Environmental factors and human health: approaches and assessment

Varvara Mironova
Lomonosov Moscow State University

Multi-Scales and -Processes Integrated Modelling, Observations and Assessment for Environmental Applications
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Lomonosov Moscow State University

Global threats: public perception

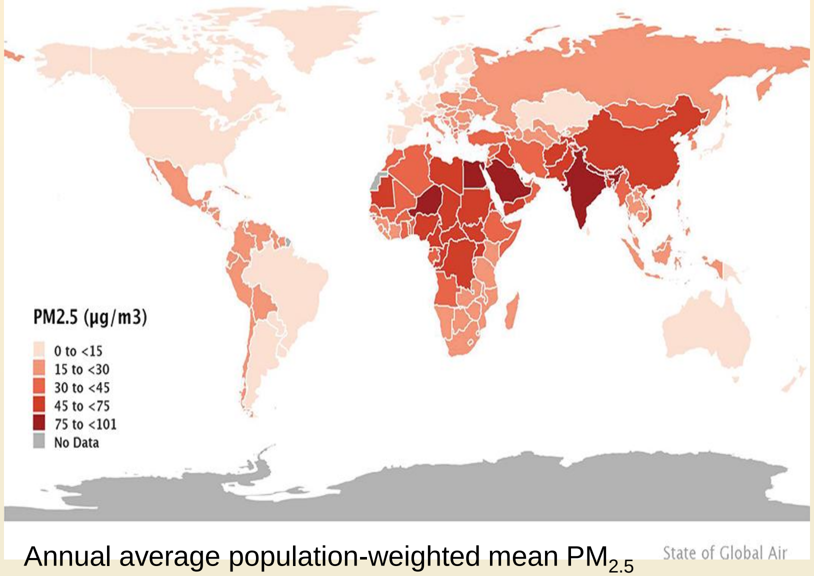
- Global warming
- Environmental pollution
- Energy resources shortage
- Loss of biodiversity
- Lack of fresh water
- Infectious diseases
- Hunger
- Household waste

The 10 biggest global health threats (according to WHO): 2019

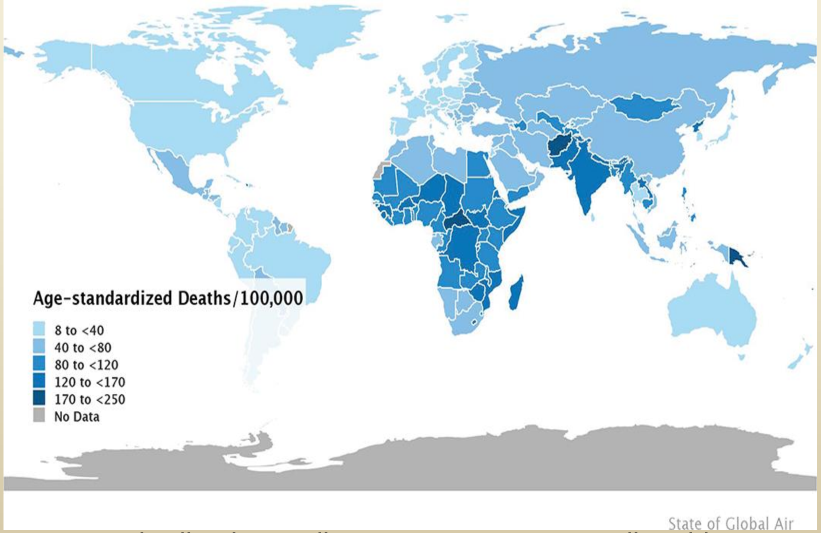
1. Air pollution and climate change
2. Non-communicable diseases
3. Influenza
4. Fragile and vulnerable settings
5. Antimicrobial resistance
6. Ebola and high-threat pathogens
7. Weak primary care
8. Vaccine hesitancy
9. Dengue
10. HIV

Air pollution

- Air pollution is now recognized by governments, international institutions and civil society as one of a major global public health risk factor.
- This is the result of the remarkable growth of scientific knowledge enabled by advances in epidemiology and exposure assessment.
- There is now a broad scientific consensus that exposure to air pollution increases mortality and morbidity from cardiovascular and respiratory disease and lung cancer and shortens life expectancy.
- Fine particle mass with aerodynamic diameters <2.5 µm ($PM_{2.5}$) and ground-level (tropospheric) ozone are indicators of two relatively distinct air pollution mixtures commonly used to quantify exposure to air pollution and its health effects.



Annual average population-weighted mean $PM_{2.5}$ concentrations in 2017.



Age-standardized mortality rates per 100 000 attributable to air pollution in 2017.

Source: Boogaard H, WalkerK, Cohen AJ. Air pollution: the emergence of a major global health risk factor, *International Health*, Volume 11, Issue 6, November 2019, Pages 417–421

Environment pollution

- At first glance, it seems very common to think that economic growth is bound to be accompanied by environmental pollution.
- Many people believe that the world is less beautiful today than it was decades ago, and that more and more environmental pollution awaits us in the future.
- The facts refute these popular beliefs.
  - Economic growth should result in increased availability of benefits such as fresh air, clean water and healthier surroundings in general, just as food, energy and other resources are becoming more available.
  - Our natural environment will increasingly meet the requirements of a healthy life, and in this sense there can be no limits to progress.

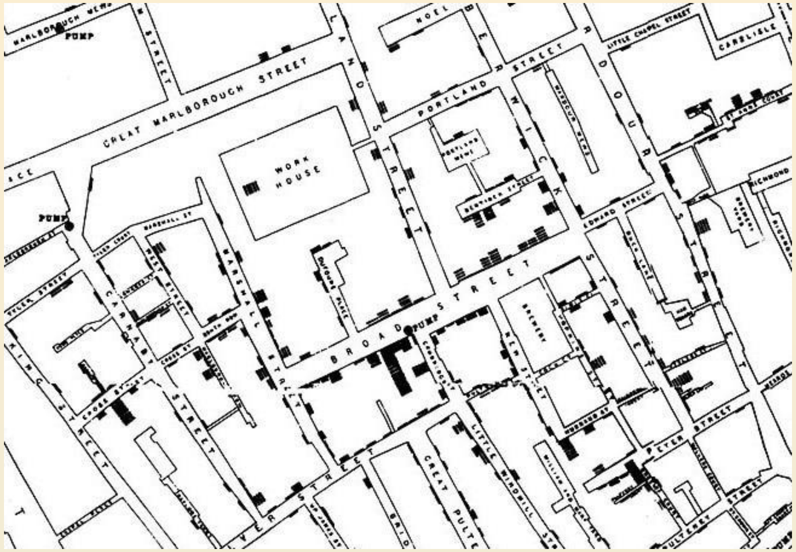
Environment pollution

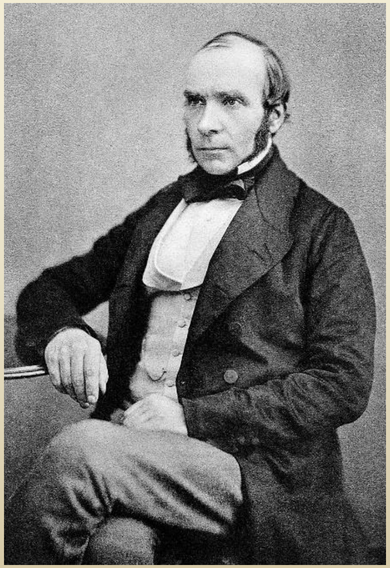
- There are different types of pollution
- Over time, many of them were almost completely eliminated.
  - household waste on city streets
  - infectious diseases.
- Others have emerged relatively recently and have become a serious problem:
  - gasoline exhaust from cars
  - urban and industrial noise
  - nuclear waste
  - municipal solid waste
  - Infectious diseases in poor countries

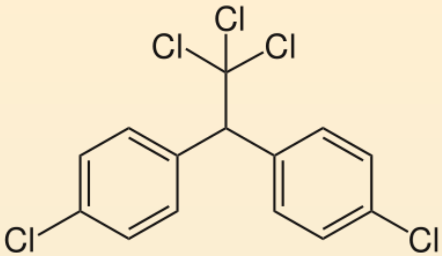


Environment pollution

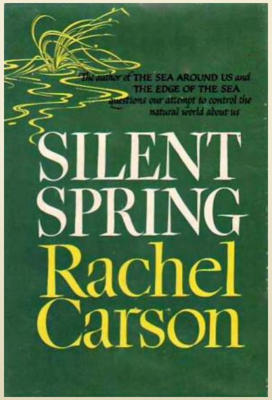
- There is a difference between really serious environmental pollutants and exaggerated or minor
- In the past, the worst contaminants were bacterial and viral infections, which were spread through unclean water, air, and insects.
- Now in developed countries, no one even means infectious diseases when talking about pollution, although in poor countries they continue to cause many deaths







DDT (dichlorodiphenyltrichloroethane)



- First synthesized in 1873 by an Austrian chemist Othmar Zeidler, but remained unused for a long time
- Swiss chemist Paul Müller discovered its insecticidal properties in 1939
  - And for this he received the Nobel Prize in Physiology or Medicine in 1948
- DDY was attacked by environmental activists after the publication in 1962 of Rachel Carson's book "Silent Spring"
- Then it was banned for use in the United States and other countries.
- In 2006, WHO authorizes indoor DDT as an anti-malaria measure

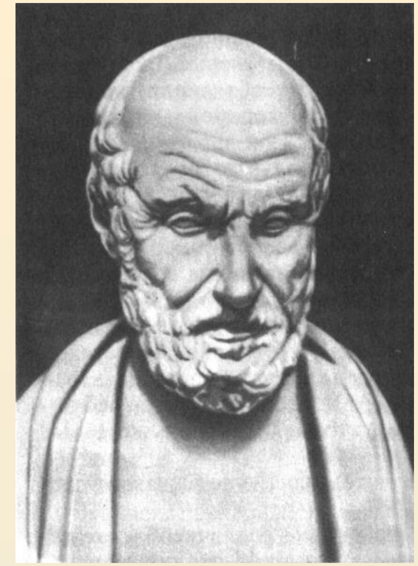
Disease preconditions

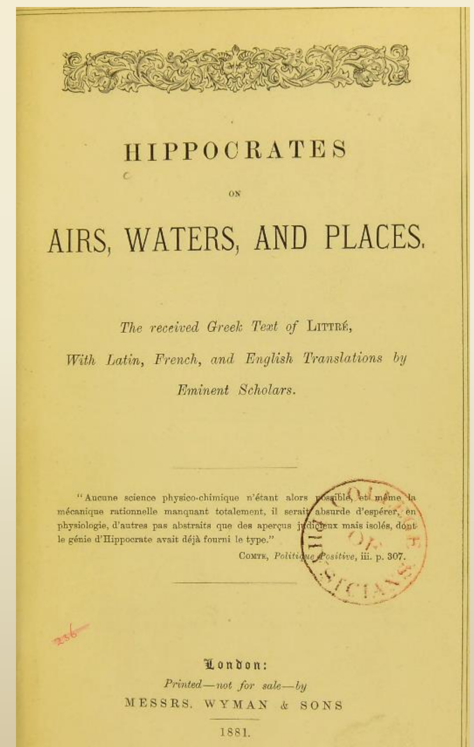
- Information on the relationship of certain diseases with environmental conditions can be found in ancient sources for 2-3 thousand years BC.
- Since ancient times, a belief of "miasms" as the causes of mass diseases of people in certain places was widely spread
- Disease preconditions
  - Abiotic: climatic, geochemical, hydrological, landscape
  - Biotic
  - Socio-economic

Hippocrates

- *Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces (for they are not at all alike, but differ much from themselves in regard to their changes).*
- *Then the winds, the hot and the cold, especially such as are common to all countries, and then such as are peculiar to each locality.*
- *We must also consider the qualities of the waters, for as they differ from one another in taste and weight, so also do they differ much in their qualities…*
- *In the same manner, when one comes into a city to which he is a stranger, he ought to consider its situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or the south, to the rising or setting sun.*

— Hippocrates. On Airs, Waters, and Places (c. 400 B.C.)





HIPPOCRATES

ON

AIRS, WATERS, AND PLACES.

The received Greek Text of Littré,

With Latin, French, and English Translations by

Eminent Scholars.

"Aucune science physico-chimique n'étant alors possible, et même la mécanique rationnelle manquant totalement, il serait absurde d'espérer, en physiologie, d'autres pas abstraits que des aperçus judicieux mais isolés, dont le génie d'Hippocrate avait déjà fourni le type."

Comte, *Politique Positive*, iii. p. 307.

London:

Printed—not for sale—by

MESSRS. WYMAN & SONS

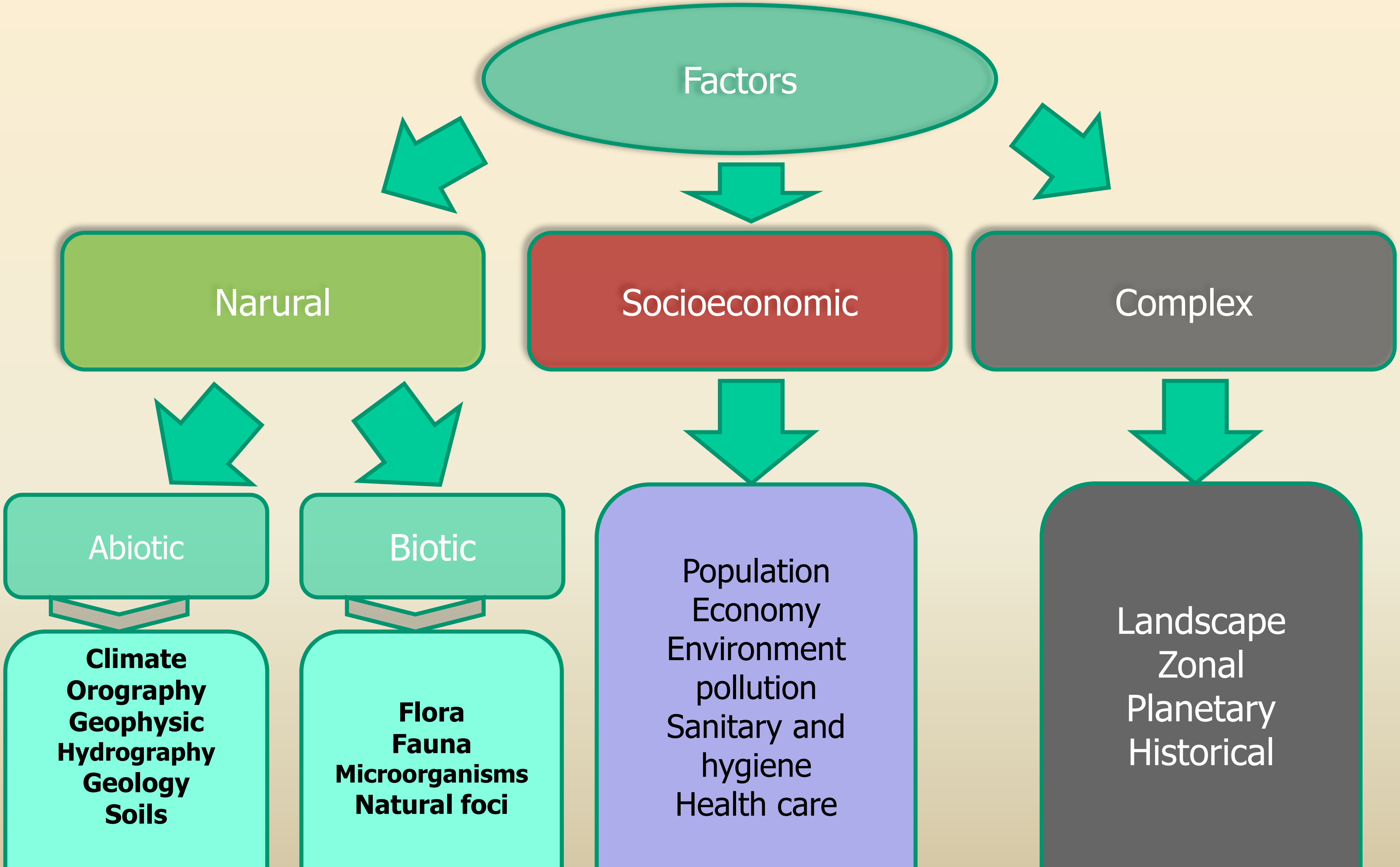
1881.

Comfort and extreme environment

- Climate comfort: an optimal level of physiological reactions is ensured, while a person does not feel either heat or cold
- Climate extremity: being in extreme climatic conditions can affect not only working and living conditions, but also threaten human health
  - Especially among non-indigenous people
- Why is it the climatic component of the extreme nature of natural conditions that prevails against the other components of the extreme environment?

Environmental comfort

Environmental factors



Examples of the influence of geophysical factors on human health

- Height above sea level
  - Hypoxia, altitude sickness (anorexia, headache, insomnia, nausea), other (rare) disorders
- The influence of various meteorological parameters (heat, cold, high humidity, atmospheric pressure drops, etc.)
  - Dehydration of the body, heatstroke, skin irritation (prickly heat, etc.), eye irritation when in a dry, arid climate, exacerbation of chronic diseases, frostbite, anemopathy

Geochemical factors

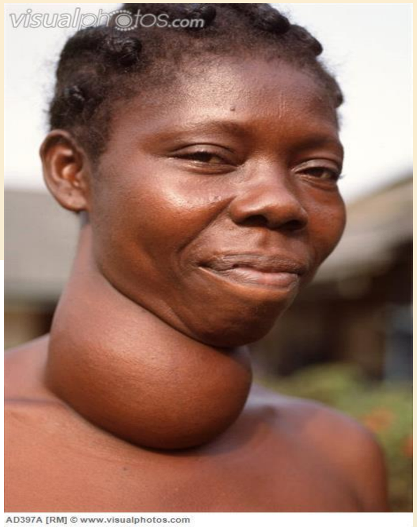
Evaluated by the content of chemical elements and their compounds in the soil and natural waters of the landscape.

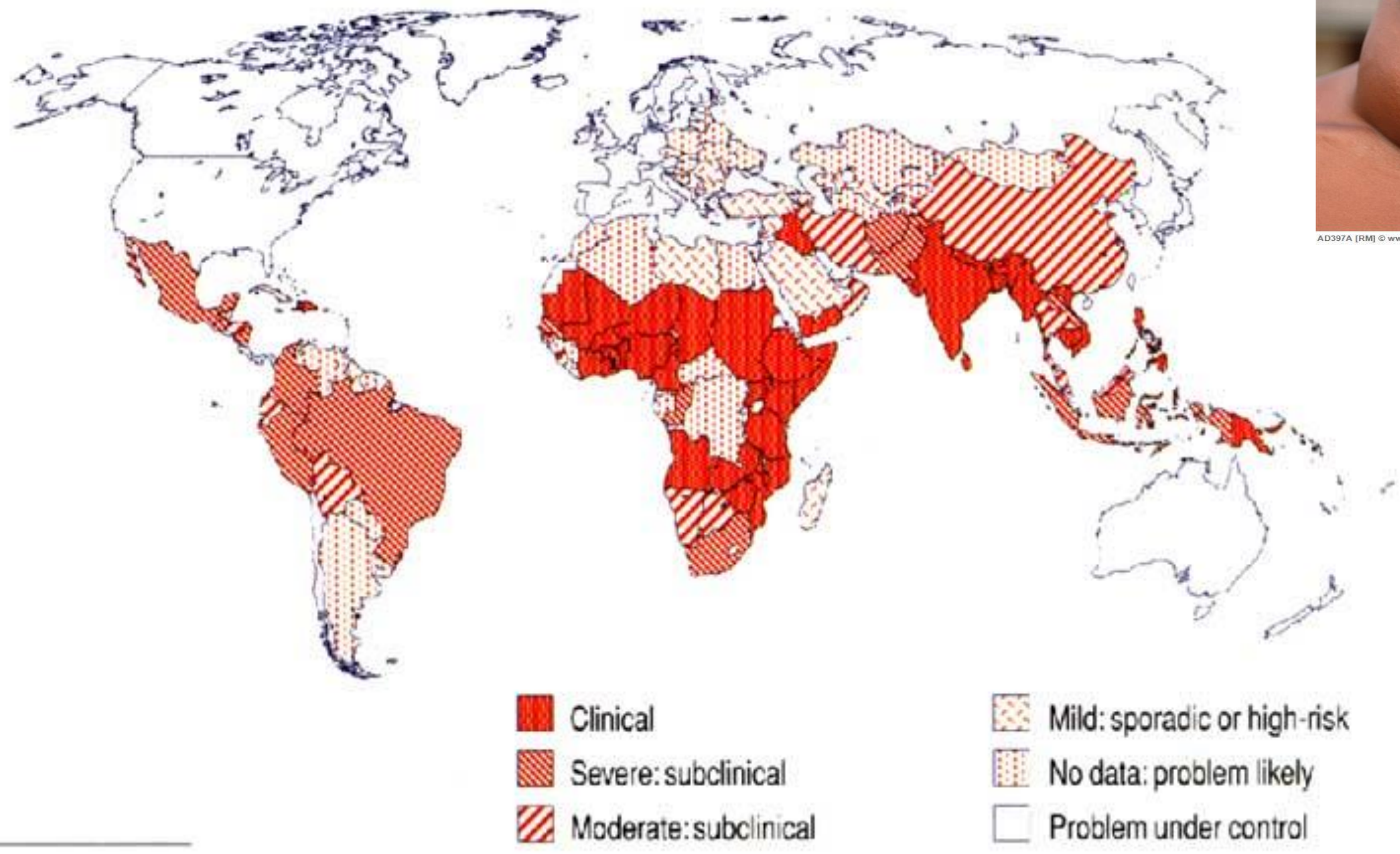
- The lack or excess of these elements causes pathological deviations in the state of health of the population

Microelementoses are diseases that arise from an imbalance of vital microelements (zinc, copper, manganese, iron, iodine, selenium) in natural ecosystems.

Endemic goiter

Increase in the thyroid gland associated with iodine deficiency in the environment





Data from the World Health Organization.

Climatic factor

- The spread of almost all diseases caused by living pathogens is determined primarily by environmental conditions.
- The role of factors that affect the spread of the natural diseases is unequal.
- The climatic factor is deemed one of the main determinants for the spread of naturally determined diseases.
- An essential part of any medico-geographical assessment is the search for links between the spread of diseases and factors of the geographical environment.

Emerging and re-emerging diseases

- “Emerging” infectious diseases can be defined as infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range.
- Specific factors precipitating disease emergence can be identified in virtually all cases. These include ecological, environmental, or demographic factors that place people at increased contact with a previously unfamiliar microbe or its natural host or promote dissemination.
- Two-step process of emergence:
  - Introduction of the agent into a new host population (whether the pathogen originated in the environment, possibly in another species, or as a variant of an existing human infection)
  - establishment and further dissemination within the new host population (“adoption”)

Emerging and re-emerging diseases

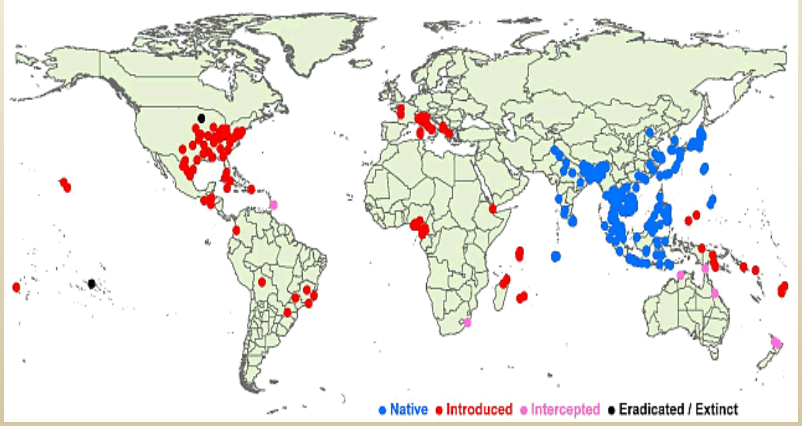
- ***Emerging***: A new disease that occurs in an area / host population spreads further and takes root due to lack of awareness, lack of diagnostics, experience or other factors. Diseases that are recognized in the human host for the first time
- ***Re-emerging.*** Diseases that historically have infected humans, but continue to appear in new locations or in drug-resistant forms, or that reappear after apparent control or elimination
- **There can be:**
  - Entirely new infections (Bourbon virus, SARS, MERS, **Covid-19**).
  - New diseases in a specific geographic region (West Nile fever in North America, chikungunya fever in Italy).
  - Re-emerging in the region after a long absence (dengue fever in the southern United States)
  - Disorders caused by antibiotic-resistant bacteria (*Staphylococcus aureus*), or drug-resistant tuberculosis.

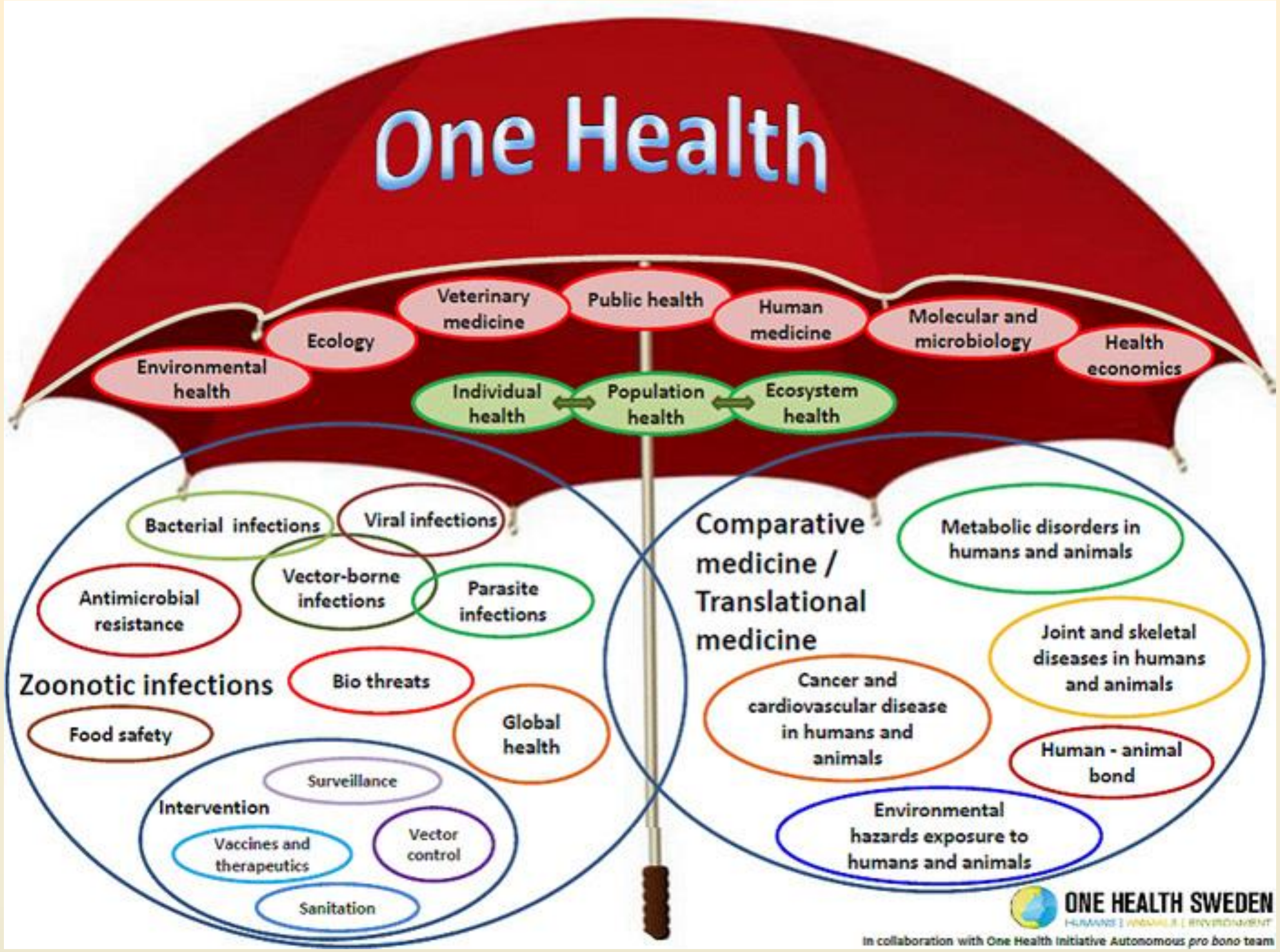
Some major factors that underlie disease emergence and reemergence

The Microbial Agent	The Human Host	The Human Environment
Genetic adaptation and change	Human susceptibility to infection	Climate and weather
Polymicrobial diseases	Human demographics and behavior	Changing ecosystems
	International trade and travel	Economic development and land use
	Intent to harm (bioterrorism)	Technology and industry
	Occupational exposures	Poverty and social inequality
		Lack of public health services
		Inappropriate use of antibiotics
		Animal populations
		War and famine
		Lack of political will

Emerging diseases, emerging challenges: a case of *Aëdes albopictus*

- *Aëdes albopictus* ("tiger mosquito") has spread worldwide from Asia with loads of old tires sent for recycling.
- Mosquitoes breed in the water that collects in the tires.
- It is a vector of dengue and chikungunya fevers.
- Spreading out of its initial habitat, it appeared in Hawaii, then in the USA, Latin America, Europe.
- In an experiment, it becomes infected with other arboviuses.
- Suspected vector of Zika virus



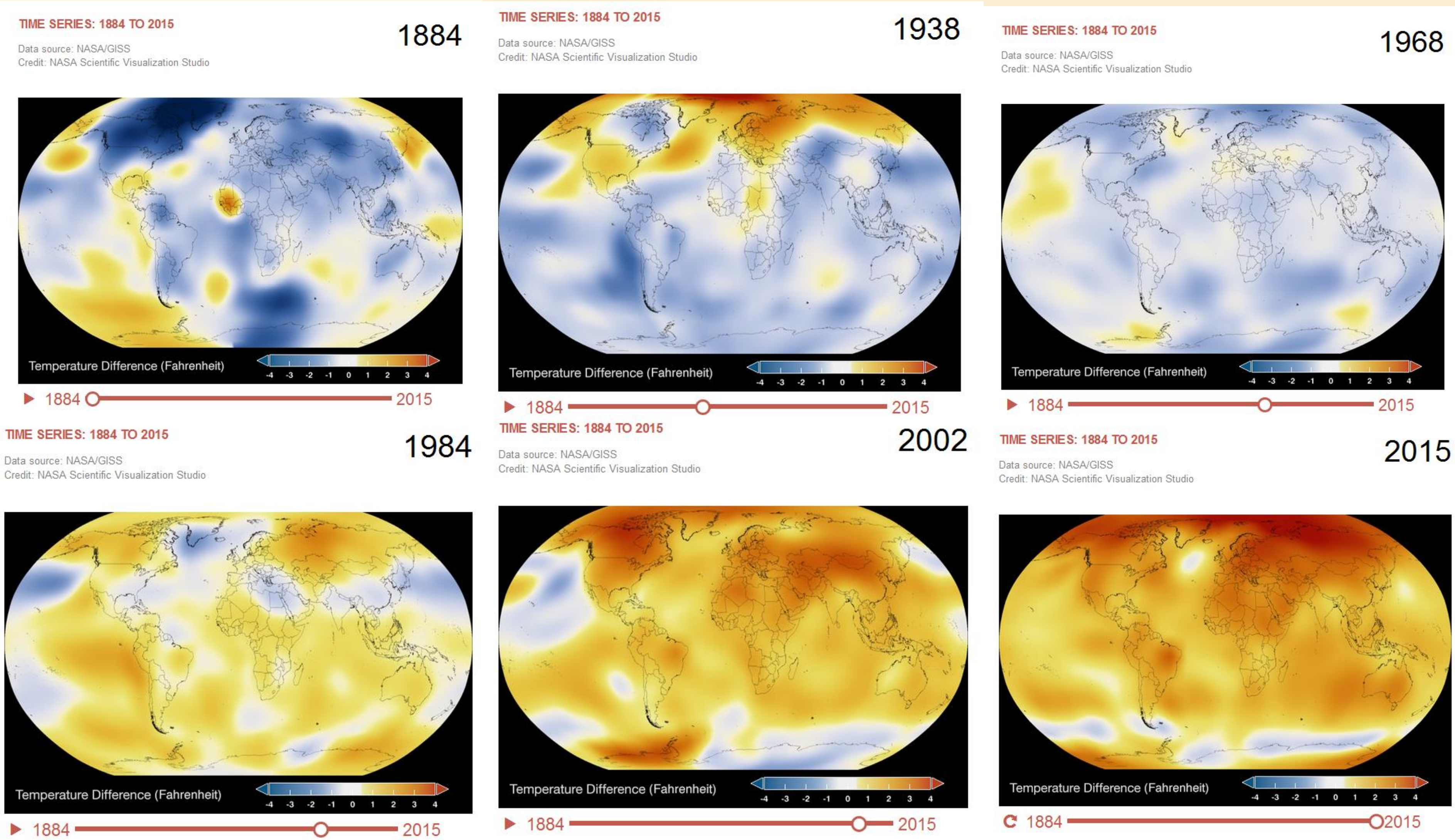


The concept of "One Health" is being formed, which is based on the idea of the close relationship between the health of people, animals, plants and the environment.

Climate change

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

Earth surface temperatures change



Climate change

- The world’s climate is changing, and among the most significant negative consequences is to human health. While climate change is a global health issue, its health impacts vary across geographies and populations.

Climate change

- Climate change can no longer be classified as solely an environmental, scientific, or technological issue.
- Heat waves, hurricanes, floods constitute a severe health hazard
- Climate change has increased the incidence of infectious disease throughout the world.
  - Vector-borne diseases are spreading to areas previously unaffected due to climate change. It adds that climate change also creates potentially deadly heat waves and decreases air quality.
- Children, people living in poverty, and the aging population are among the most vulnerable to the health effects of climate change
- People with weakened or impaired immune systems are also susceptible to climate change's effects.
- **Climate change is a threat that magnifies other threats**

Climate change and health

Climate change affects health both through extreme natural events (hurricanes, tornadoes, typhoons, the likelihood of which is increasing), and through direct temperature increases, the effect of which is especially noticeable in the summer heat in cities (so-called "heat waves") ...

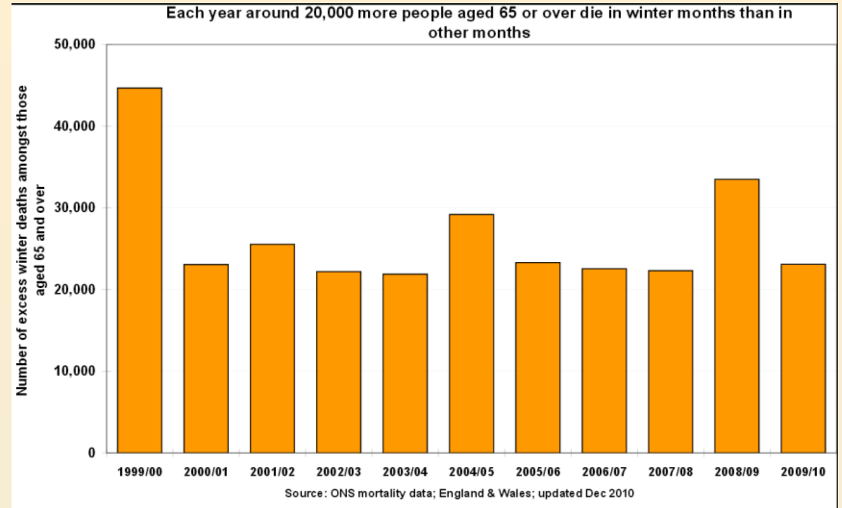
Climate change and health

“The heat wave in Europe in the summer of 2003 caused 35,000 additional deaths. In France alone, from August 1 to August 20, 2003, the number of additional deaths reached 15 thousand. In Spain, during hot August 2003, 6 thousand more deaths were recorded than usual. "

Heat waves

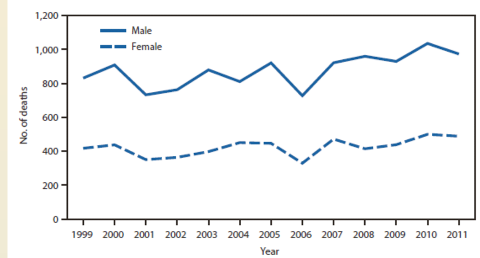
Country	Additional deaths
UK	2045 (16%)
France	14802(60%)
Italy	3134 (15%)
Portugal	2099 (26%)
Germany	About 7000

“The heat wave in Europe in the summer of 2003 caused 35,000 additional deaths. In France alone, from August 1 to August 20, 2003, the number of additional deaths reached 15 thousand. In Spain, during hot August 2003, 6 thousand more deaths were recorded than usual. "



QuickStats: Number of Hypothermia-Related Deaths,* by Sex — National Vital Statistics System, United States,† 1999-2011§

Weekly
January 4, 2013 / 61(51);1050



* Deaths attributed to exposure to excessive natural cold as underlying and contributing causes of death, which were coded as X31, T68, and T69 according to the *International Classification of Diseases, 10th Revision*.

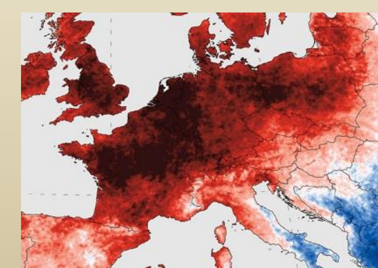
† U.S. residents only.

§ Data for 2011 are preliminary.

From 1999 to 2011, a total of 16,911 deaths in the United States, an average of 1,301 per year, were associated with exposure to excessive natural cold. The highest yearly total of hypothermia-related deaths (1,536) was in 2010 and the lowest (1,058) in 2006. Approximately 67% of hypothermia-related deaths were among males.

Source: National Vital Statistics System. Mortality public use data files, 1999–2010. Available at http://www.cdc.gov/nchs/data_access/vitalstatsonline.htm.

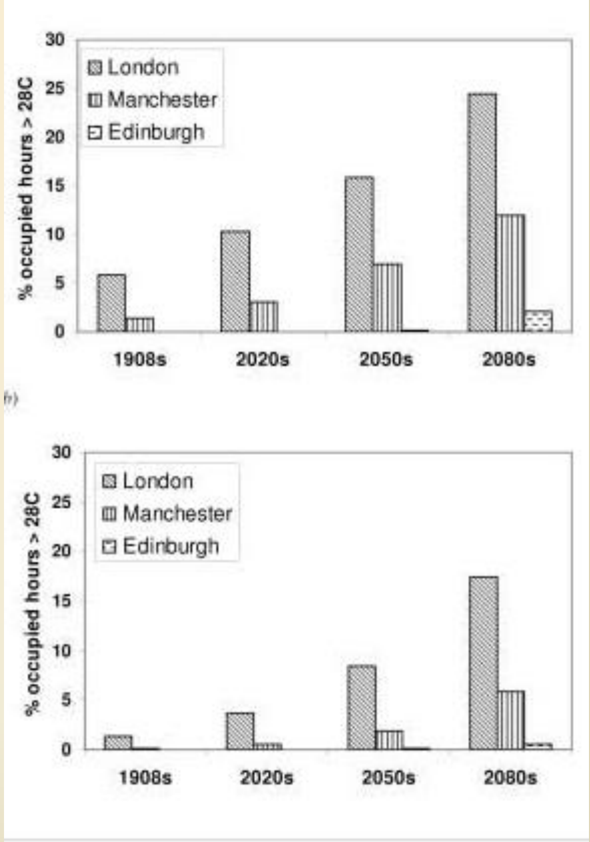
Фото: Ian Langsdon/EPA/TASS



https://nplus1.ru/news/2018/07/31/heatwave-deaths

Overheating

- A major anticipated impact of climate change on the built environment in the temperate regions is an increase in the occurrence of overheating in buildings, due to reduced efficacy of the traditional and still widely used method of cooling buildings comfort ventilation with outside air. As outside temperatures become higher, the potential to provide cooling with comfort ventilation falls off.



Predicted hours of exceedance of 28°C operative temperature for the mid-floor of (a) 1960s office and (b) mixed-mode office, under DSYs for London, Manchester and Edinburgh morphed under the UKCIP02 Medium-High emissions scenario.

Hacker, Holmes, 2007

Some good news

- Adaptations
  - Philadelphia, 1960:
  - 100ºF (≈37.8ºC) caused a sharp rise in mortality
  - 2000: Temperature rise to 100ºF (≈37.8ºC) resulted in almost no additional mortality
- Why?

Extreme natural events

Katrina hurricaine, 2005

1926 Miami hurricane

From Wikipedia, the free encyclopedia

The **1926 Miami Hurricane** (or **Great Miami Hurricane**) was a Category 4 hurricane that devastated Miami, Florida in September 1926. The storm also caused significant damage in the Florida Panhandle, the U.S. state of Alabama, and the Bahamas. The storm's enormous regional economic impact helped end the Florida land boom of the 1920s and pushed the region on an early start into the Great Depression.

1926 Great Miami Hurricane

Category 4 hurricane (SSHS)

Miami Beach after the 1926 Miami Hurricane

Formed	September 11, 1926
Dissipated	September 22, 1926
Highest winds	150 mph (240 km/h) (1-minute sustained)
Lowest pressure	935 mbar (hPa; 27.61 inHg)
Fatalities	265–373
Damage	$100 million (1926 USD) $1.2 billion (2010 USD)
Areas affected	Bahamas, Florida, Alabama, Mississippi, Louisiana

Part of the
1926 Atlantic hurricane season

Contents [hide]

Meteorological history [edit]

Storm path

The Cape Verde-type hurricane formed on September 6. Moving west-northwest while traversing the tropical Atlantic, the storm later passed near St. Kitts on September 14. By September 17 it was battering the Bahamas, impacting the Turks and Caicos Islands with winds estimated at 150 mph (240 km/h).[1] Then, in the early morning hours of September 18, it made landfall just south of Miami between Coral Gables and South Miami as a devastating Category 4 hurricane on the Saffir-Simpson Hurricane Scale. The storm crossed the peninsula south of Lake Okeechobee, entered the Gulf of Mexico, and made another landfall near Mobile, Alabama as a Category 3 hurricane on September 20 before hooking westward along coastal Alabama and Mississippi, eventually dissipating on September 22 after moving inland over Louisiana.

Impact [edit]

In Florida, winds on the ground were reported around 125 mph (201 km/h) and the pressure measured at 935 mbar (27.61 inHg) — though all such data is suspect. Most of the coastal inhabitants had not evacuated, partly because of short warning (a hurricane warning was issued just a few hours before landfall) and partly because the "young" city's population knew little about the danger a major hurricane posed. A 15-foot (4.6 m) storm surge inundated the area, causing massive property damage and some fatalities. As the eye of the hurricane crossed over Miami Beach and downtown Miami, many people believed the storm had passed. Some tried to leave the barrier islands, only to be swept off the bridges by the rear eyewall. "The lull lasted 35 minutes, and during that time the streets of the city became crowded with people," wrote Richard Gray, the local weather chief. "As a result, many lives were lost during the second phase of the storm."[2]

Inland, Lake Okeechobee experienced a high storm surge that broke a portion of the dikes, flooding the town of Moore Haven and killing many. This was just a prelude to the deadly 1928 Okeechobee Hurricane, which would cause a massive number of fatalities estimated at 2,500 around the lake.

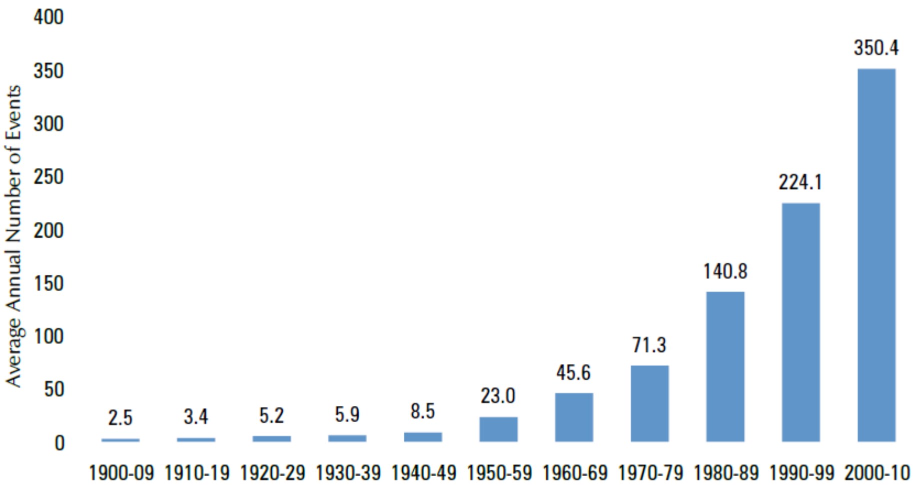
Coastal regions between Mobile and Pensacola, Florida also suffered heavy damage from wind, rain, and storm surge, but this paled beside the

Hurricane and Tropical Cyclones

The 31 Deadliest Atlantic Hurricanes / Tropical Cyclones (1492-2006)

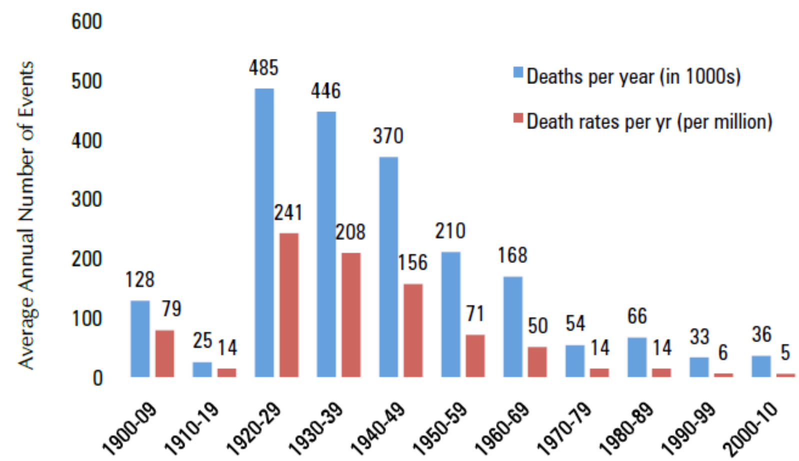
Rank	Name / Areas of Largest Loss	Dates	Deaths
1.	"Great Hurricane" Martinique, Barbados, St. Eustatius	10-16 Oct 1780	22000
2.	Great Galveston Hurricane	8 Sep 1900	8000-12000
3.	Mitch: Honduras, Nicaragua	10/22 - 11/5 1998	9086
4.	Fifi: Honduras	14-19 Sep 1974	8000-10000
5.	Dominican Republic	1-6 Sep 1930	8000
6.	Flora: Haiti, Cuba	9/30-10/8 1963	8000
7.	Pointe-a-Pitre Bay, Guatemala	6 Sep 1776	6000
8.	Newfoundland Banks	9-12 Sep 1775	4000
9.	Puerto Rico, Carolinas	8-19 Aug 1899	3433
10.	FL, PR, Martinique, Guadeloupe, Turks	12-17 Sep 1928	3411

Figure 1: Average Number of Extreme Weather Events per Year by Decade, 1900–2010



Note: For the last period, 2000–2010, the annual number of events is based on an 11-year average. Statistics from the last "decade"—2000–2010—and the data for 2010 and perhaps even 2009 must necessarily be considered preliminary at this writing (March 2011).
Source: EM-DAT (2011).

Figure 2: Global Death and Death Rates Due to Extreme Weather Events, 1900–2010



Note: For the last period, 2000–2010, annual deaths and death rates are based on an 11-year average.
Source: I. M. Goklany, "Deaths and Death Rates from Extreme Weather Events: 1900-2008," 2009, *Journal of American Physicians and Surgeons*, vol. 14 (4), pp. 102–09. Available at http://www.jpands.org/vol14no4/goklany.pdf; EM-DAT: The OFDA/CRED International Disaster Database, 2011, Université Catholique de Louvain, Brussels, Belgium. Available at http://www.em-dat.net. Accessed Mar 26, 2011; C. McEvedy, R. Jones, Atlas of World Population History (New York, N.Y.: Penguin, 1978); and WRI [World Resources Institute], 2011, EarthTrends Database. Available at www.wri.org. Accessed Mar 23, 2011.

Climate-related diseases

The effect of the climatic factor on the spread of infectious diseases

- Main characteristics
  - average monthly temperatures,
  - rainfall,
  - snow cover height,
  - duration of the frost-free period
- They are important for poikilothermic (cold-blooded) animals - arthropod vectors, as well as for pathogens that spend part of their life cycle in their bodies.
- Important also for warm-blooded carriers of diseases (wintering conditions, possibility of breeding under the snow, etc.)

Malaria as a reality of everyday life in Europe in the 19th century

Hébert "La Malaria", approx. 1850, Museum d'Orsay, Paris

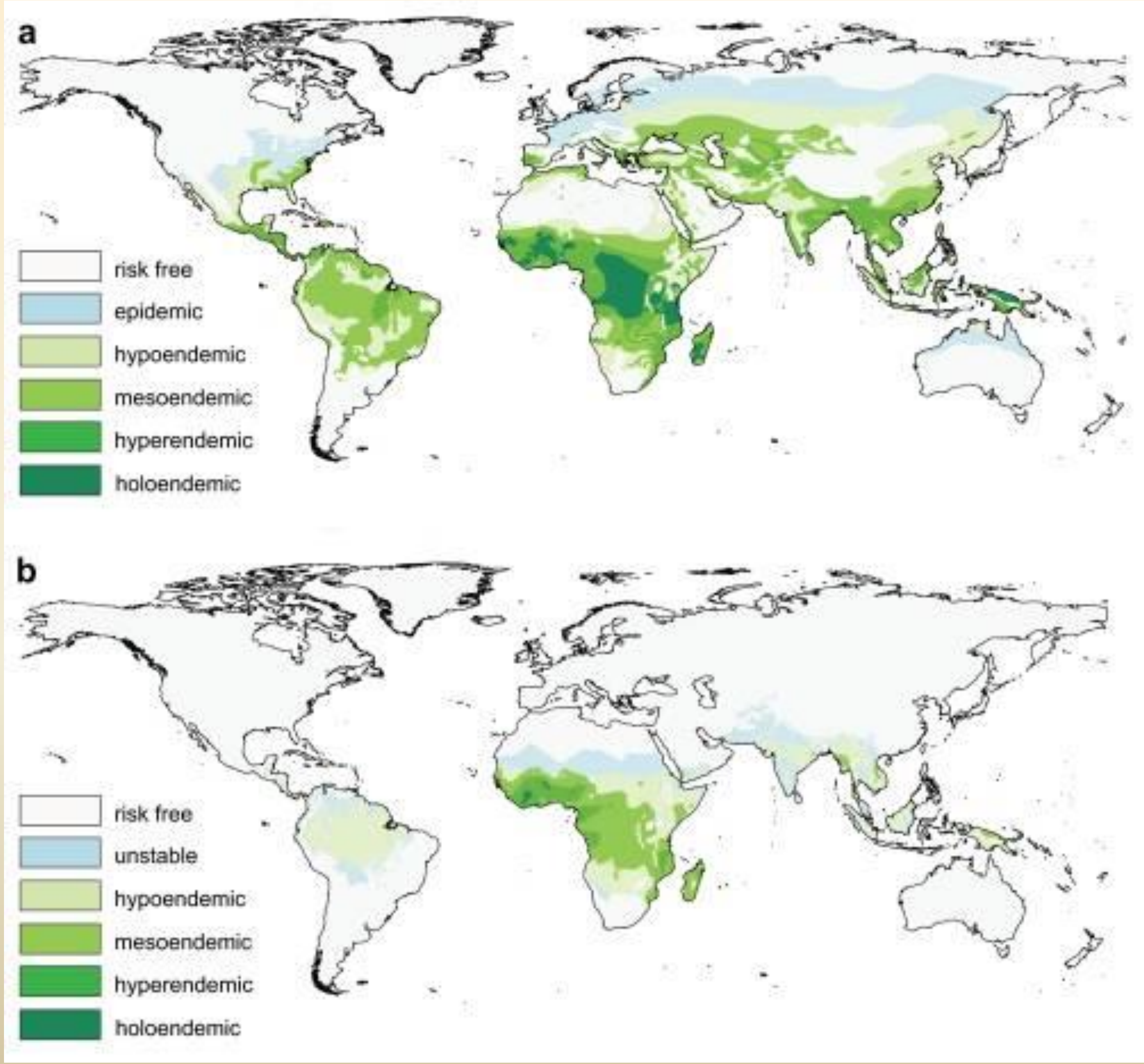
Factors limiting the spread of malaria

- The main abiotic factor limiting the spread of malaria is the presence of sufficiently high temperatures for a sufficient time, i.e.
  - For Central and northern Europe:
    - The average daily temperature is above 16 ° C
    - For at least 1 month

Factors limiting the spread of malaria

- Altitude is also a limiting factor
- because above a certain mark (“cut-off altitude”), the heat is no longer enough to complete the development of the parasite in the mosquito. In addition, the vector is absent at high altitudes.
    - Closer to the equator, malaria rises to a greater altitude, as the initial average temperature at sea level is higher there.

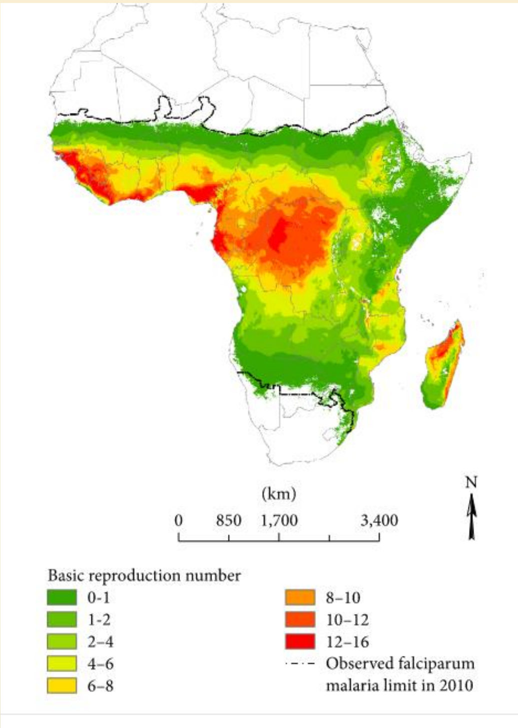
Changes in malaria endemicity

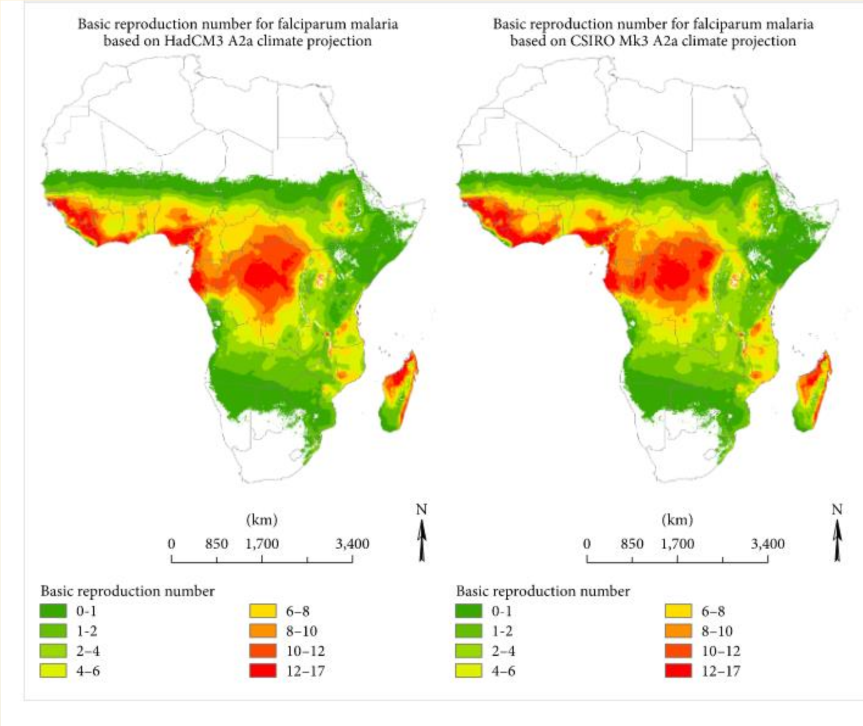


1900

2007

Climate change and disease: an example of malaria

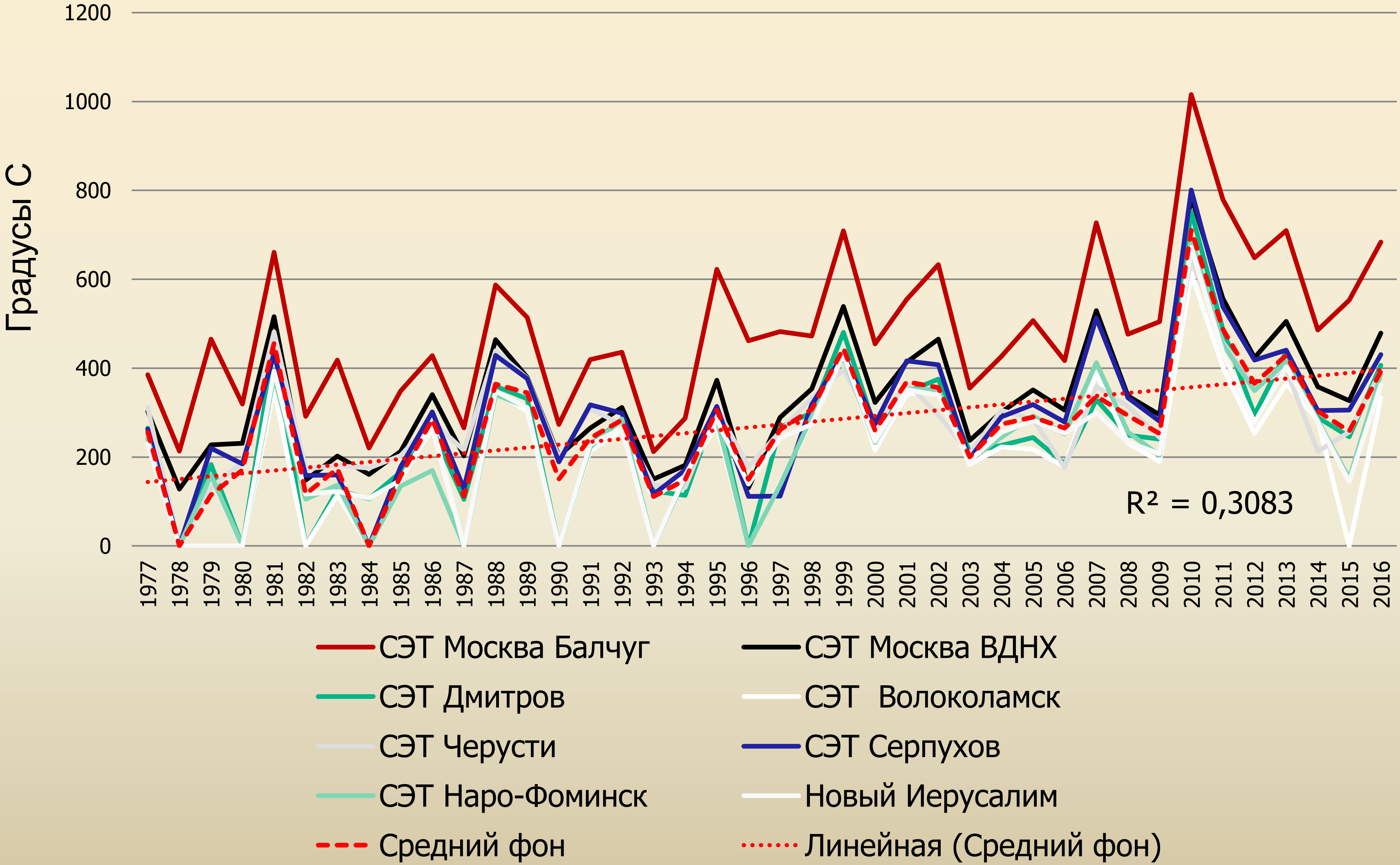




Basic reproduction number for falciparum malaria based on the baseline climate.

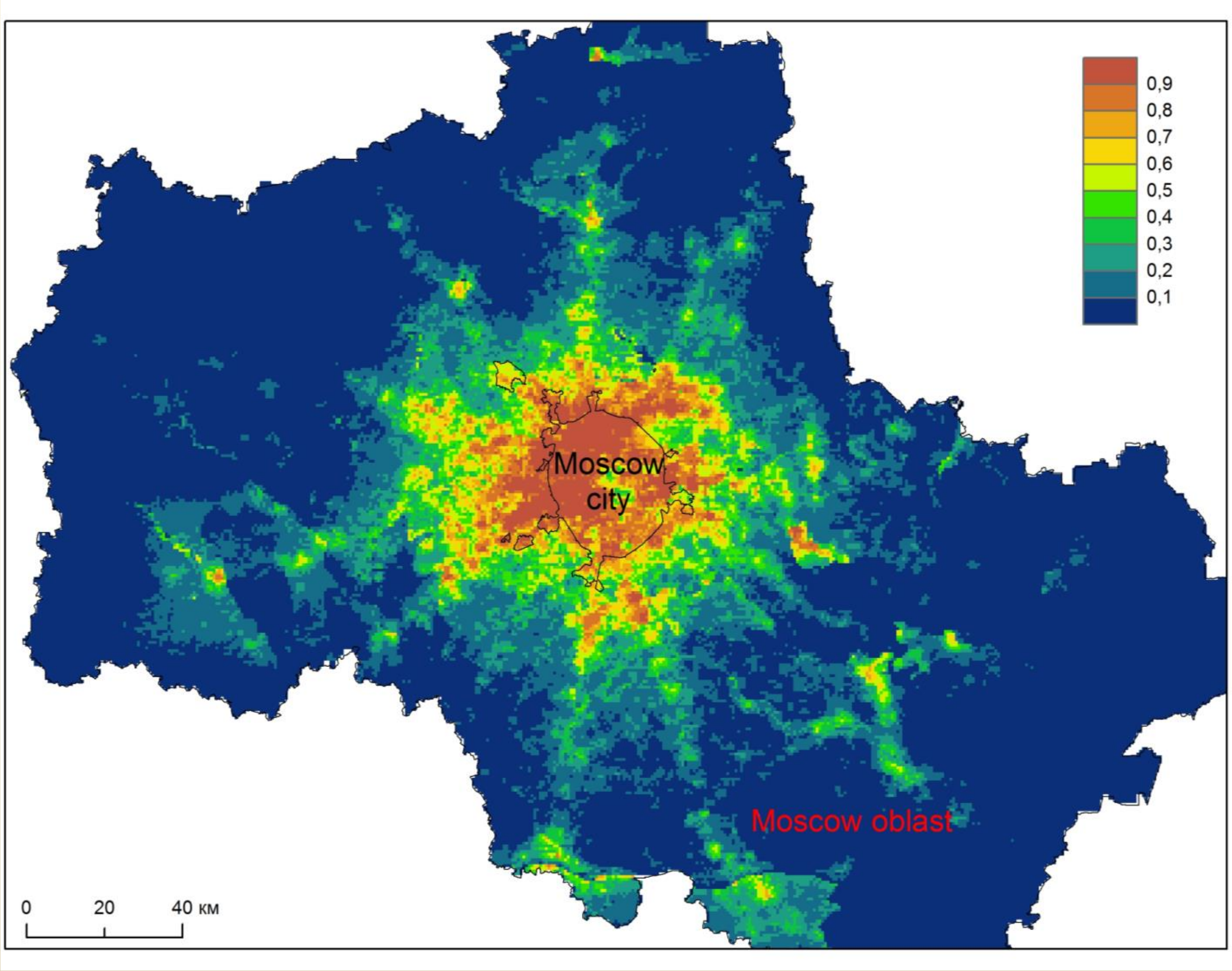
2040 projected basic reproduction number for falciparum malaria

Sum of effective temperatures: evaluation for Central Russia



The length of effective mosquito infectivity season

A model of environmental sutability for malaria transmission

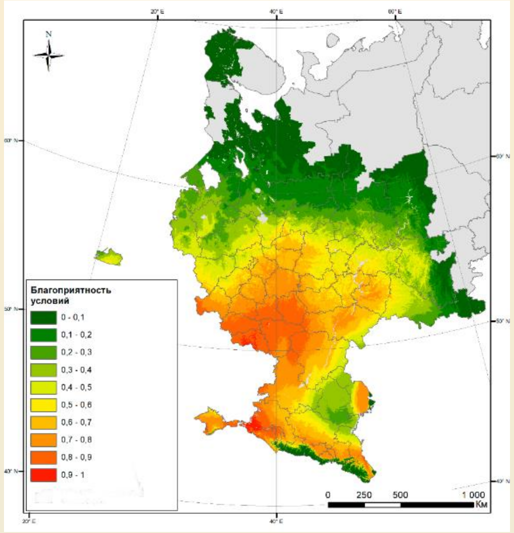


Mironova et al., 2019

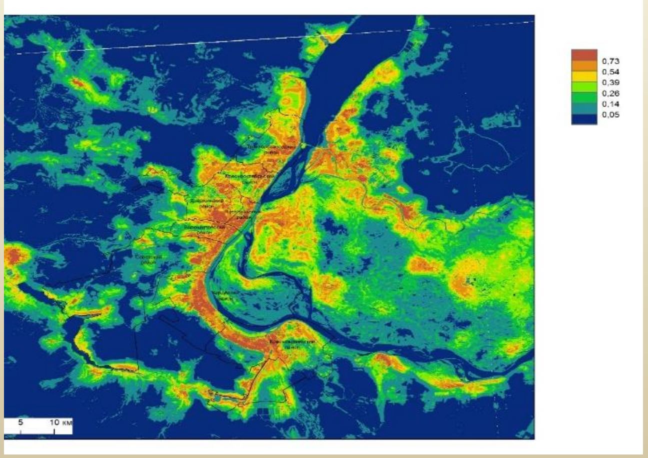
Modeling conditions for the spread of disease

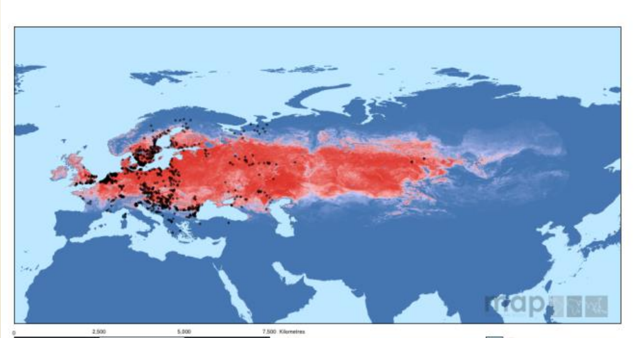
- The environmental suitability to a disease transmission can be exalyated by an ecological niche modelling (ENM) approach.
- This method produces a map, where each grid cell expresses the suitability to the studied species' habitat as a function of the environmental variables, based on the input presence data.

Dirofilariasis [Шедько и др., 2020]



West Nile fever in Southern Russia [Зелихина и др., 2021]





The predicted distribution of *Anopheles* (*Anopheles*) *messeae*

Natural focal diseases and climate

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- Natural focal diseases are diseases whose causative agents, like any other biological species, have originated and exist under the influence of the main factors of evolution, regardless of humans, and are natural members of ecosystems.





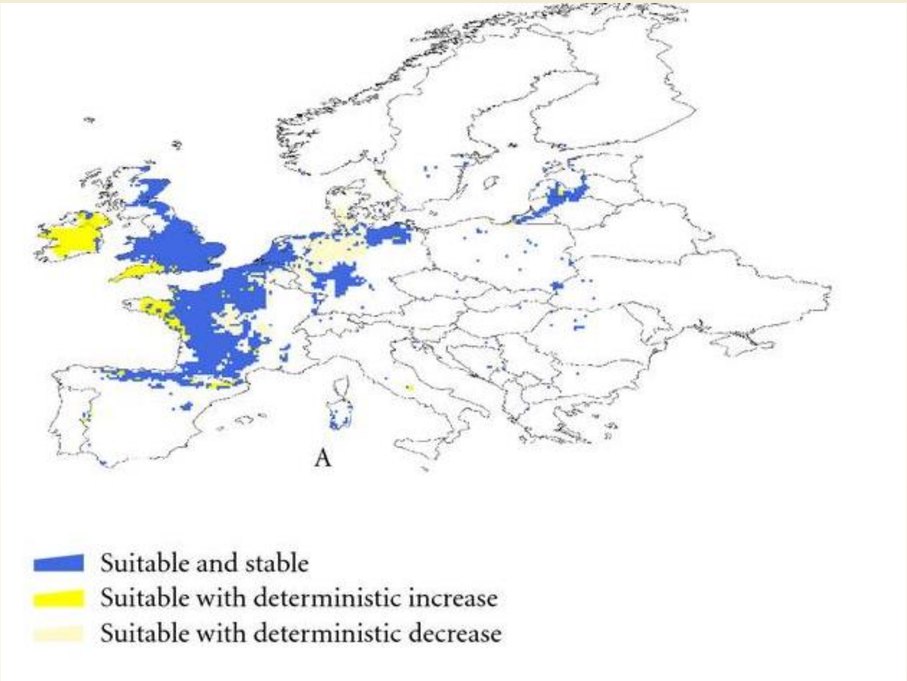

Tick-borne encephalitis

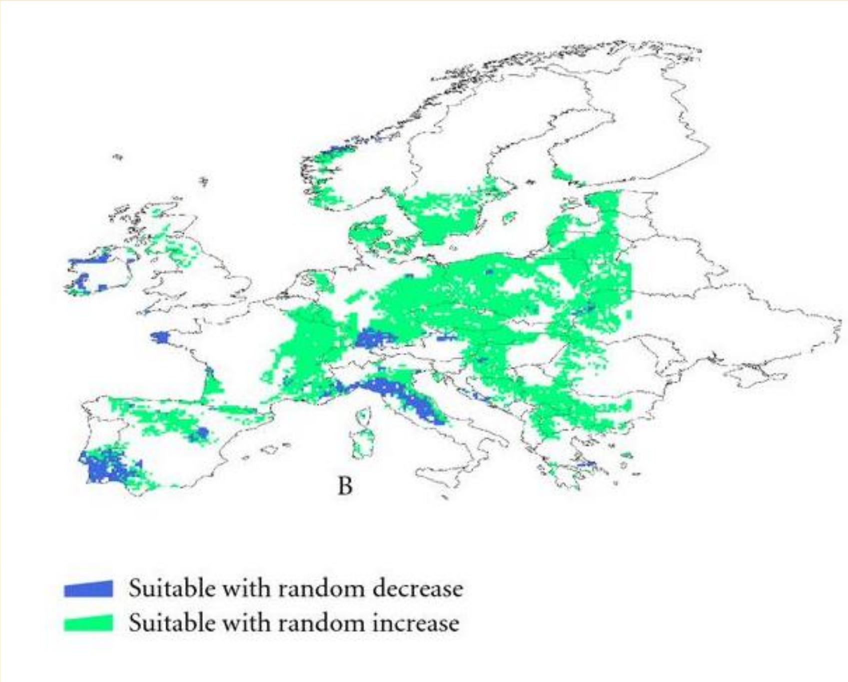
- Effective temperatures for the period above + 5ºC
- Combined with moisture index
  - I. persulcatus (taiga tick):
  - 1600-1900º - poor heat supply
  - 2000-2300º - moderate heat supply
  - more than 2300º - good heat supply
- **Best conditions for transmission**:

Moderate heat supply + Moderate humidification (0,35-045)

Good heat supply + Increased humidification 0,45-0,60

How does climate change affect ticks?

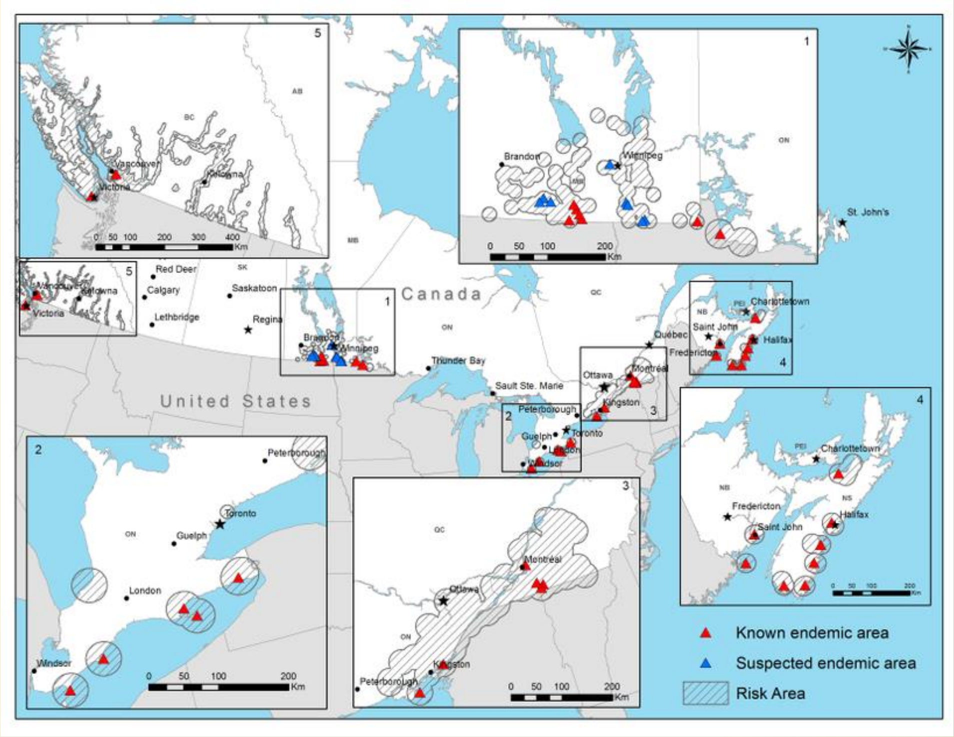


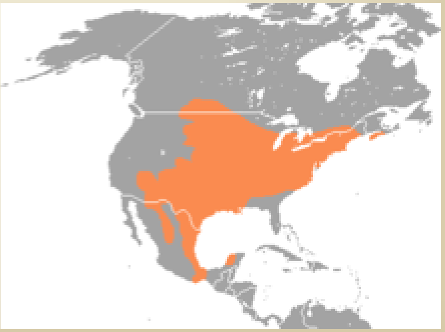


An analysis of the long-term changes in climate suitability for the tick *Ixodes ricinus* in Europe (1900–1999) (Gray et al., 2009).

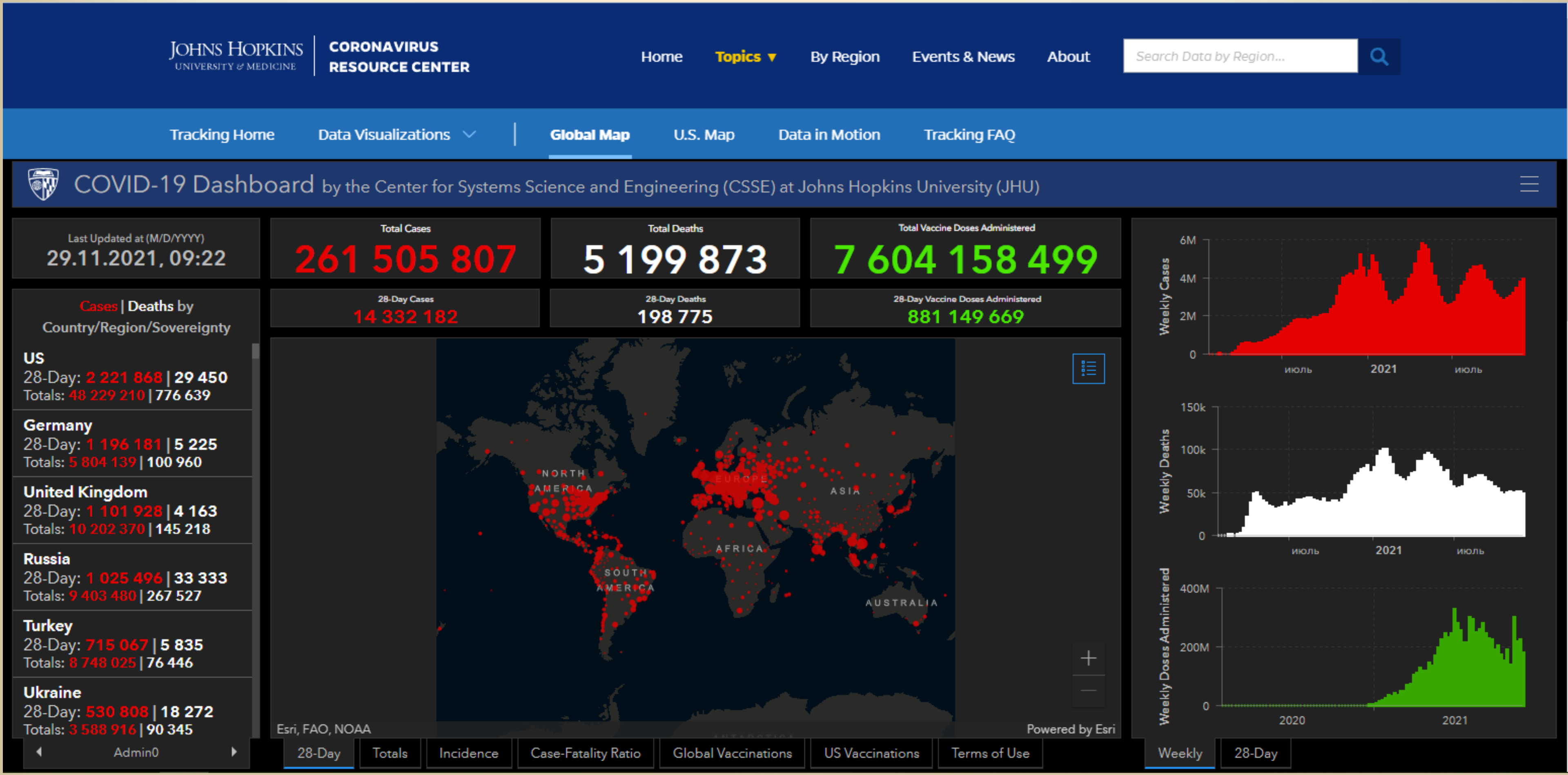
Other examples: Lyme disease

- Changes in the boundaries of the ranges of some animal species may lead to changes in the nosoareals of diseases





A newcomer: SARS Covid-19



Solutions

1. Climate crisis: working toward creating "a set of policy options for governments" that aim to lower the health risks associated with air pollution.

2. Health care delivery in areas of conflict and crisis

3. Health care equity: to address disparities in health equity by improving "child and maternal care, nutrition, gender equality, mental health, and access to adequate water and sanitation“

4. Access to treatments

5. Infectious disease prevention

6. Epidemic preparedness

7. Unsafe products: to combat health risks related to unsafe foods

8. Underinvestment in health workers: to combat a shortage of health workers around the world because of low pay

9. Improving public trust of health care workers

10. Capitalizing on technological advancements

11. **Threat of anti-microbial resistance and other medicines**

12. Health care sanitation


Thanks for your attention