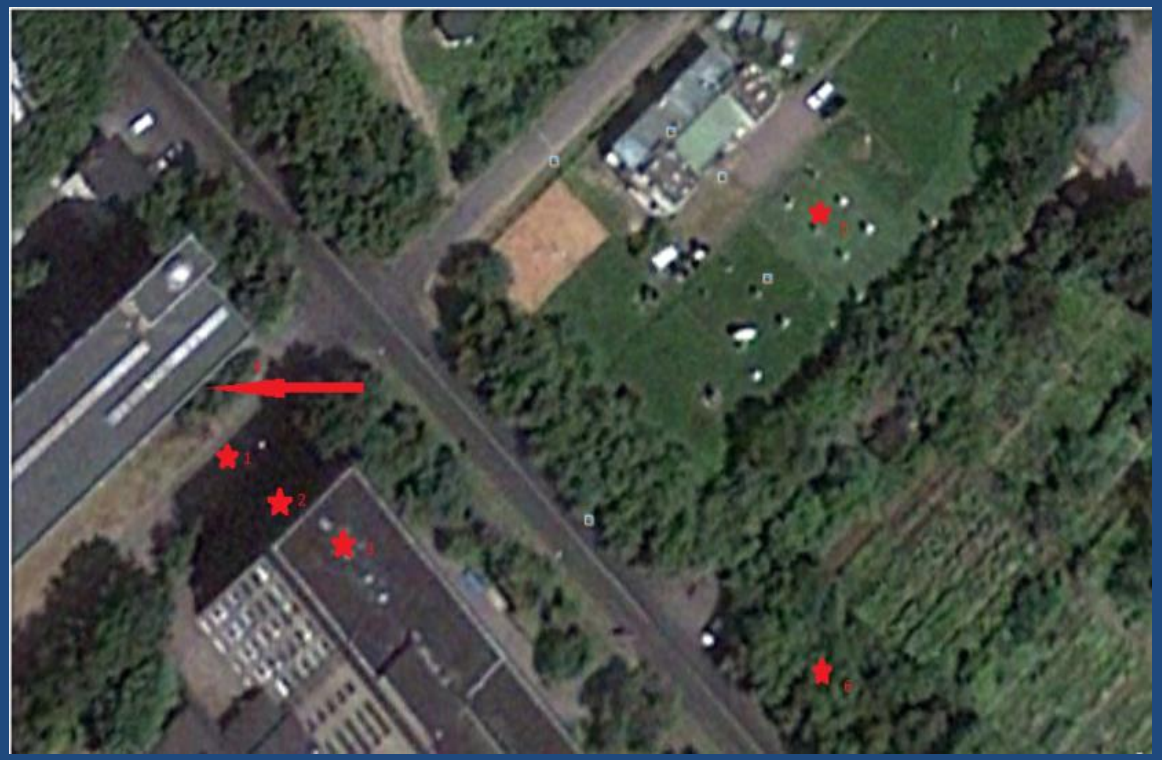


mPET

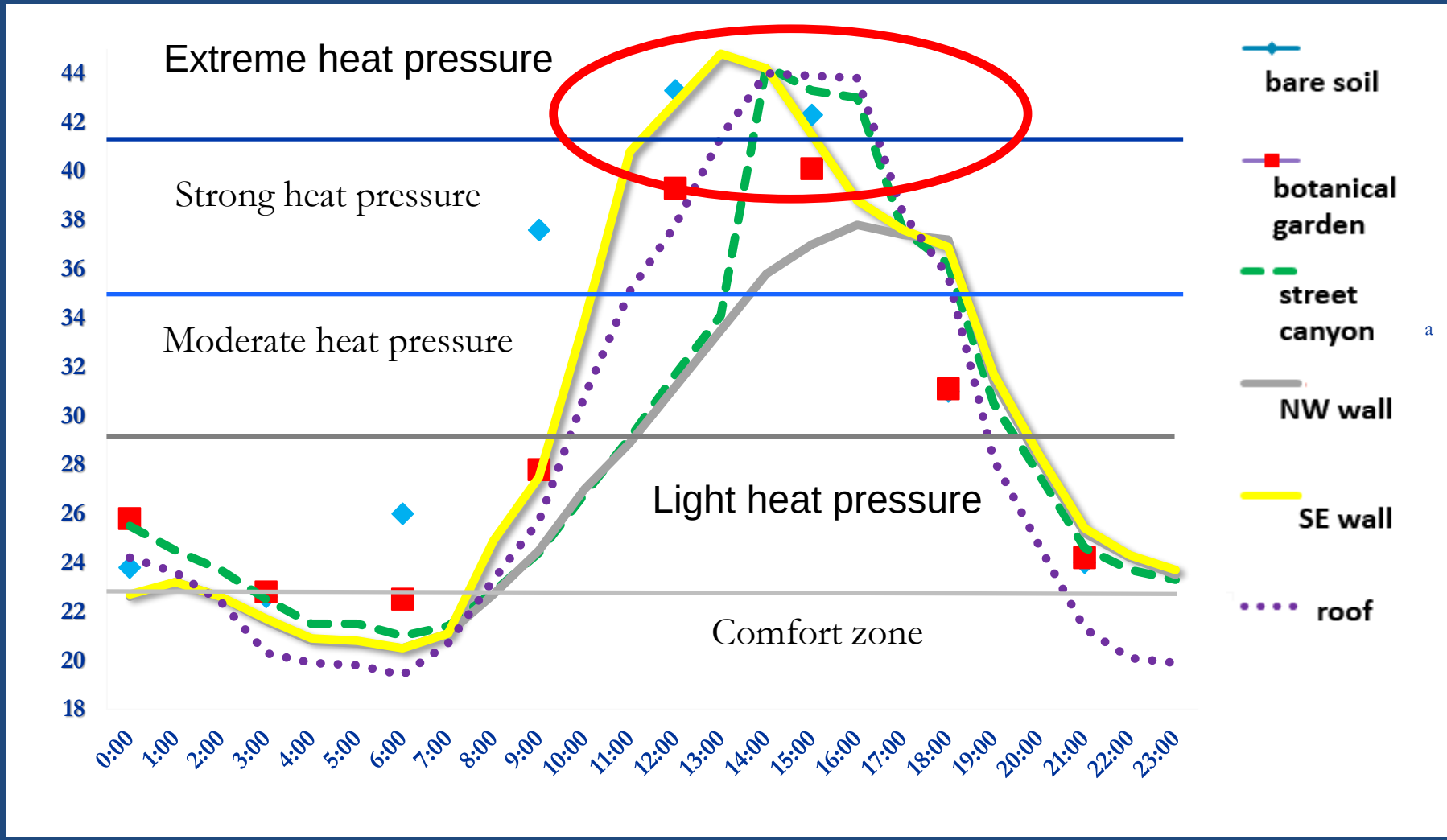
- **mPET** – самый современный тепловой индекс, основанный на физиологических параметрах человека. Он преобразован из индекса PET, но основан на другом уравнении теплового баланса человека и он лучше оценивает влажность и теплоизоляционные свойства одежды.
- Сейчас это самый универсальный индекс, который лучше всего оценивает термический комфорт **в разных климатических зонах** и **в разные периоды года**

Heat pressure in different urban landscapes

1. At the lane (between two buildings)
2. Balcony on the wall faced northwestward
3. At the roof of a building
4. Balcony on the wall faced southeastward
5. Weather shelter of MSU observatory
6. Botanical garden



Diurnal course of PET 29.07.2010



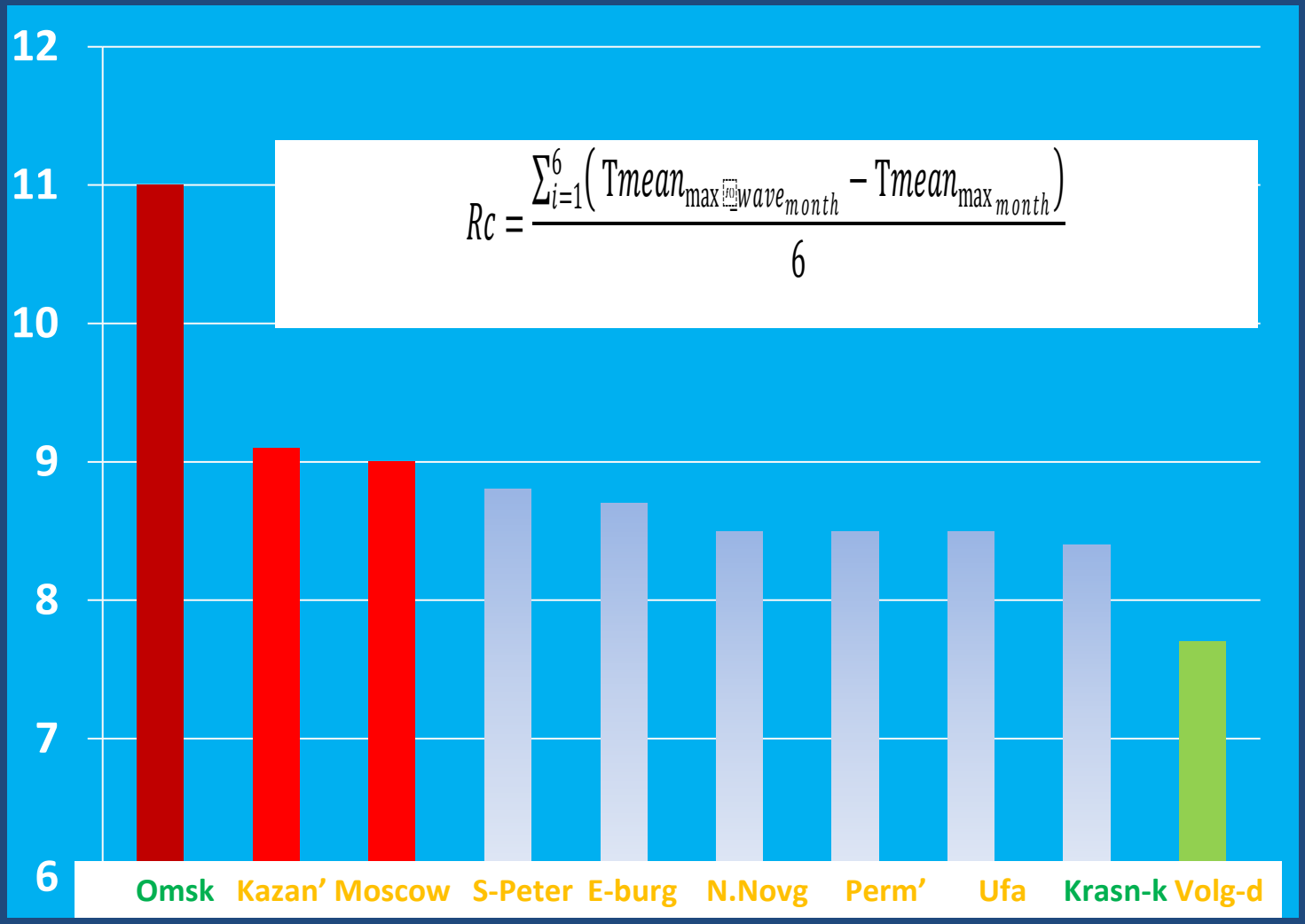
Point name	Duration of extreme heat pressure Period of extreme heat pressure	Duration of extreme heat pressure Period of extreme heat pressure
The lane	3 hours	13:30 – 16:30
Wall faced northwestward	Not observed	Not observed
The roof	3,5 hours	13:00 – 16:30
Wall faced southeastward	4 hours	11:00 – 15:00
Botanical garden	Not observed	Not observed

Heat syncope is possible

Heat-wave intensity

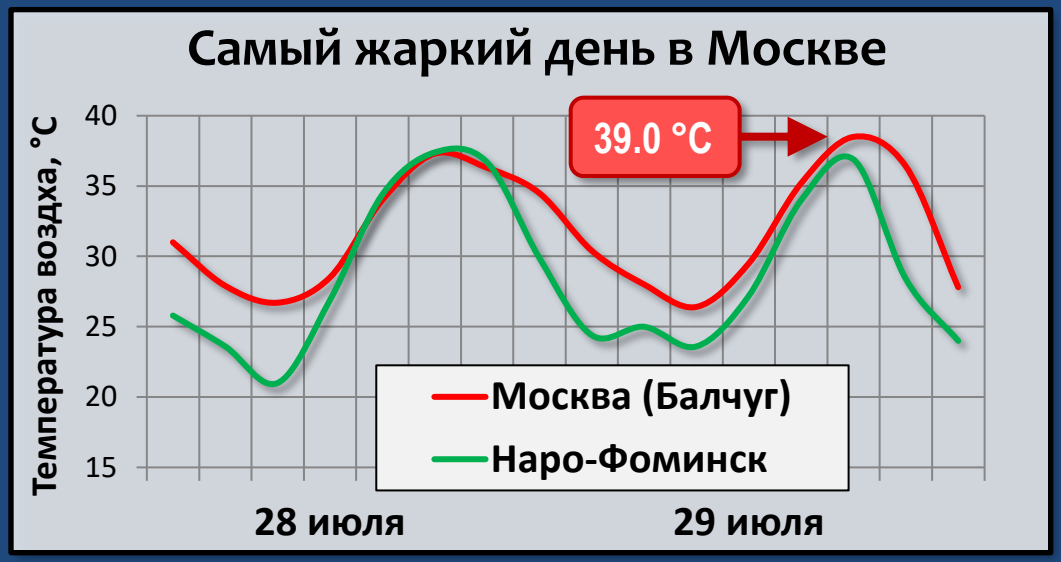
	April	May	June	July	August	September	mean Tc
Ekaterinburg	10,1	9,0	7,8	7,9	8,4	9,2	8,7
Kazan’	10,5	8,6	8,1	10	8,4	9	9,1
Krasnoyarsk	9,6	10,1	7,5	7	7,9	8,1	8,4
Moscow	12,4	8,5	7,7	8,1	9,2	8,3	9,0
Nizhnij Novgorod	9	8,7	7,7	7,9	9,3	8,6	8,5
Omsk	11,2	12,3	11,2	11	9,9	10,5	11,0
Perm’	10,1	8,8	8	6,8	8,3	8,7	8,5
Volgograd	8,4	7,4	7,9	7,6	8	7,1	7,7
Sankt-Petersburg	10	9,4	8,6	8,5	7,7	8,6	8,8
Ufa	10,3	8	8	7,9	8,1	8,6	8,5

«Strangeness» of heat wave events



Где это находит свое применение?

Точки особого риска – города!



Не только в реальных городах

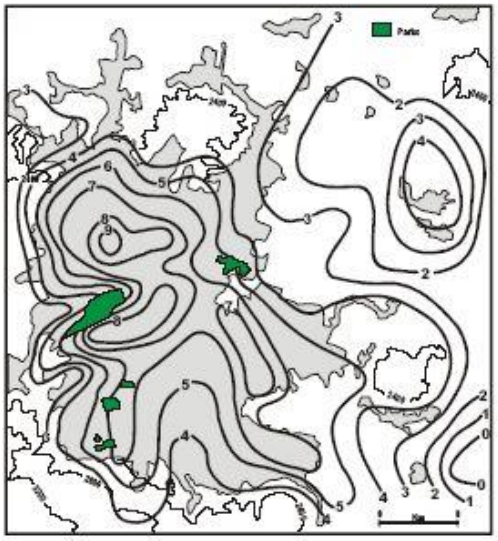
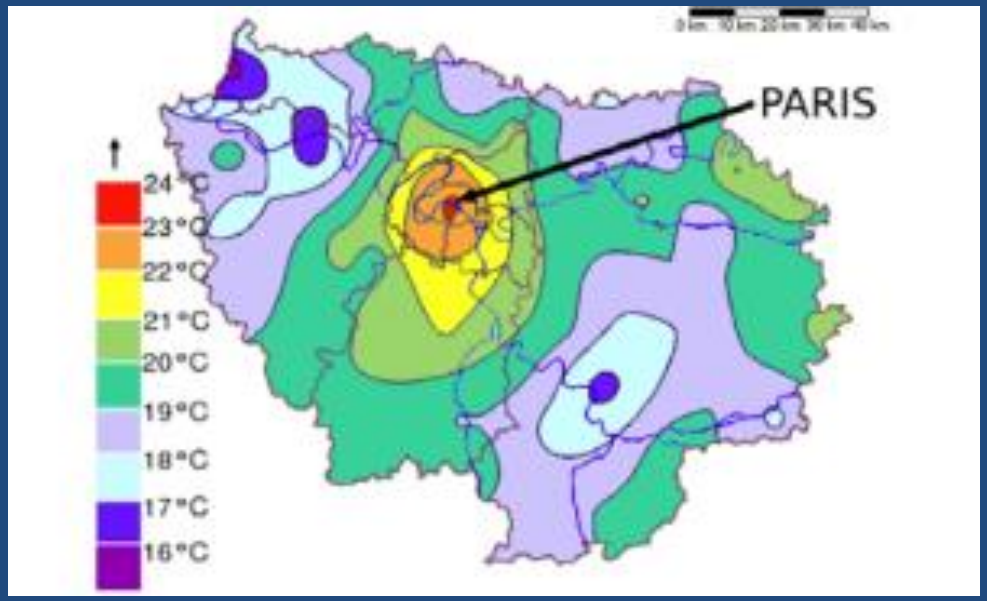


Figure 2: Mean minimum temperature for November 1981 in Mexico City. Redrawn from [4].



„The King‘s Landing Effect“

or

transforming social inequalities into environmental problems on an example of urban climate of a fantasy city

Imaginary city King's Landing

King's Landing - Game of Thrones

Dubrovnik, Croatia

Model Setup

Domain: 10.1 km x 7.6 km x 0.5 km
Resolution: 60 m horizontal, 10-50 m vertical
Grid points: 168x126x25
Land use: 14 classes
Max elevation: 100 m
16 idealized simulations, 24 h duration, two wind directions (NW and SE) for low and high wind speed, temperature and relative humidity conditions.

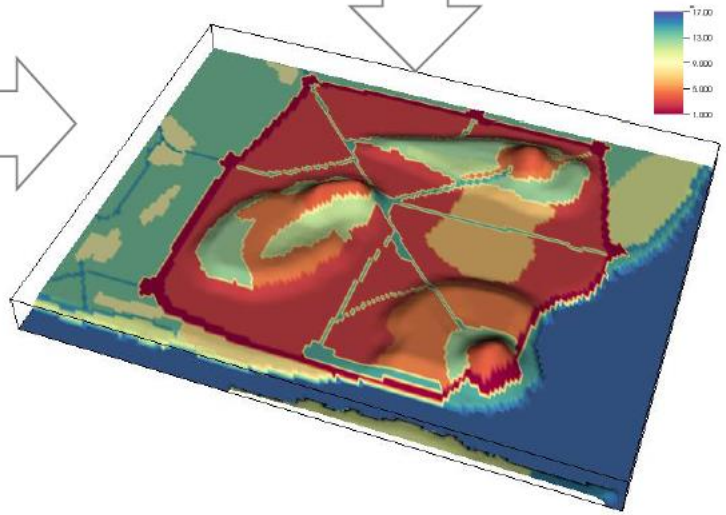
Map digitalization

Local Climate Zone (LCZ) classification system

(Stewart and Oke, 2012)

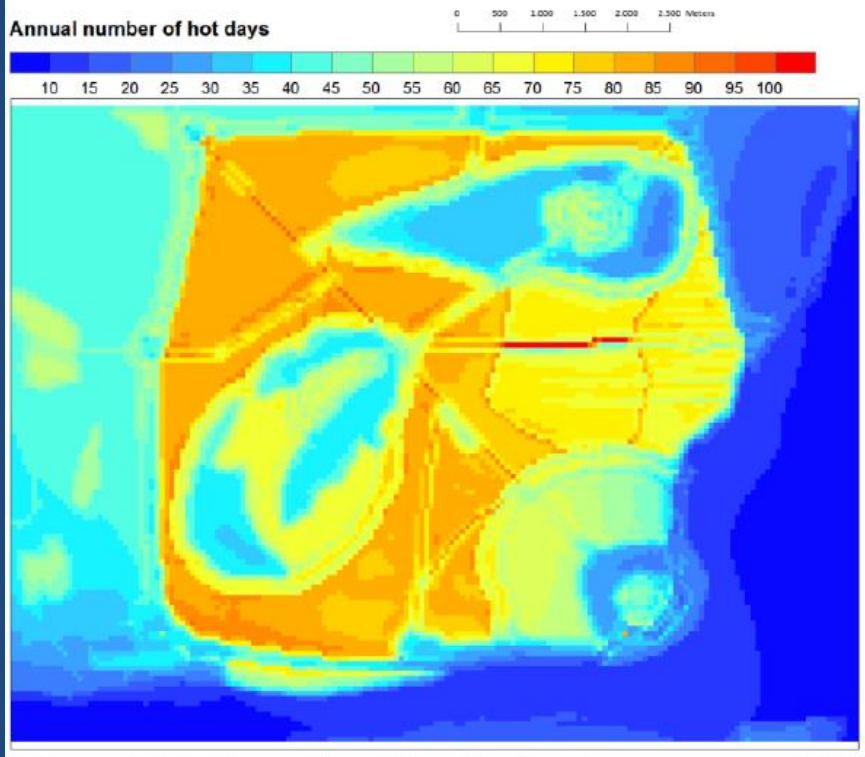
Built types	Definition	Land cover types	Definition
1. Compact high-rise	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural
3. Compact low-rise	Dense mix of low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.		

+ Building structure and climate data from Dubrovnik

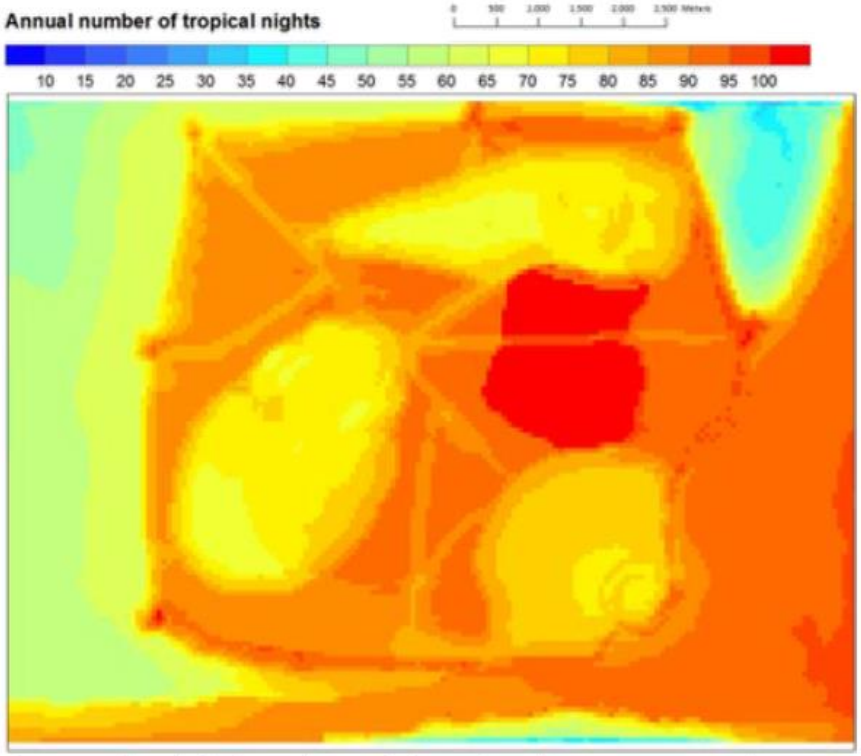


Model results for King‘s Landing

DAY



NIGHT

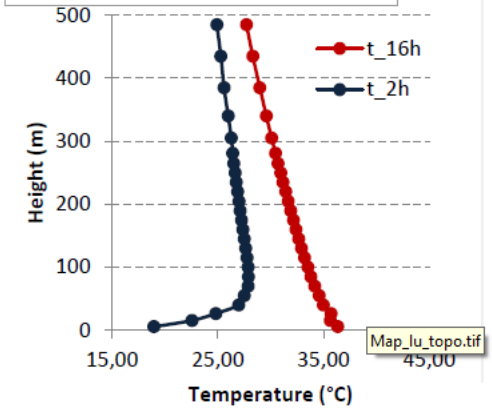


Day: high heat load in the built-up area within the walls, higher head load values towards inland

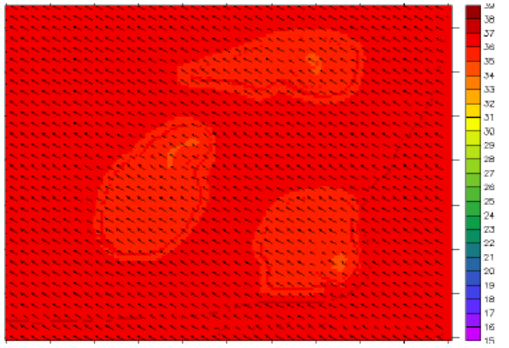
Night: high heat load towards sea and maximum heat load in the area of the poor

Natural Factors

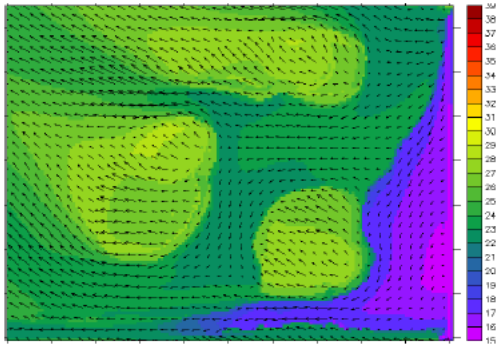
Orography



DAY

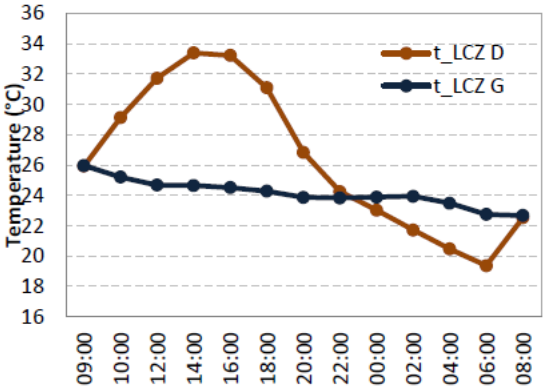


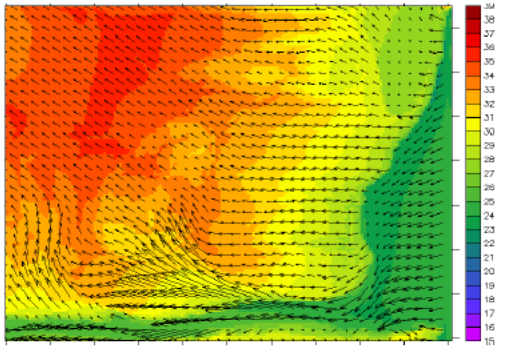
NIGHT

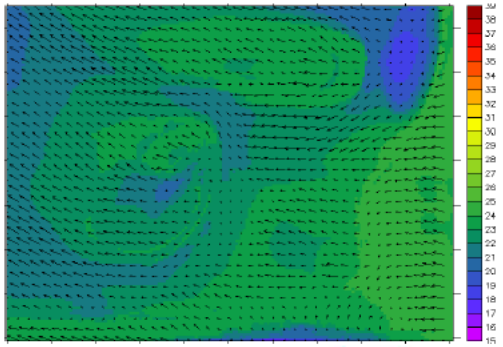


Temperature (°C) and wind field (m/s)

Landuse



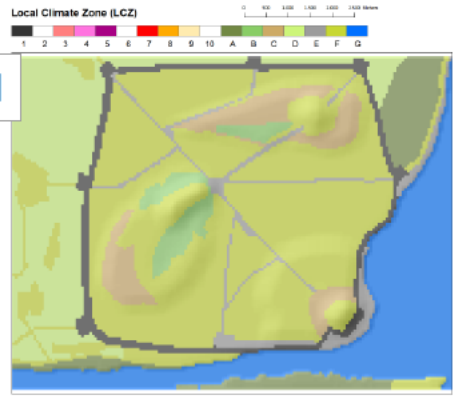




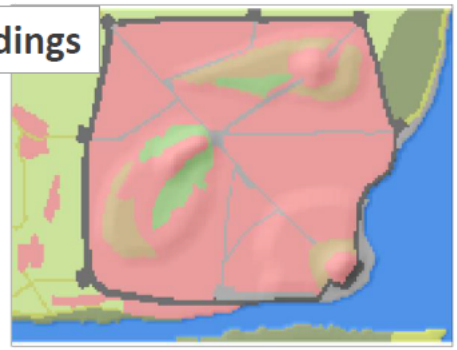
Temperature (°C) and wind field (m/s)

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

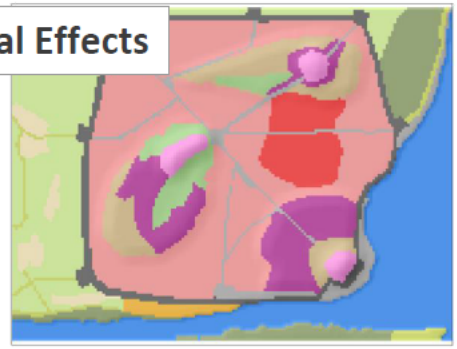
Antropogenic Factors



Wall

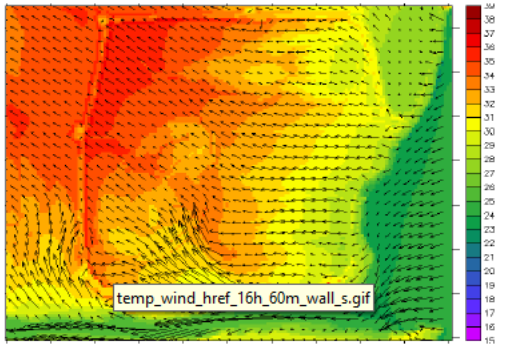


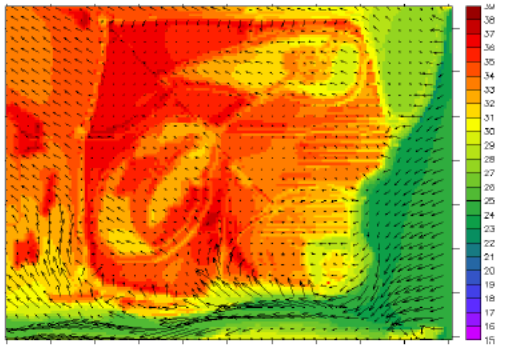
Buildings

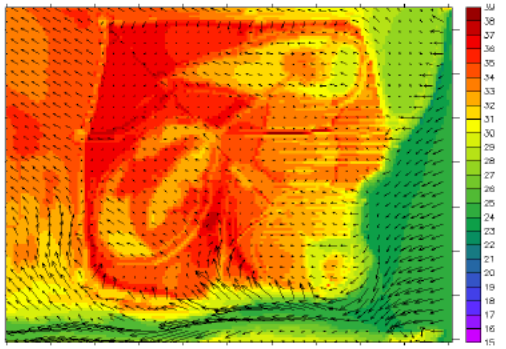


Social Effects

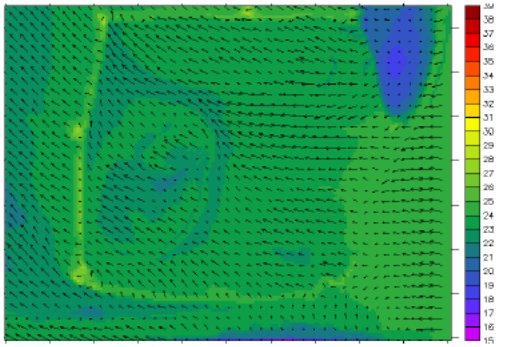
DAY

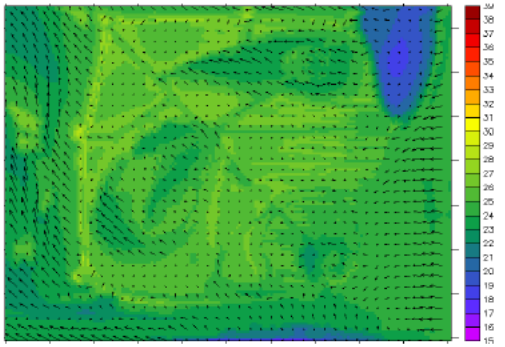


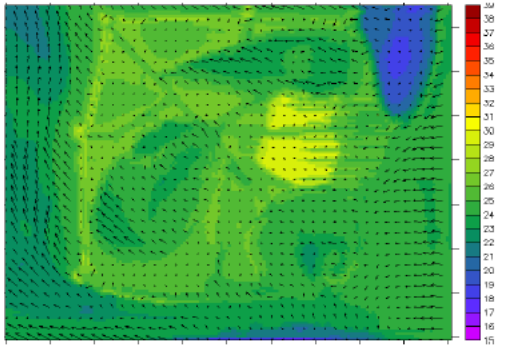




NIGHT





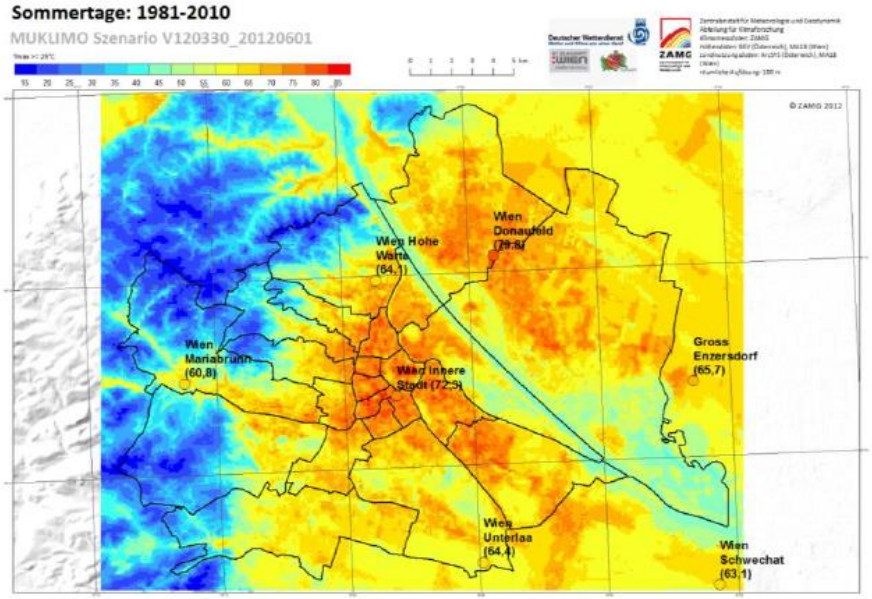


The King‘s Landing Effect

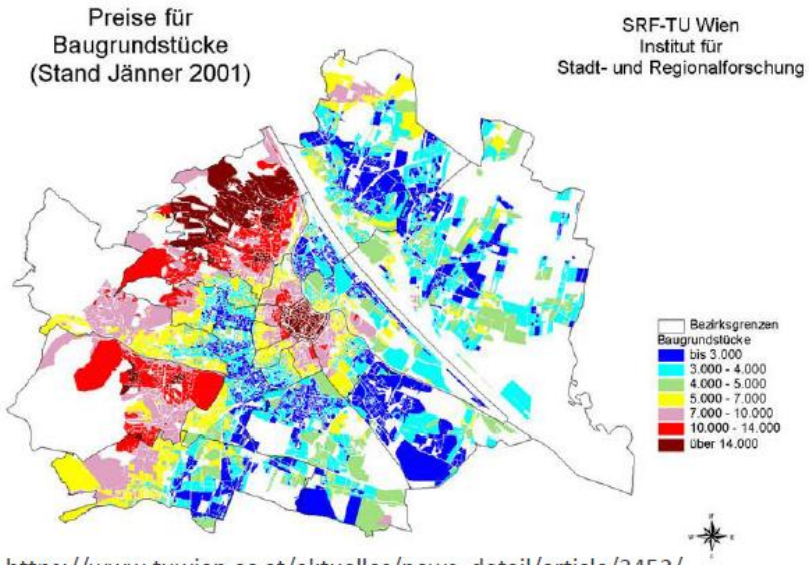
- Excessive heat load can be formed in the socially unprivileged areas as a **result of natural and human induced factors.**
- **Basic mechanism that relates social inequalities with environmental problems** in urban areas:
  - naturally advantageous areas are expected to populated by higher classes and maintain good quality due to careful planning
  - less favorable areas are expected to be inhabited by lower social classes and can further lose their quality due to impropriate planning
- An example of an imaginary city serves as an illustrative example that does not deal with any actual city, but **the concept of the city itself.**
- The fantasy books describe social relationships, while environmental processes and related **climatic consequences are not intentional, but develop as a result of social division**.

Is there a King‘s Landing effect in Vienna?

Urban heat load



Real-estate prices



https://www.tuwien.ac.at/aktuelles/news_detail/article/3452/

Climate Change question: in which direction are we driving the system?

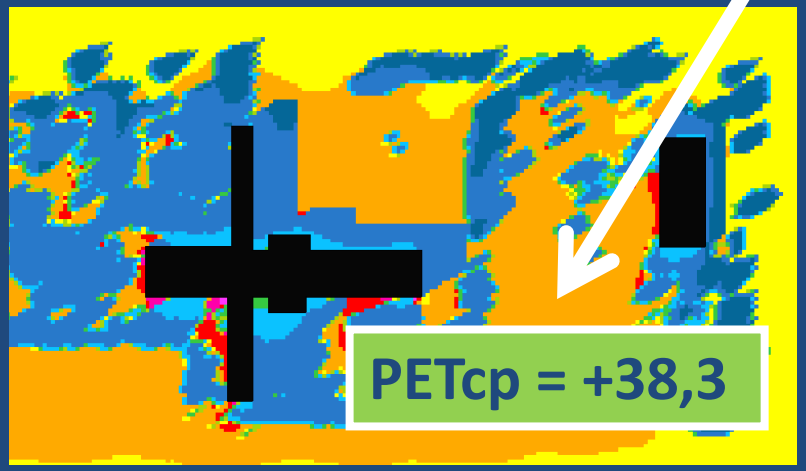
В каких областях мы это применяем?

1. Изучение влияния преобразования городской среды (Urban Greening etc.)

Пример: прогноз термического стресса в Москве. 13 июля 2010 года 19:00 (волна жары)

Территория без деревьев

Территория с деревьями

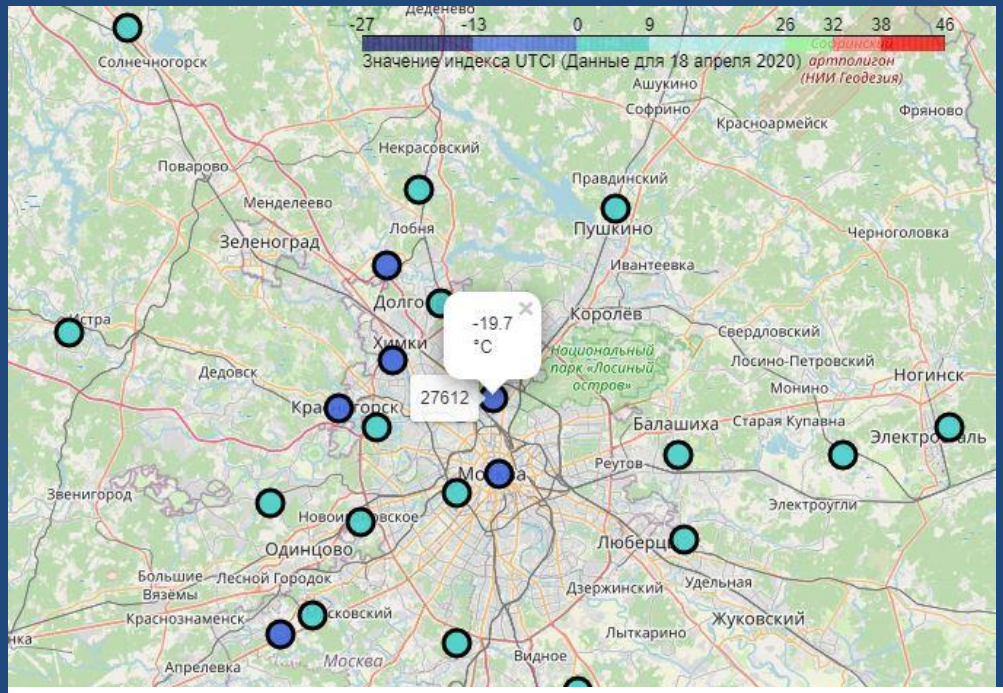


Экстремальный тепловой стресс

Сильный тепловой стресс

А если этот стресс длится >3 часов, то это уже увеличение смертности !

2. Онлайн-прогнозирование условий термического комфорта



Визуализация значений индекса UTCI на территории Москвы и прилегающих регионов (18 апреля 2020 г.)

15:05 Устные доклады

15:05-15:20 Варенцов М.И.1,2,3,4, Самсонов Т.Е.1,3, Каргашин П.Е1, Коростелева П.А.1, Варенцов А.И. 1, Перхурова А.А.1, Константинов П.И.1,4 (1МГУ им.М.В. Ломоносова/ НИВЦ, 2ИФА им.А.М. Обухова РАН, 3Гидрометцентр РФ, 4Центр смарт технологий устойчивого развития городских экосистем в условиях глобальных изменений РУДН, Москва)

Применение данных персональных метеостанций Netatmo для исследования городского климата, мониторинга и картографирования метеорологических условий и термического комфорта Московском мегаполисе

11 сентября

16:55-17:00 Перхурова А.А.1, Константинов П.И.1, Варенцов М.И.1,2, Самсонов Т.Е.1, Каргашин П.Е.1 (1 МГУим.М.В.Ломоносова, 2НИВЦ МГУим.М.В.Ломоносова, Москва)

Разработка системы мониторинга условий термического комфорта для населения Московского мегаполиса в режиме реального времени

11 сентября

3. Прогнозирование условий термического комфорта на масштабе России

Тестовый проект heat2020.ru

ЛЕТО 2020 | Выбери город | Как вести себя в жару | О технологии | О статусе информации | О нас | www.heat2020.ru | тестовый режим

ЛЕТО В ГОРОДЕ
HEAT2020
БЕРЕГИСЬ ЖАРЫ

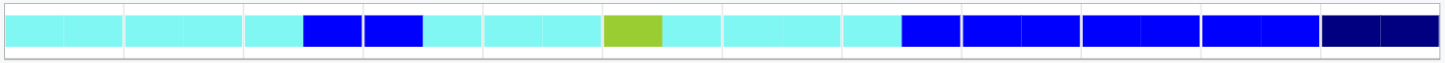
ЖАРА В ГОРОДАХ РОССИИ

*ПО ДАННЫМ ОПЫТНОЙ ТЕХНОЛОГИИ ПРЕДСКАЗАНИЯ ТЕПЛОВОГО СТРЕССА ДЛЯ 30 КРУПНЕЙШИХ РОССИЙСКИХ ГОРОДОВ

Самые жаркие города в предстоящие сутки*	Максимумы теплового стресса в предстоящие сутки*	Самые комфортные города в предстоящие сутки*	Самые прохладные города в предстоящие сутки*
1 Ростов-на-Дону	1 Ростов-на-Дону	1 Нижний Новгород	1 Омск
2 Краснодар	2 Краснодар	2 Ульяновск/li>	2 Барнаул
3 Ялта	3 Ялта	3 Ярославль	3 Красноярск

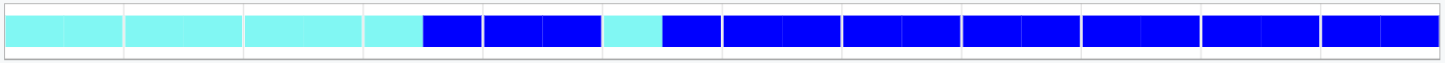
1 МОСКВА Население: 12 290 700 чел (2019) Подходящее время для прогулок/пробежек : с 10:00 до 11:00

условия термического комфорта в естественных условиях освещенности - "на солнце"



00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 00:00

условия термического комфорта без прямых солнечных лучей - "в тени"



00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 00:00

Прохладно* Слегка прохладно* Комфортно* Слегка тепло* Тепло* Жарко* Очень жарко* Холодно*

*теплоощущение человека, одетого в летнем стиле (плотная футболка/рубашка + брюки/юбка)

**согласно фактору теплового стресса/комфорта, без учета вероятности выпадения осадков

Наверх

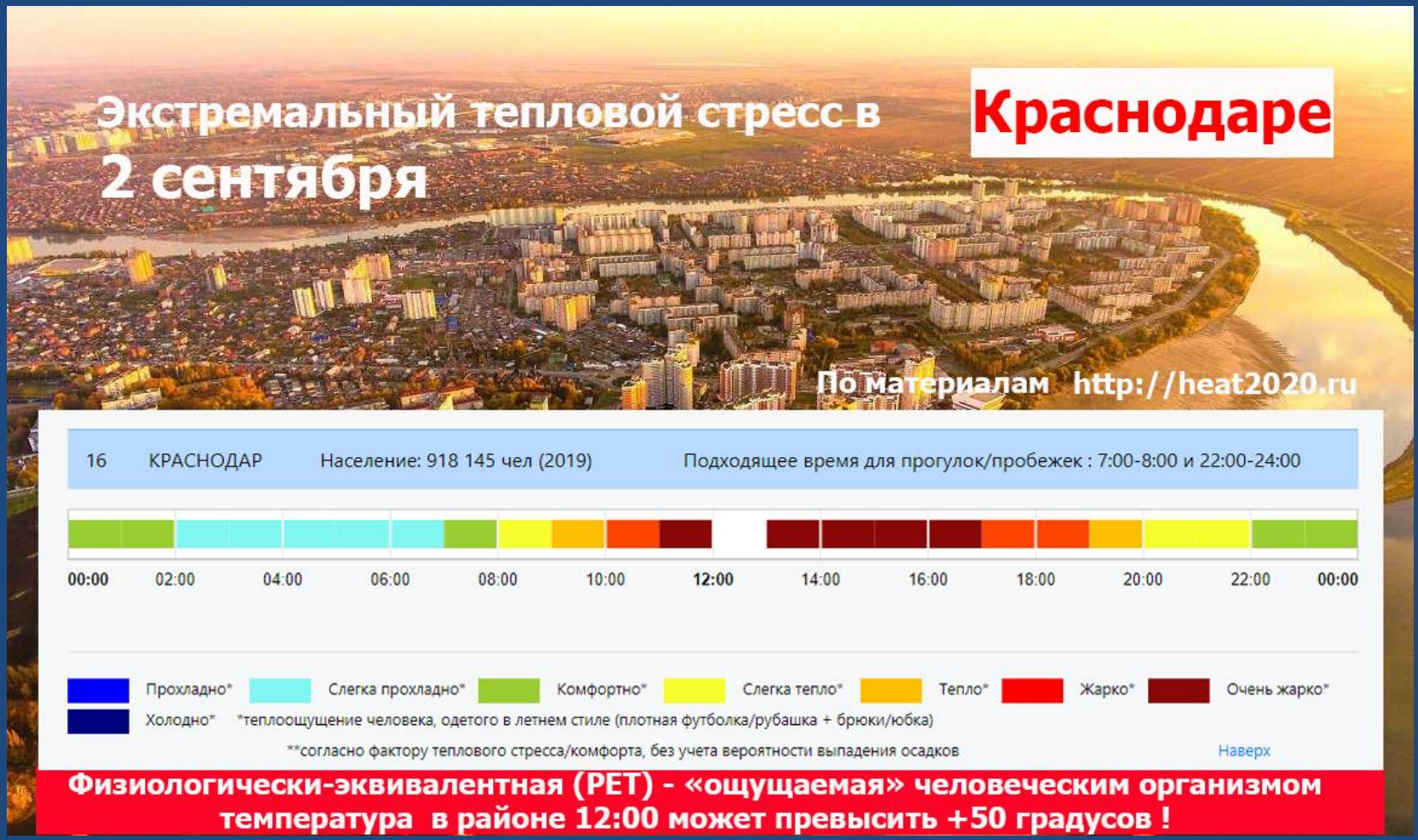
28 ТОМСК Население: 575 352 чел (2019) Подходящее время для прогулок/пробежек : 12:00-13:00

условия термического комфорта в естественных условиях освещенности - "на солнце"

условия термического комфорта без прямых солнечных лучей - "в тени"

Прохладно* Слегка прохладно* Комфортно* Слегка тепло* Тепло* Жарко* Очень жарко*

Холодно* *теплоощущение человека, одетого в летнем стиле (плотная футболка/рубашка + брюки/юбка)



18:20 Краткое устное сообщение

18:20-18:25 Каковкина А.Г.1, Константинов П.И.1,2 (1МГУим. М.В.Ломоносова, 2Научный центр «Смарт технологии устойчивого развития городской среды в условиях глобальных изменений» РУДН, Москва)

Первые результаты исследования условий термического комфорта в крупнейших административных центрах РФ

11 сентября

4. Климатическая оценка изменений термического комфорта

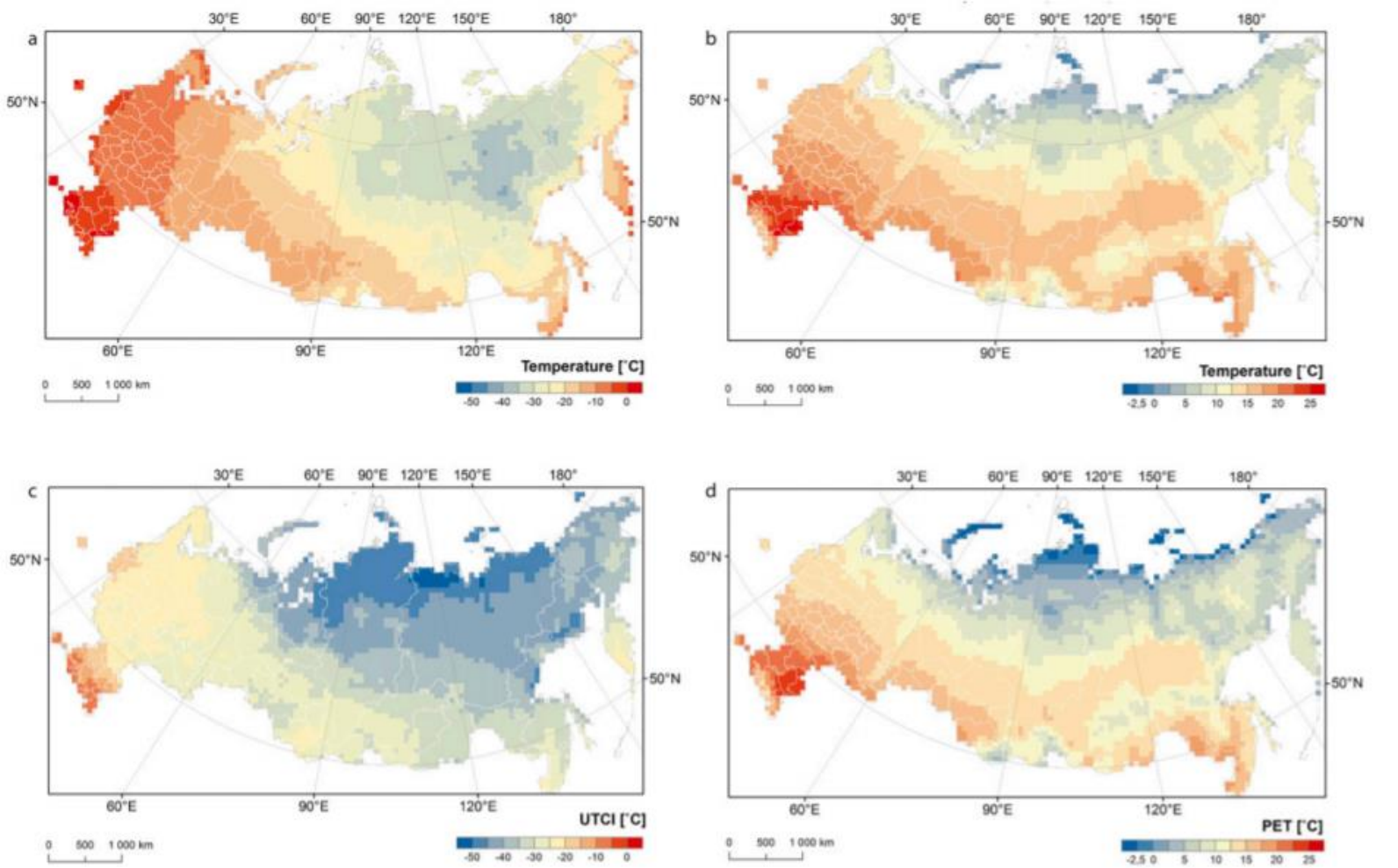


FIG. 1. Spatial distribution of mean (a) winter and (b) summer air temperatures for Russia, as well as the (c) mean winter UTCI and (d) mean summer PET, for 1981–2010.

Mikhail Varentsov, Natalia Shartova, Mikhail Grischenko, and Pavel Konstantinov. Spatial patterns of human thermal comfort conditions in russia: Present climate and trends. WEATHER CLIMATE AND SOCIETY, 12(3):629–642, 2020.

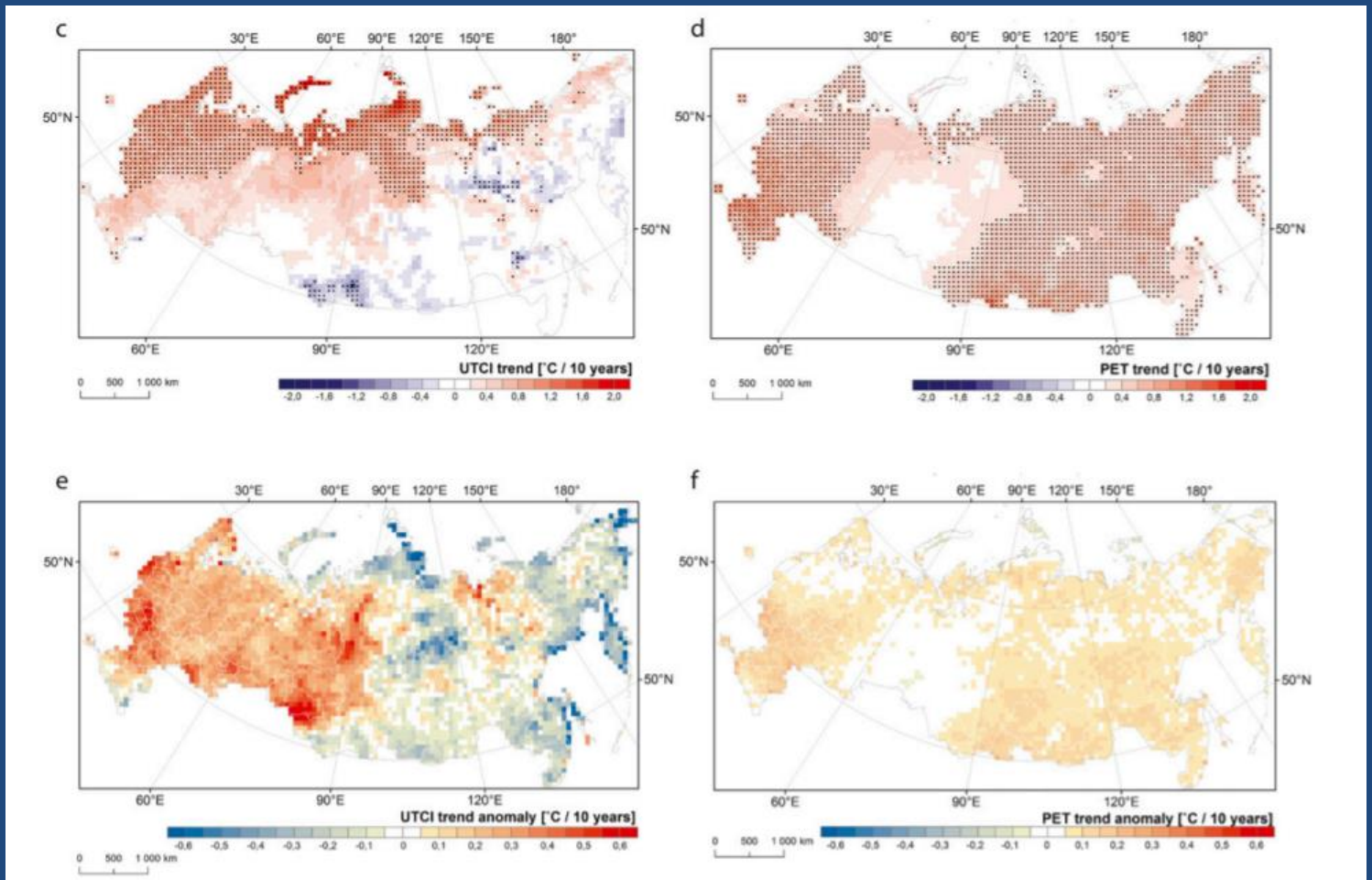
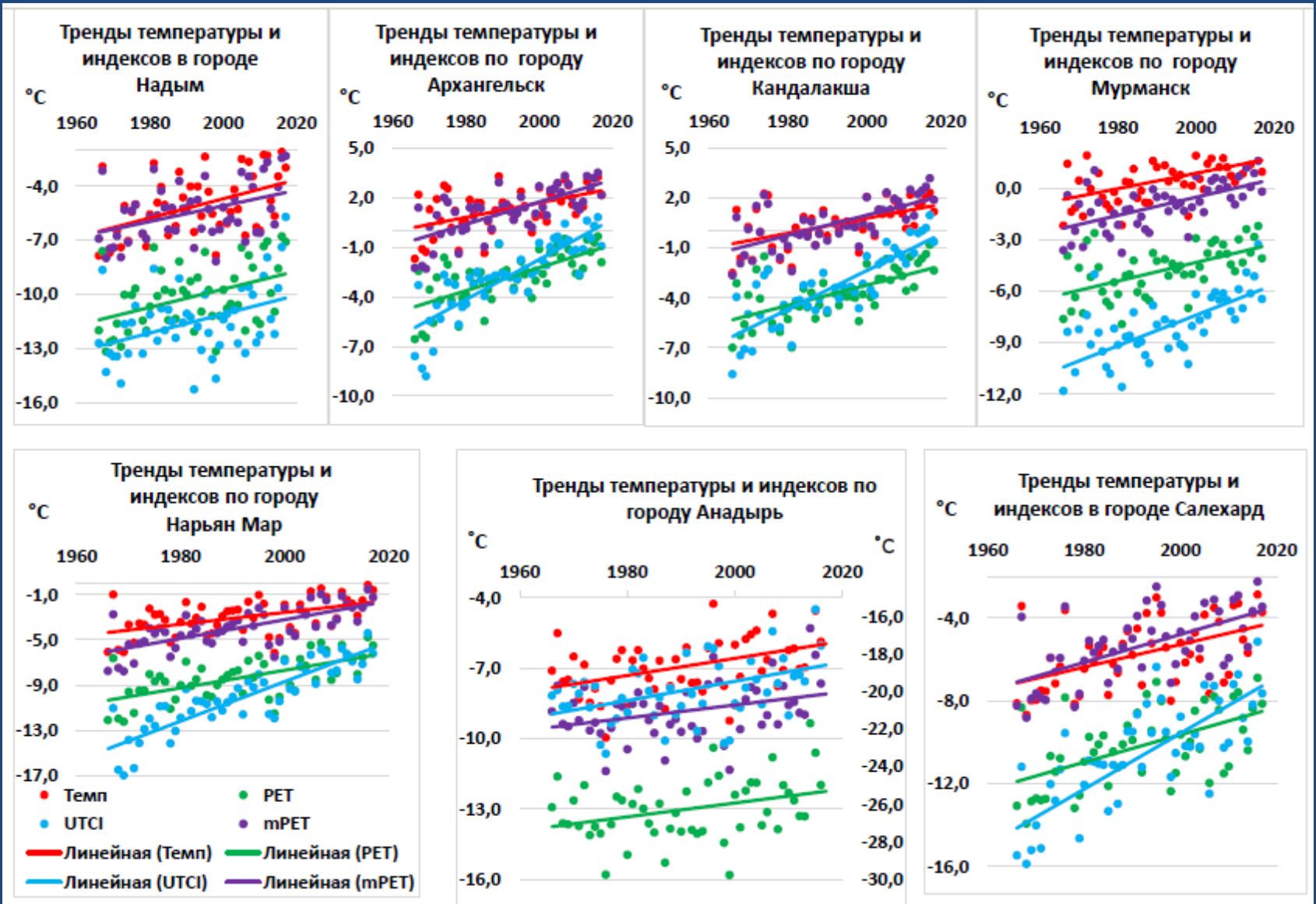


FIG. 3. Spatial distribution of Sen's slope coefficients of linear temperature trends for (a) winter and (b) summer, (c) UTCI for winter, (d) PET for summer, (e) trend anomaly defined as the difference between the UTCI trend slope and the temperature trend slope for winter, and (f) PET trend slope and temperature trend slope for summer for 1979–2018. Stippling in (a)–(d) indicates grid cells for which the trend was significant at $p < 0.05$ according to the Mann–Kendall test.

Mikhail Varentsov, Natalia Shartova, Mikhail Grischenko, and Pavel Konstantinov. Spatial patterns of human thermal comfort conditions in russia: Present climate and trends. WEATHER CLIMATE AND SOCIETY, 12(3):629–642, 2020.

5. Изменение климата Арктики



A. A. Semenova, P. I. Konstantinov, M. I. Varentsov, and T. E. Samsonov. Modeling the dynamics of comfort thermal conditions in arctic cities under regional climate change. IOP Conference Series: Earth and Environmental Science, 386:012017, 2019.