Lesson /week 6 and 7

Climate and Weather: Influences on Health

- ✓ Direct Biometerological Influences
- ✓ The Influence of the Weather
- ✓ Acclimatization
- ✓ Seasonality of Births and Deaths
- ✓ How Climate Change is Likely to Affect Health and Disease

Direct Biometerological Influences

- ✓ The Radiation Spectrum
- ✓ Atmospheric Ionization
- ✓ Extremely Low Frequency Waves and Infrasound ELF
- ✓ Infrasound
- ✓ Atmospheric pressure
- ✓ Temperature and Relative Humidity
- ✓ Cold and wind chill
- ✓ Air mass Movement, and Air-borne Life.

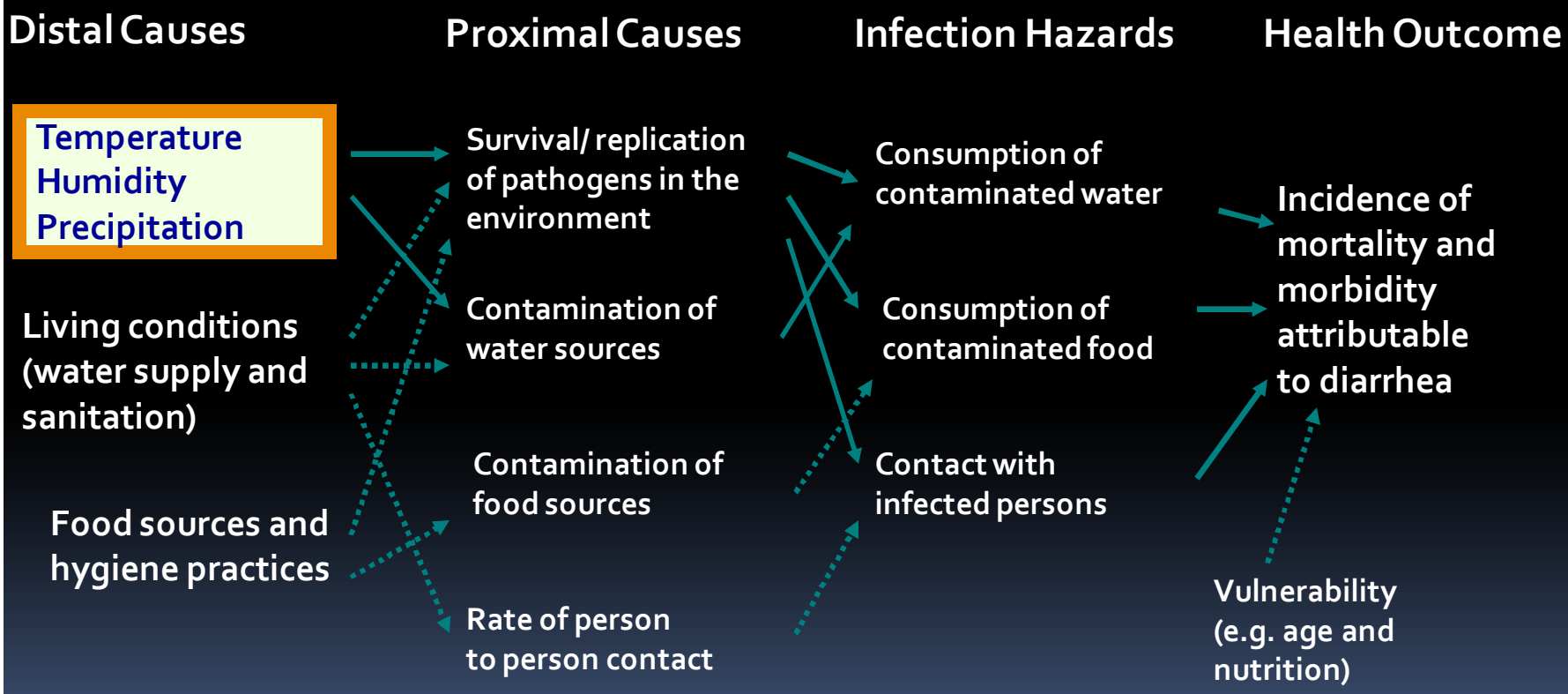
❑Basic facts about the influence of climate and weather on health.

✓Certain health outcomes are known to be associated with weather and/or climate. These include illnesses and deaths associated with temperature; extreme precipitation events; air pollution; water contamination; and diseases carried by mosquitoes, ticks, and rodents.

✓Because human health is intricately bound to weather and the many complex natural systems it affects, it is possible that projected future climate changes will have measurable impacts, both beneficial and adverse, on health.

✓Projections of the extent and direction of potential impacts of climate variability and change on health are extremely difficult to make because of many confounding and poorly understood factors associated with potential health outcomes, population vulnerability, and adaptation.

Pathways for Weather to Affect Health: Example = Diarrheal Disease



WHO

Facts contd…..

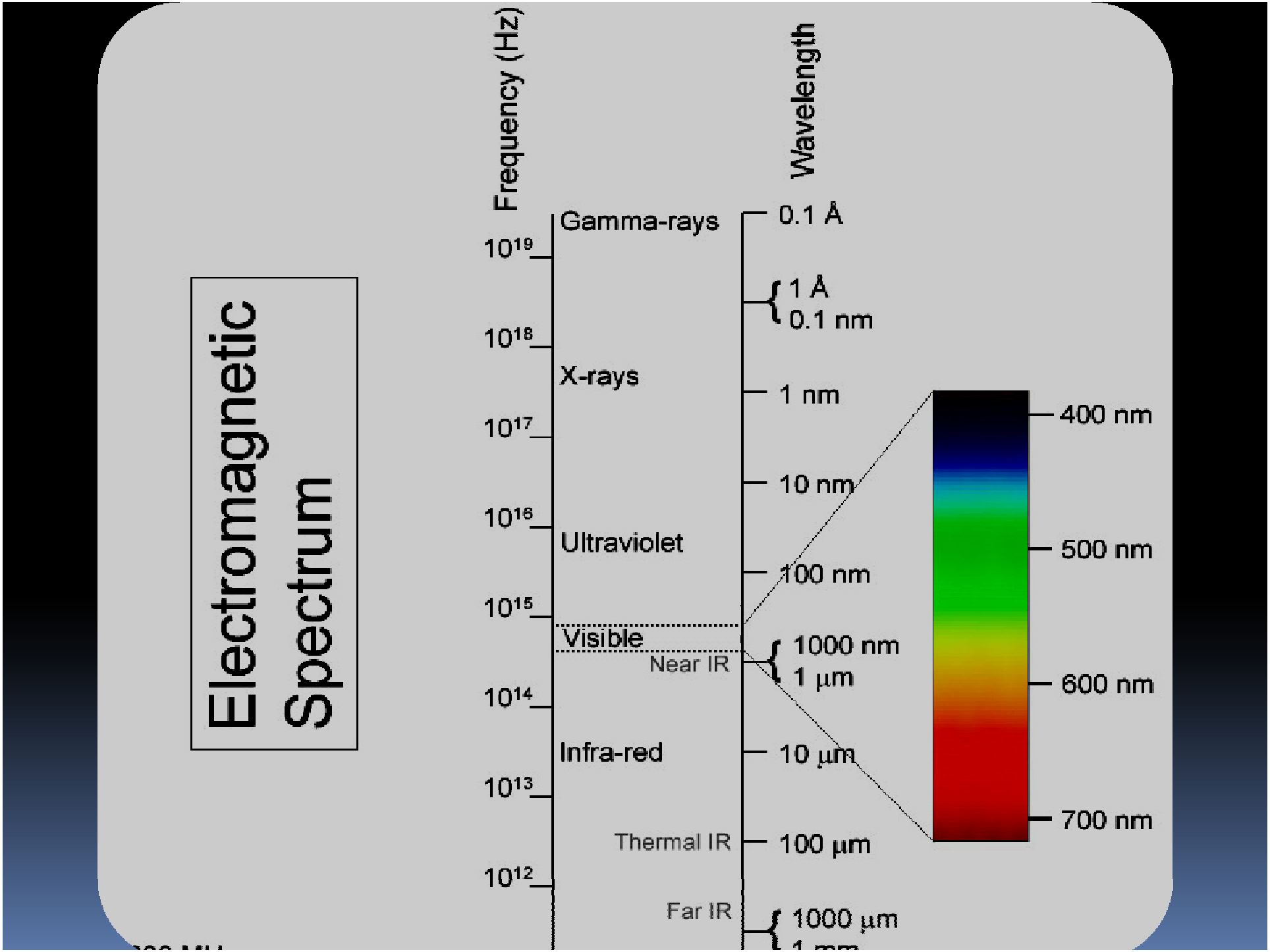
✓• Understanding of the sensitivity of human health to aspects of weather and climate is incomplete.
✓• It is difficult to anticipate what adaptive measures might be taken in the future to mitigate risks of adverse health outcomes, such as vaccines or improved use of weather forecasting.
✓• Health outcomes in response to climate change are highly uncertain.

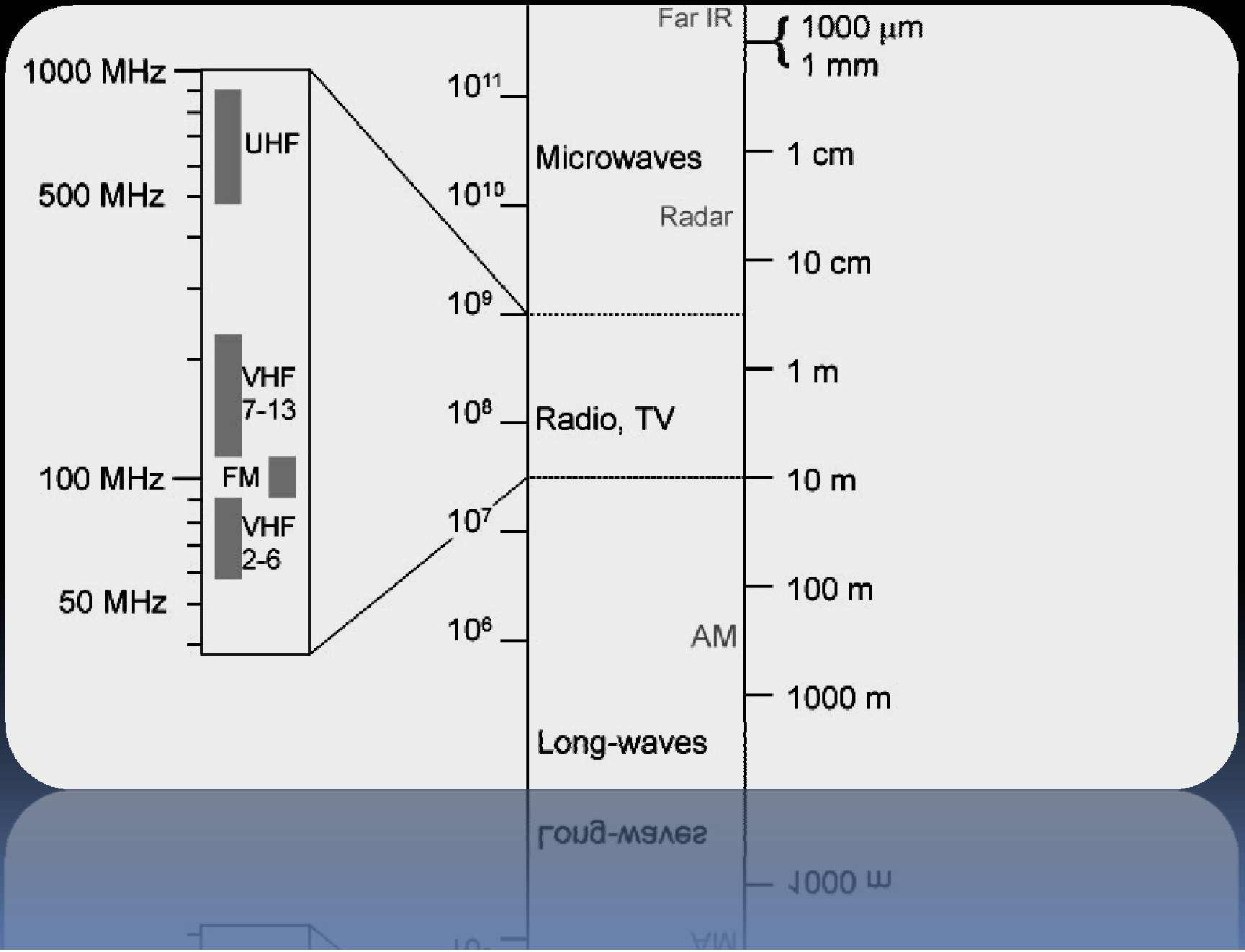
What are the possible health impacts of climate change?

✓• Currently available information suggests that a range of negative health impacts is possible.
✓• Some positive health outcomes, notably reduced cold-weather mortality, are possible.
✓• The balance between increased risk of heat-related illnesses and death and changes in winter illnesses and death cannot yet be confidently assessed.

Direct Biometeorological Influences:

I. The Radiation Spectrum


Electromagnetic Spectrum
Frequency (Hz)
Wavelength
Gamma-rays
X-rays
Ultraviolet
Visible
Near IR
Infra-red
Thermal IR
Far IR
10^{19}
10^{18}
10^{17}
10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
0.1 Å
1 Å
0.1 nm
1 nm
10 nm
100 nm
1000 nm
1 μm
10 μm
100 μm
1000 μm
400 nm
500 nm
600 nm
700 nm


1000 MHz
500 MHz
100 MHz
50 MHz
UHF
VHF
7-13
FM
VHF
2-6
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
Far IR
Microwaves
Radar
Radio, TV
AM
Long-waves
1000 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1000 m

Gamma rays and X-rays: **Reflected/scattered by the atmosphere**

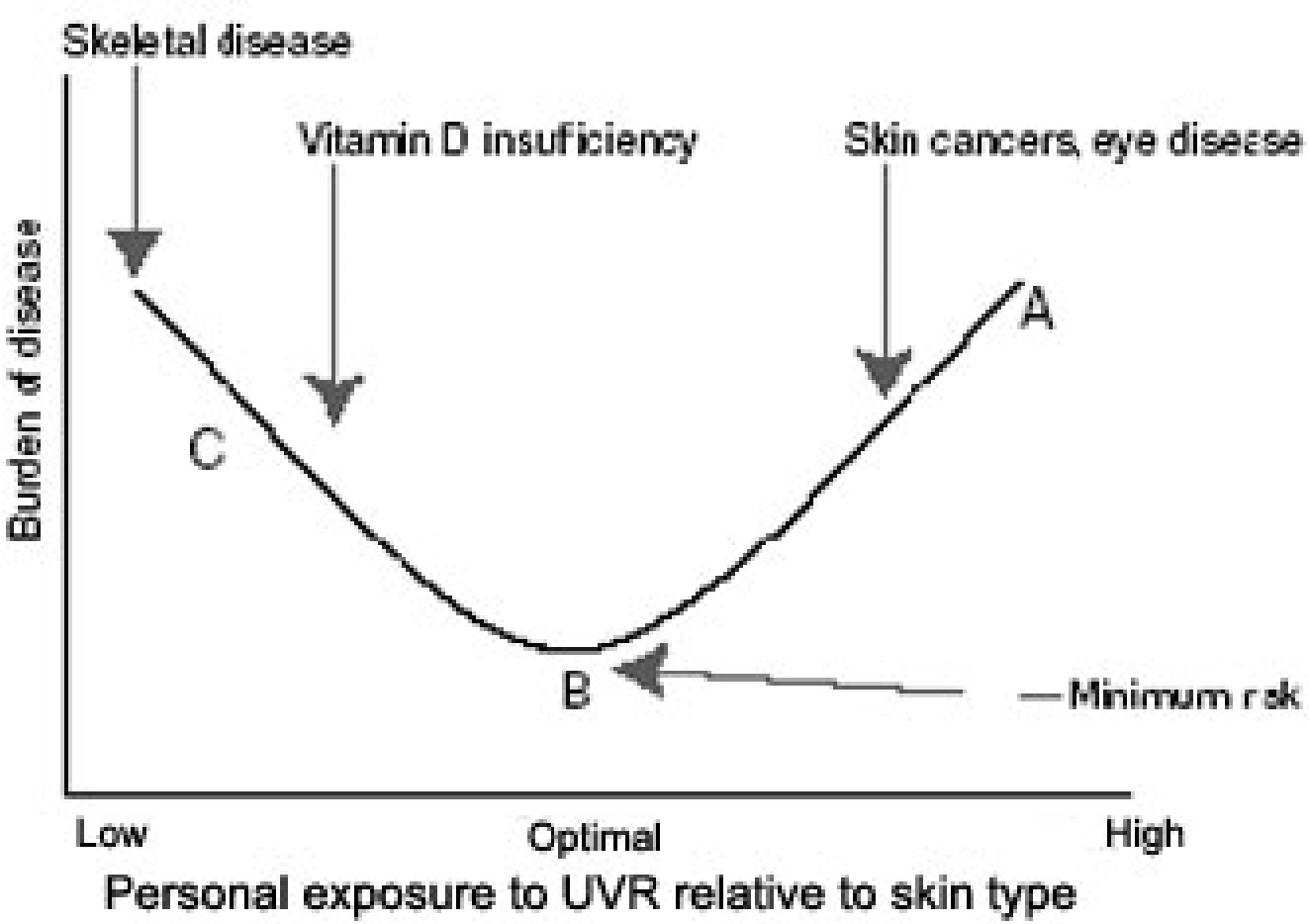
Most people's primary source of **gamma exposure** is naturally occurring radionuclides, particularly potassium-40, which is found in soil and water.
A large portion of gamma radiation largely passes through the body without interacting with tissue--**the body is mostly empty space at the atomic level** and gamma rays are vanishingly small in size.

Exposure to **x-rays** is almost entirely from dental and medical x-rays, including mammograms.
http://www.epa.gov/radiation

Health effects of UV radiation

Small amounts of UV are beneficial for people and essential in the production of vitamin D. UV radiation is also used to treat several diseases, including rickets, psoriasis, eczema and jaundice. This takes place under medical supervision and the benefits of treatment versus the risks of UV radiation exposure are a matter of clinical judgment

http://www.photobiology.info/Roberts-CR.html



Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Sunburn (erythema) is the best-known acute effect of excessive UV radiation exposure. Over the longer term, UV radiation induces degenerative changes in cells of the skin, fibrous tissue and blood vessels.

Visible Light and Biological Rhythms

"**The presence or absence of light is one of the oldest and most universal selective pressures to which all living things have had to adapt**. An important part of that adaptation has been the development of **daily and seasonal rhythms**."

"The precise synchronicity of breeding swarms, of many sea creatures and insects, the beaching and egg-laying of many turtles and crabs that travel great distances to appear simultaneously at a specific place, and the migration of birds and bats are phenomena that have long fascinated scientists and testified to the existence of ***biological clocks*"**

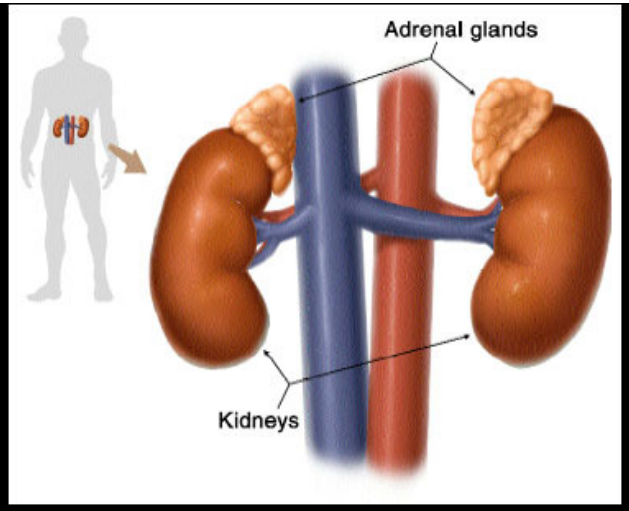
The rhythms with a 24 hour span are known as ***circadian.***

"In humans they include sleep and wakefulness; body temperature; renal function; and ionization of blood calcium and phosphate, which affects hormone regulation"

Visible Light contd…: Visible light between 460 - 500 nm received by the human eye is a **regulator of the circadian response in humans.**

When circadian light impinges on the retina it sends a signal to the SCN (Suprachiasmatic nucleus) in the hypothalamus leading to a cascade of hormonal changes in the pituitary, pineal, adrenal, and thyroid glands.

Many aspects of mammalian behavior and physiology show circadian rhythmicity, including sleep, physical activity, alertness, hormone levels, body temperature, immune function, and digestive activity. Remarkably, all of these diverse rhythms are controlled by a single tiny brain area, the SCN- the size of a grain of rice.



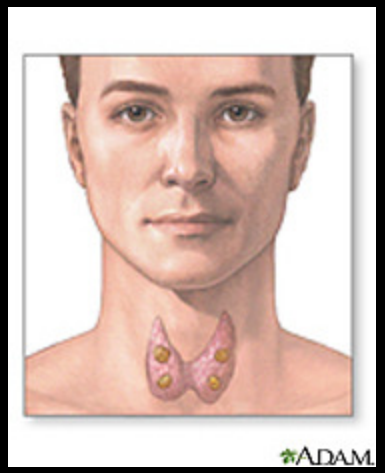
http://www.nlm.nih.go

Releases hormones that help in:

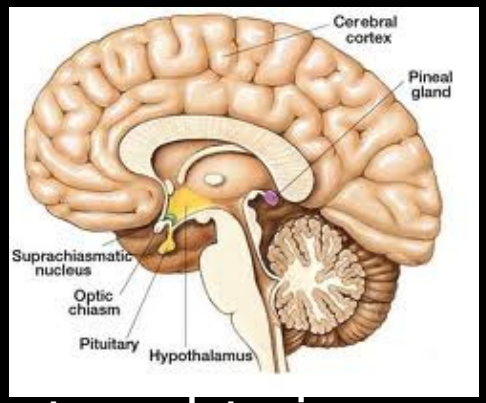
✓Maintaining metabolic processes (managing blood sugar levels and regulating inflammation)

✓Regulating the balance of salt and water

✓Controlling the "fight or flight" response to stress



The thyroid helps set metabolism - how the body gets energy from the foods we eat. http://www.nlm.nih.gov



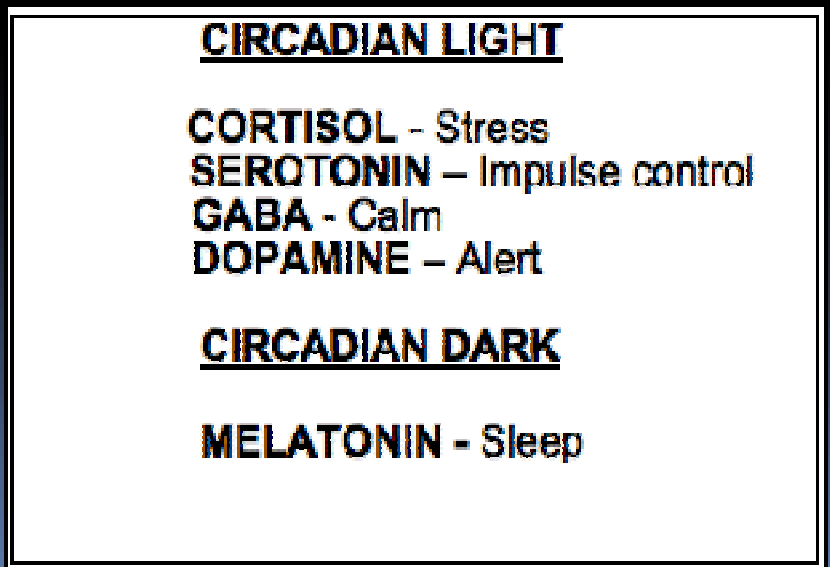
The pineal gland secretes melatonin, a structurally simple hormone that communicates information about environmental lighting to various parts of the body.

Visible light contd.. .

The absence of circadian blue light in the evening is equally important to the daily oscillation of human hormones . Different neurohormones and neuropeptides are produced in the presence and absence of circadian light.

Melatonin regulates healthy sleep cycles. It is **produced in response to darkness** and results in nightly sleep.

Removal of circadian light exposure at night allows for the production of melatonin [sleep], vasointestinal peptide [lowers blood pressure] and growth hormone [metabolism and repair] .



http://www.photobiology.info/Roberts-CR.html

Seasonal affective disorder, or SAD, is a type of depression that affects a person during the same **season** each year. If you get depressed in the winter but feel much better in spring and summer, you may have SAD. Anyone can get SAD, but it is more common in:

✓People who live in areas where winter days are very short or there are big changes in the amount of daylight in different seasons.

✓Women.

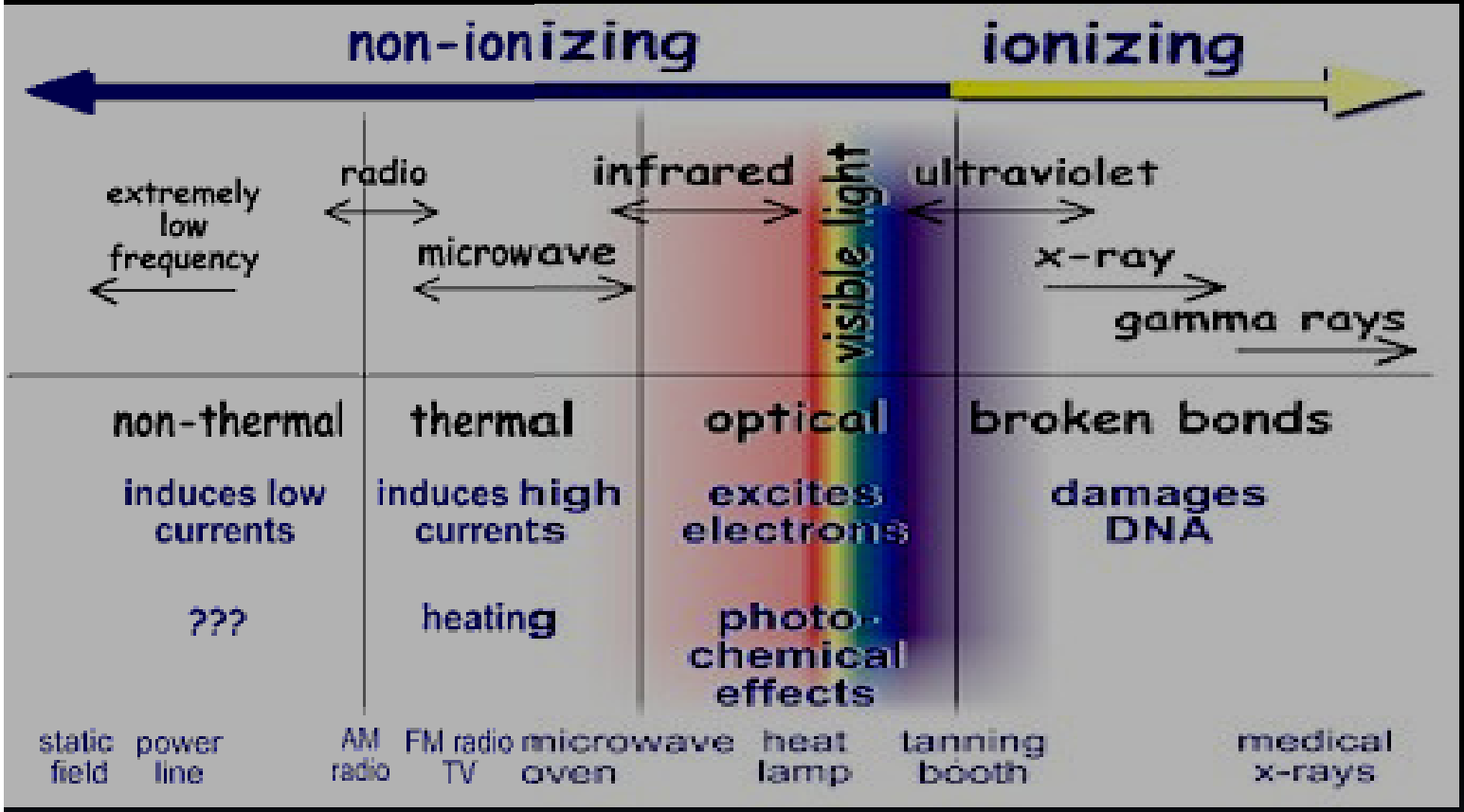
✓People between the ages of 15 and 55 (the risk of getting SAD for the first time goes down as you age).

✓People who have a close relative with SAD.

Light therapy: **Bright white fluorescent light has been shown to reverse the winter depressive symptoms of SAD.**

http://www.nami.org

2. Atmospheric Ionization



http://www.epa.gov/radiation/understand/ionize_nonionize.html

We take advantage of the properties of non-ionizing radiation for common tasks:

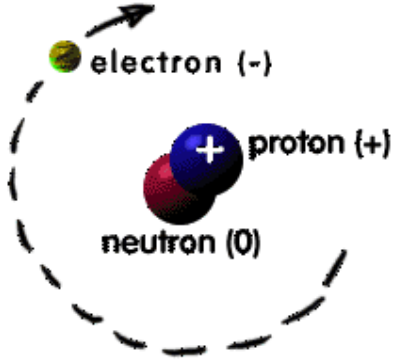
Microwave radiation-- telecommunications and heating food

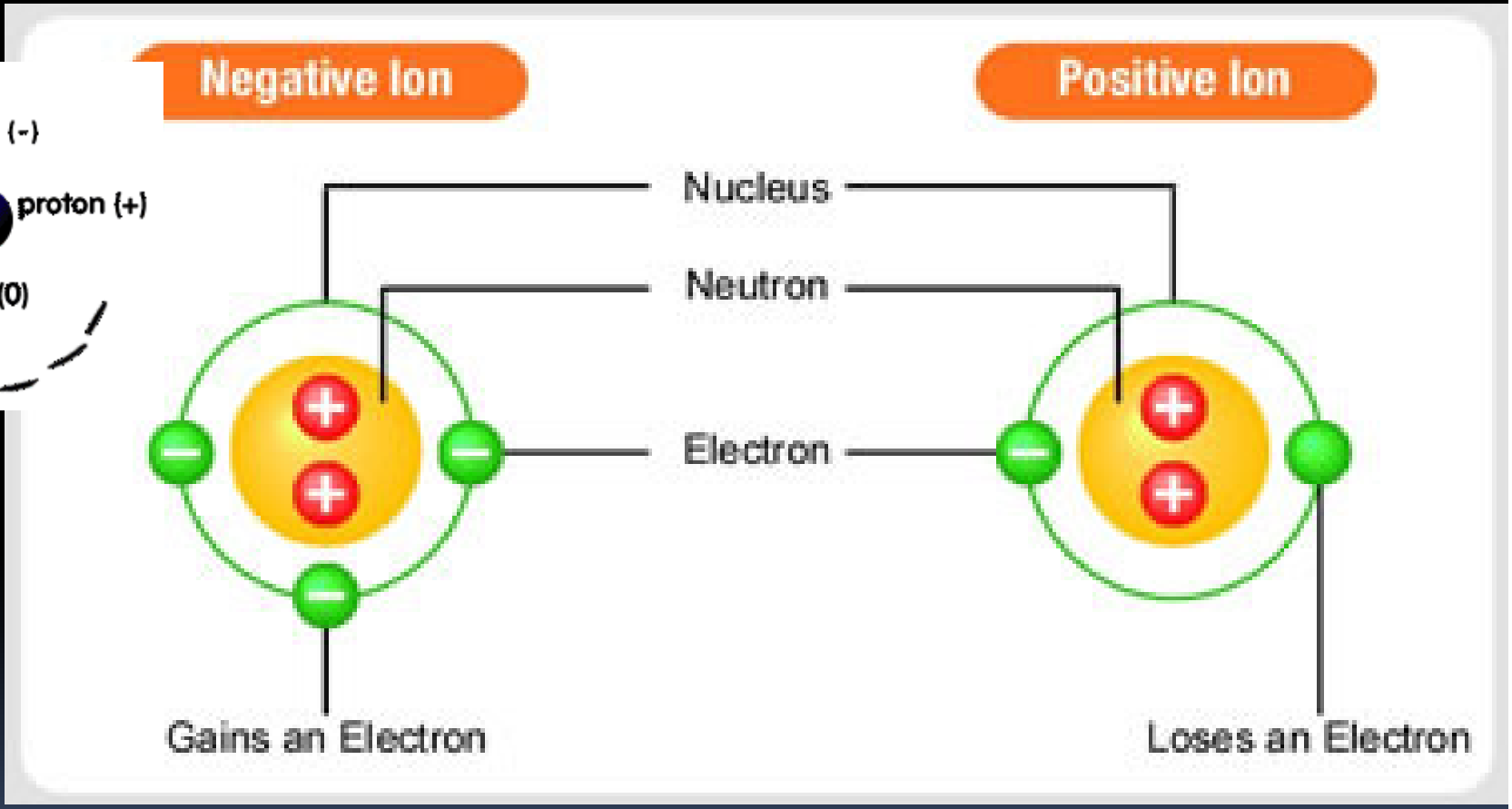
Infrared radiation --infrared lamps to keep food warm in restaurants

Radio waves-- broadcasting

II. Atmospheric Ionization

Ionizing radiation is high-frequency radiation that has enough energy to remove an electron from (ionize) an atom or molecule.





Atmospheric Ionization

Natural Sources of Atmospheric Ionization

- ✓Air masses moving against the earth, or against other air masses.
- ✓The decay of naturally occurring terrestrial radioactive materials
- ✓Radiation from the sun and cosmic radiation

All cause ionization in the atmosphere by stripping electrons from air molecules.

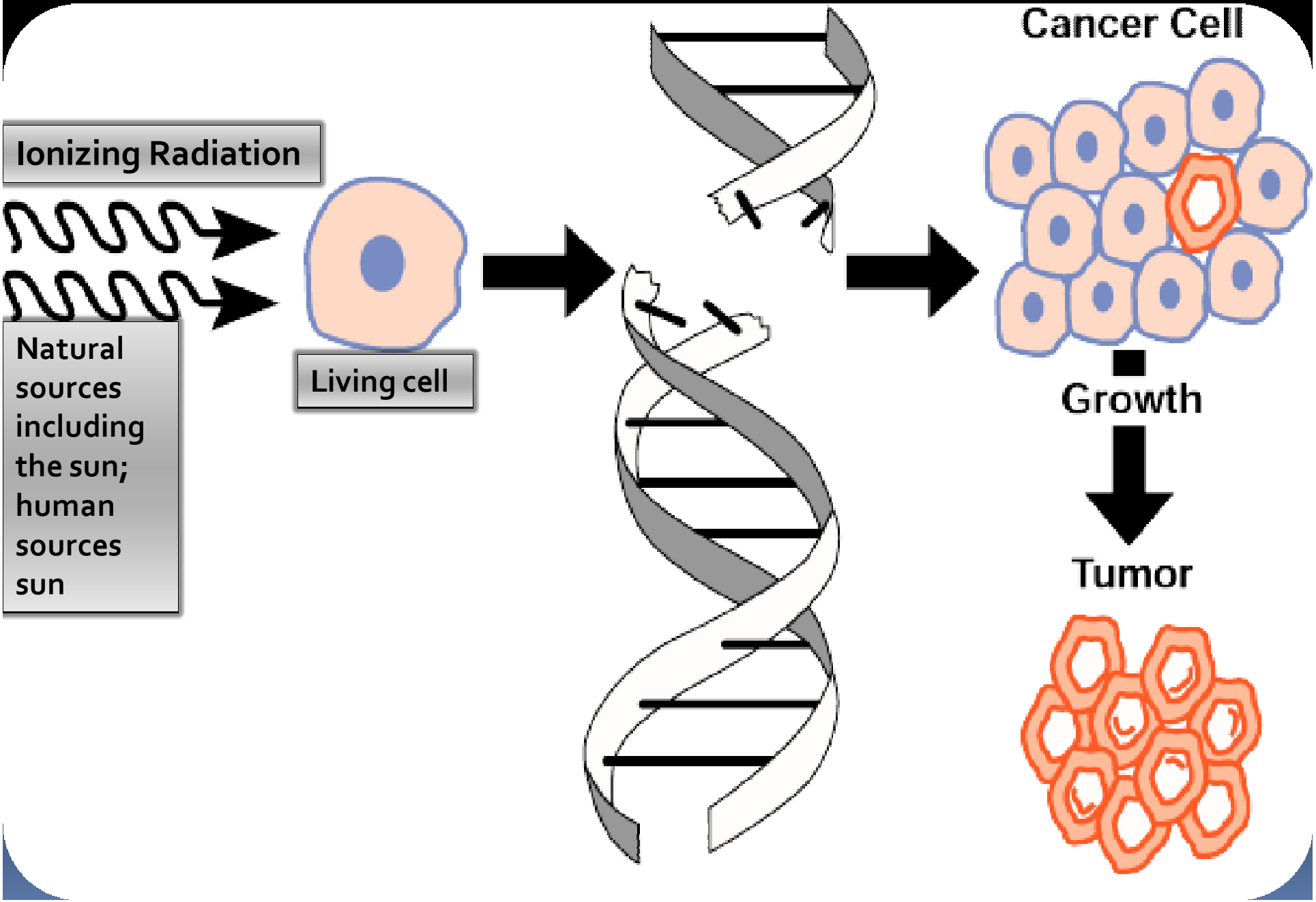
- ✓The molecules effected in this way become positive ions due to the loss of electrons.
- ✓The free electrons immediately get picked up by the surrounding neutral molecules, which thus become negative ions.

Negative ions are good: "In studies conducted by the Air Ion Research Laboratory at the University of California, evidence show that negative air ions **kill** many forms of molds and bacteria. ….Negative ionization also has the effect of **cleansing** the atmosphere by removing particulate and chemical pollutants. "

Positive ions are bad: "positive ionization are …. associated with the phenomena known as "evil winds" such as the ***sharav*** in Israel, the ***foehn*** in Europe, and the ***Santa Ana*** winds in southern California….. Effects associated with these winds include stress reaction, thyroid problems, breathing difficulties, disrupted biorhythms, and an increase in aches and pains).

People who are especially sensitive to weather suffer the most from the effects of positive ionization in the atmosphere. Weather-sensitive people comprise approximately 30% of the general population".

Ionizing Radiation and Cancer Risks



Ionizing radiation….contd

Ionizing radiation passing through a cell in the body, can lead to mutations (changes) in the cell's DNA - the part of the cell that contains its genes (blueprints).
This could contribute to cancer, or to the death of the cell.
The amount of damage in the cell is related to the dose of radiation it receives.
The damage takes place in only a fraction of a second, but other changes such as the beginning of cancer may take years to develop.

Examples:

Sun (UV-rays): Skin cancer (the most serious form is Melanoma)
Fallout from nuclear bomb explosions: Japan WWII
Fallout from nuclear reactor accidents: Chernobyl
Side-effects of man-made X-rays and other body scans

III. Extremely Low Frequency Waves ELF

✓Extremely low frequency (ELF) fields includes alternating current (AC) fields and other electromagnetic, non-ionizing radiation from 1 Hz to 300 Hz.
✓ELF fields at 60 Hz are produced by power lines, electrical wiring,
✓and electrical equipment.
✓Some epidemiological studies have suggested increased cancer risk associated with magnetic field exposures near electric power lines.
✓The term "extremely low" is used to describe any frequency below 300 Hz.
✓Health problems, thought to be associated with ELF exposure, were first reported in a group of Russian electrical switchyard workers in the 1960's and created widespread scientific interest.

IV. Infrasound

"Infrasound shares some of the ELF characteristics, in that it can travel long distances with little loss of energy. At frequencies too low for humans to hear, the waves have the potential to generate whole-body vibrations by resonance. They are generated by severe weather disturbances and, travelling at the speed of sound, may be detectable weather precursors." Text

"In laboratory studies of infrasound, 10 Hz at 115 decibels can cause lethargy, euphoria, and loss of time judgment; these are frequencies generated inside closed automobiles travelling at 100 kilometers an hour. At other frequencies, infrasound is associated with nausea and dizziness"

V. Atmospheric pressure

About Pressure

1. "Barometric pressure is defined by the National Weather Service as the amount of pressure exerted against a surface by the weight of the air in the atmosphere. This atmospheric pressure is measured by a barometer, hence the term "barometric pressure."

Pressure Changes

2. People encounter barometric pressure changes when high and low pressure systems move through an area, or when they travel from low altitudes to high altitudes.

Effects on the Body

3. Barometric pressure changes can have little to great effect on existing medical conditions of some people, such as arthritis. Those with swelling or inflammation around the joints may feel their aches and pains exacerbated when air pressure drops. Air can also become trapped in sinuses affected by allergies; when air pressure decreases, the pressure trapped inside can cause even more pain.

http://www.nws.noaa.gov/om/brochures/heatwave.pdf

VI . Temperature and Relative Humidity

HEAT DISORDER SYMPTOMS

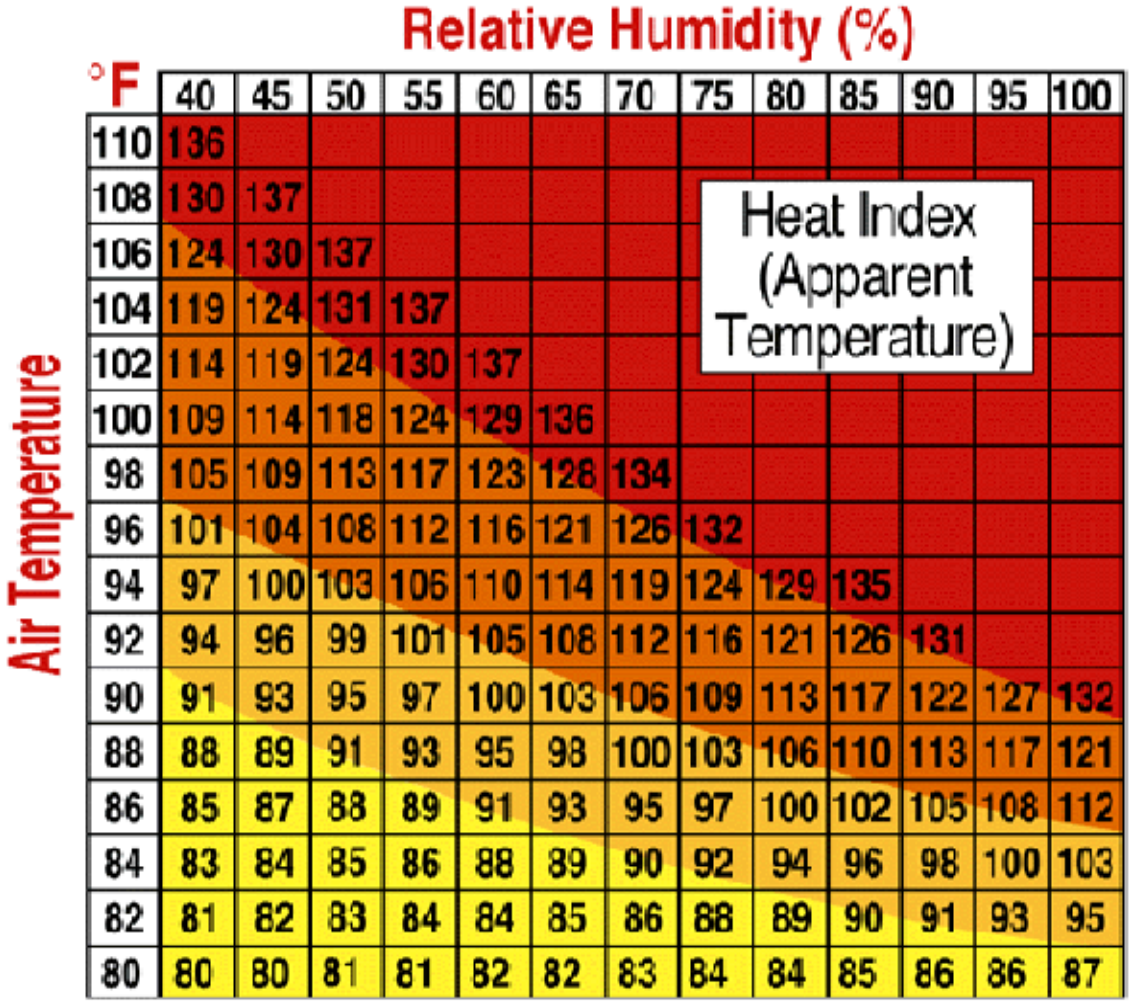
SUNBURN Redness and pain. In severe cases swelling of skin, blisters, fever, headaches.

HEAT CRAMPS Painful spasms usually in muscles of legs and abdomen possible. Heavy sweating.

HEAT EXHAUSTION: Heavy sweating, weakness, skin cold, pale and clammy. Fainting and vomiting.

HEAT STROKE (or sunstroke) High body temperature (106° F. or higher). Hot dry skin. Rapid and strong pulse. Possible unconsciousness.

High Temperature and Relative Humidity



With Prolonged Exposure and/or Physical Activity

Extreme Danger
Heat stroke or sunstroke highly likely
Danger
Sunstroke, muscle cramps, and/or heat exhaustion likely
Extreme Caution
Sunstroke, muscle cramps, and/or heat exhaustion possible
Caution
Fatigue possible

VII. Low Temperature and Wind chill

"How cold is it outside? Simply knowing the temperature doesn't tell you enough about the conditions to enable you to dress sensibly for all winter weather. Other factors including wind speed, relative humidity and sunshine play important roles in determining how cold you feel outside. A description of the character of weather known as "coldness" was proposed about 1940 by scientists working in the Antarctic. The "**wind chill index**" was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature." http://www.weatherimages.org

Temperature (°F)

Wind (mph)	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

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

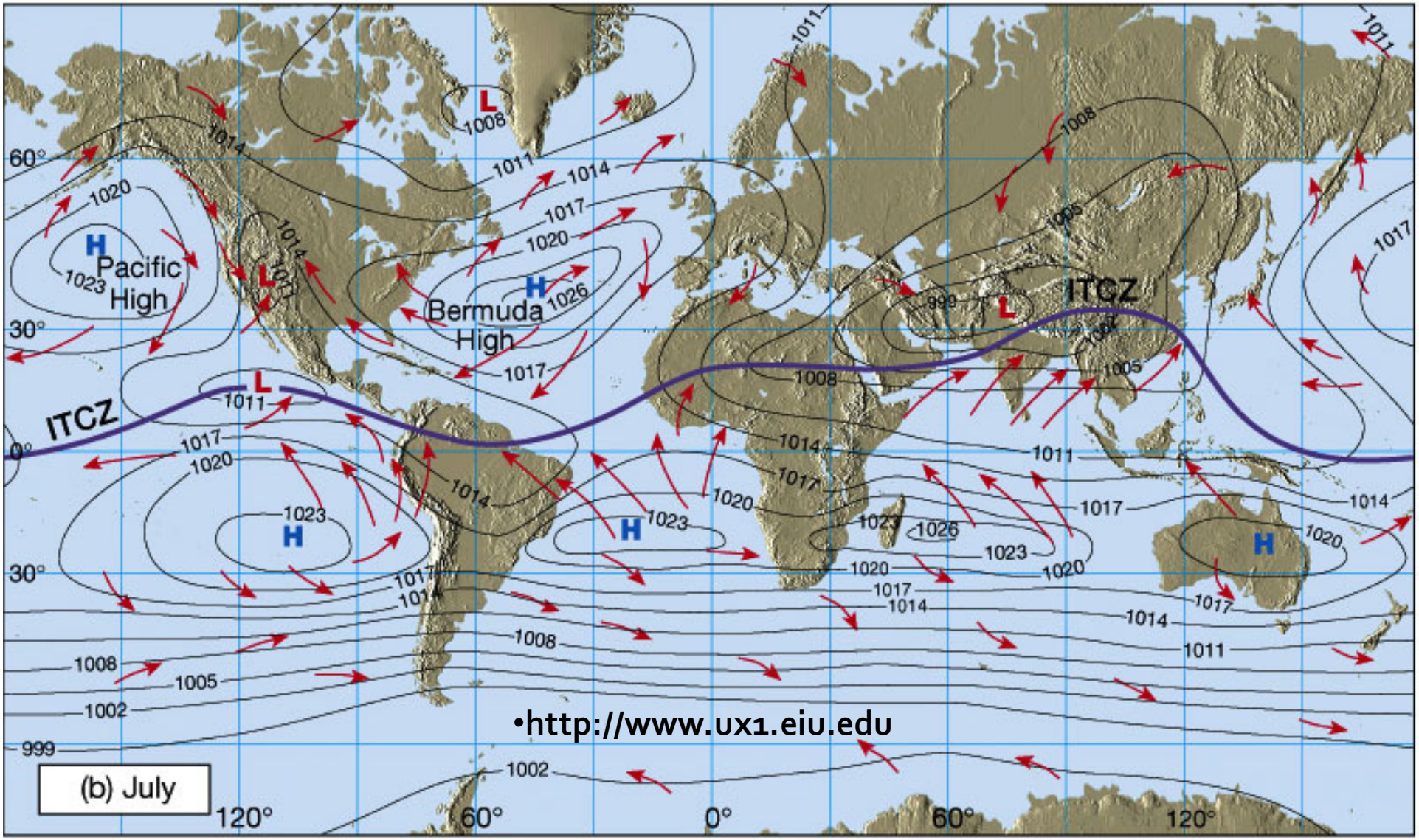
Where, T= Air Temperature (°F) V= Wind Speed (mph)

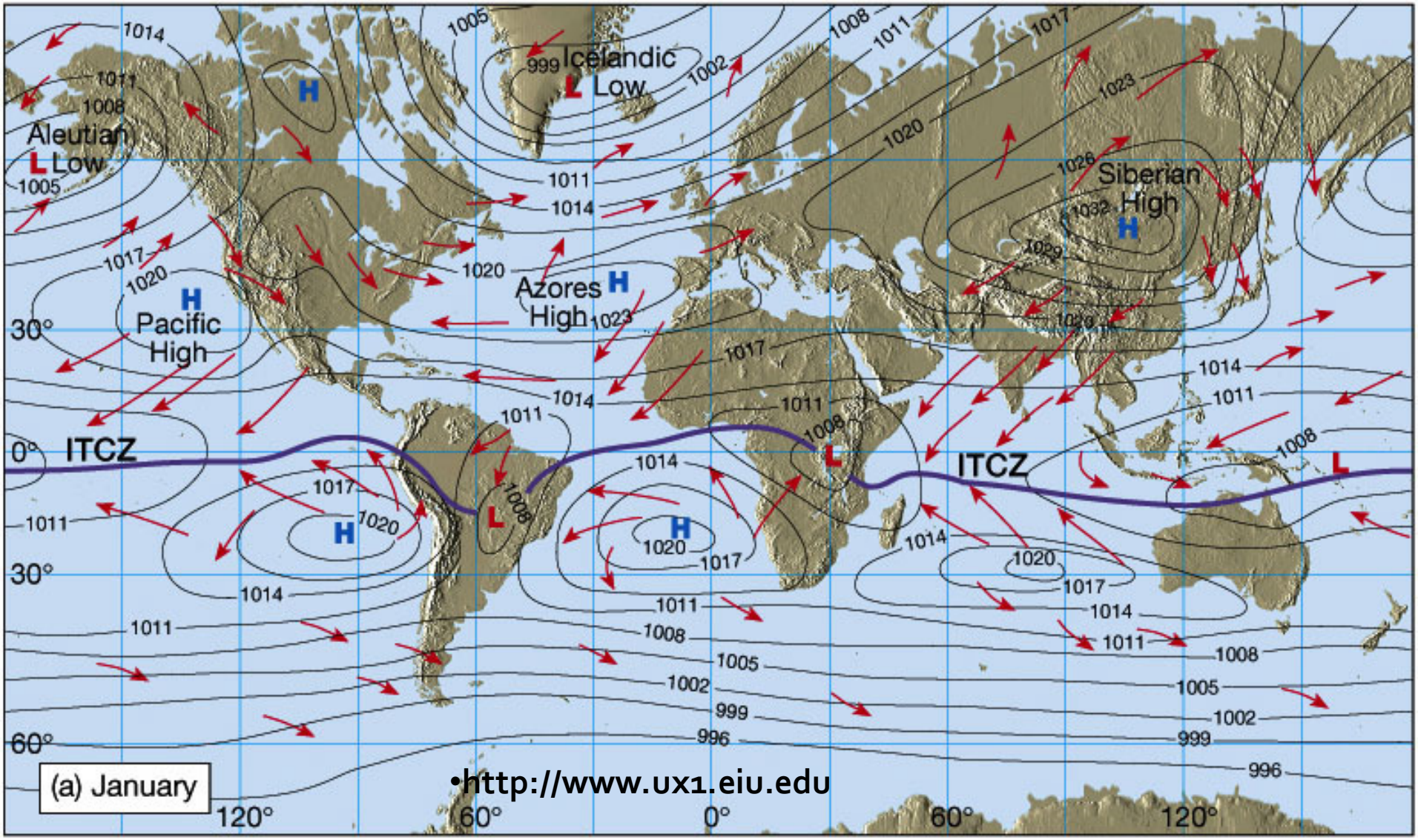
Effective 11/01/01

III. Air mass Movement, and Air-borne Life

"The air is charged with living things. The transport and survival of bacteria, viruses, fungi, and allergens such as pollen depend on certain conditions of atmospheric temperature, humidity, condensation, and movement. Agents of human disease are injected into the air by coughing and sneezing; by the shedding of hair and dead skin, and by the spray of cooling towers, air conditioners, and irrigation systems. Soil bacteria, fungi and pollen are picked up by the wind. Dispersal depends on atmospheric turbulence. To all such life forms, ultraviolet radiation is ultimately lethal." **Text**

- **http://www.ux1.eiu.edu**


Pacific High
Bermuda High
ITCZ
ITCZ
(b) July
•http://www.ux1.eiu.edu


Icelandic Low
Aleutian Low
Siberian High
Azores High
Pacific High
ITCZ
ITCZ
(a) January
•http://www.ux1.eiu.edu

Important Facts about Weather and Biological Agents:

- ✓Over land surfaces a quarter of the total airborne particulate may be made up of biological material in the form of pollen, fungal spores, bacteria, viruses, or fragments of plant and animal matter.
- ✓Meteorological variables affect the initial release of this material and its dispersal once airborne.
- ✓Bacteria may occur as agglomerations of cells, or may be rafted into the air on plant or animal fragments, on soil particles, on pollen, or on spores which have themselves become airborne.
- ✓Viruses may be transported in larger droplets emitted by animals.
- ✓The inert release of material from a surface will depend upon the balance of two groups of forces. Bonding forces such as the electrostatic force if the particle and surface are differently charged, or surface tension if the surface is wet, (it will tend to retain the particle on the surface, as will any physical attachment).

Acclimatization

What is acclimatization?

"The work of the heart, fat deposition in the blood vessels, bloodclotting time, blood sugar levels, and innumerable other physiological characteristics differ in people acclimatized to different degrees of heat or cold, and even within an individual in different seasons. Even the relative amounts of types of blood cells change from winter to summer. Blood volume also increases under heat stress and decreases under cold stress. An important adaptation to cold is deposition of a layer of fat under the skin." Text

✓ **Acclimatization :** is the adjustments of individual organisms to the environment.

✓ Neither organ systems nor populations are thought to acclimatize, but rather the individuals within a population.

✓ The acclimatization responses of a population are aggregates of the adjustments of individuals.

Acclimatization: Types

I. STRUCTURAL ACCLIMATIZATION: changes of histology (study of tissues), anatomical relationships, morphology, and body composition. An example would be muscle hypertrophy, or change of fiber type, in response to exercise.

II. FUNCTIONAL ACCLIMATIZATION: changes in organ system function, which may be further subdivided in to:

A. PHYSIOLOGICAL ACCLIMATIZATION
B. NEUROLOGICAL ACCLIMATIZATION OR HABITUATION

PHYSIOLOGICAL ACCLIMATIZATION: this is the most common meaning of acclimatization. Examples are **shivering** in cold and **sweating** in heat.

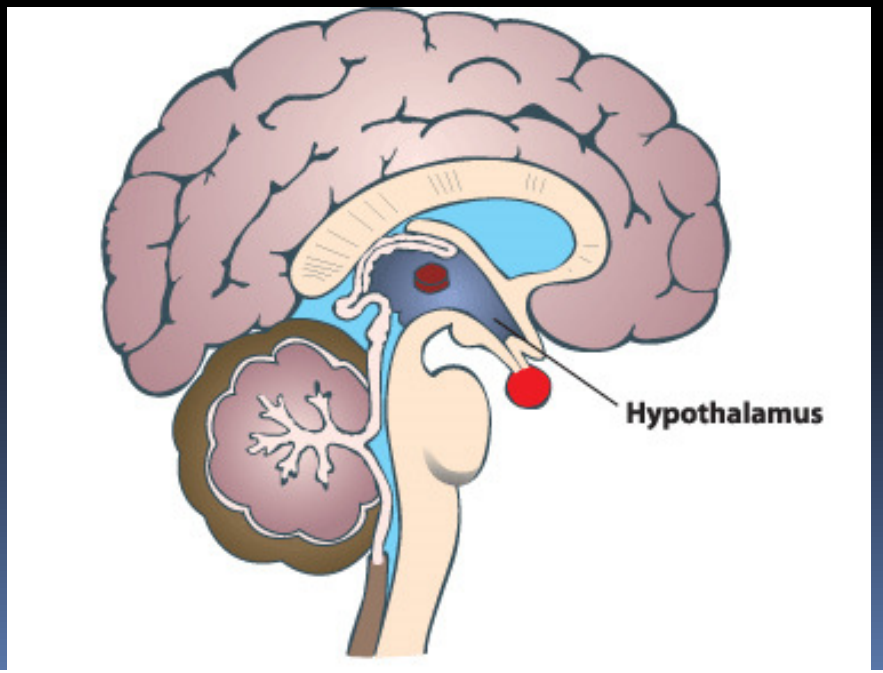
Physiological acclimatization is controlled and regulated by **the hypothalamus**. The main function of the hypothalamus is regulation of the body's internal environment, including water balance, temperature, feeding behavior, and sleep-wakefulness cycle.

NEUROLOGICAL ACCLIMATIZATION OR HABITUATION: Changes of sensory function and neural control. Habituation has usually meant diminutions of normal neural responses, for example, decreases of sensation such as pain.

More on the Hypothalamus

The hypothalamus is an area of the brain that produces hormones that control:

- ✓**Body temperature and water balance**
- ✓**Hunger**
- ✓**Moods**
- ✓**Release of hormones from many glands, especially the pituitary gland**
- ✓**Sex drive**
- ✓**Sleep**
- ✓**Thirst**



National Library of Medicine
National Institutes of Health
http://www.nlm.nih.gov

Example 1: WATER BALANCE

When the body's water level is too low:

- ✓o Osmoreceptors in the hypothalamus detect increased concentration of salt in the blood (hyperosmotic blood)
- ✓o Hypothalamus releases vasopressin (also called ADH / antidiuretic hormone) into the capillaries .
- ✓o Vasopressin makes kidney retain water
- ✓o Level of water in body increases.
- ✓o Salt concentration in blood decreases.

When the body's water level is too high

- ✓o Osmoreceptors in the hypothalamus detect decreased concentration of salt in the blood (hypotonic)
- ✓o Hypothalamus inhibits vasopressin from being released into the capillaries.
- ✓o Without vasopressin, the kidneys absorb water and urine is excreted
- ✓o Level of water in body decreases.
- ✓o Salt concentration in blood increases.

Example 2: TEMPERATURE REGULATION

Cooling the body is controlled by the Anterior Hypothalamus (i.e. Anterior Center = AC)

Heating the body is controlled by the Posterior Hypothalamus

When body temperature gets too hot

- ✓ Heat-sensitive thermoreceptors in the anterior hypothalamus are activated when arterial blood temperature goes up.
- ✓ Autonomic nervous system initiates responses that favor heat loss
- ✓ Sweating ensues
- ✓ Cutaneous vasodilation
- ✓ Body temperature goes down

When body temperature gets too cold

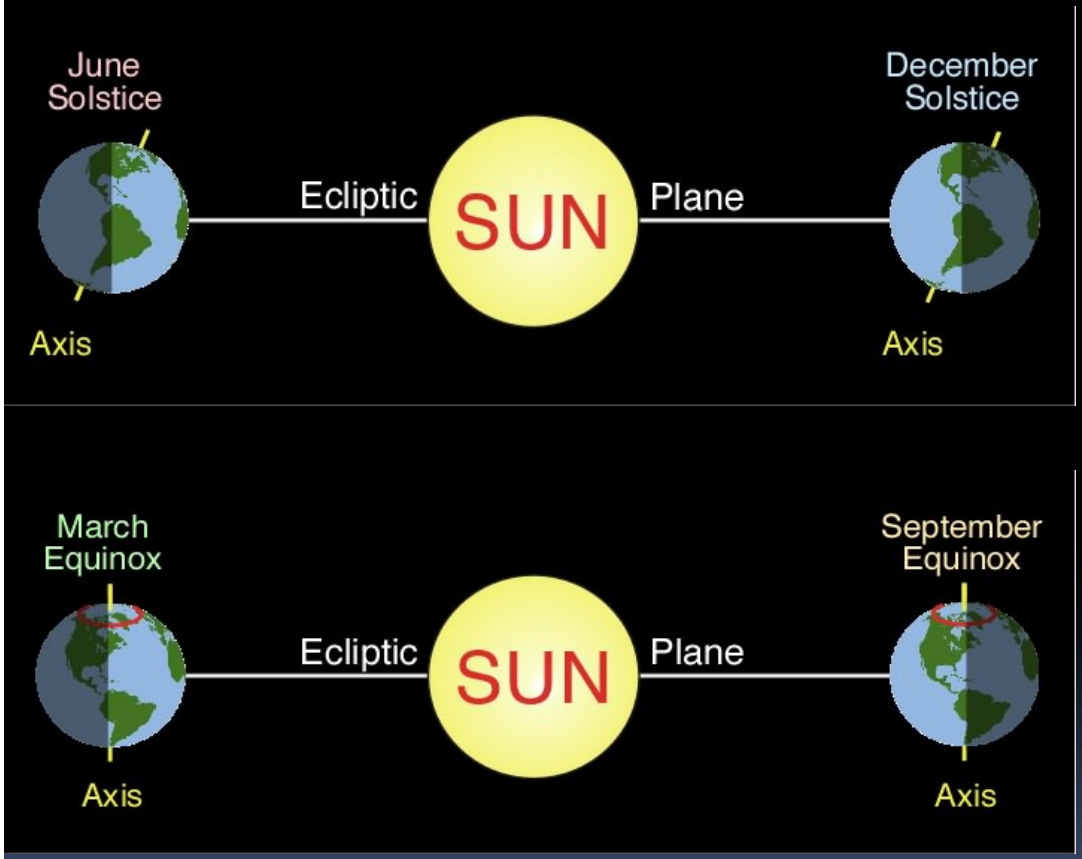
- ✓ Cold-sensitive thermoreceptors in the anterior hypothalamus are activated when arterial blood temperature goes down.
- ✓ Autonomic nervous system initiates responses that favor heat gain
- ✓ Shivering ensues
- ✓ Cutaneous vasoconstriction
- ✓ Increased heart rate
- ✓ Elevation of basal metabolic rate
- ✓ Mobilization of carbohydrate reserve
- ✓ Body temperature goes up

Seasons

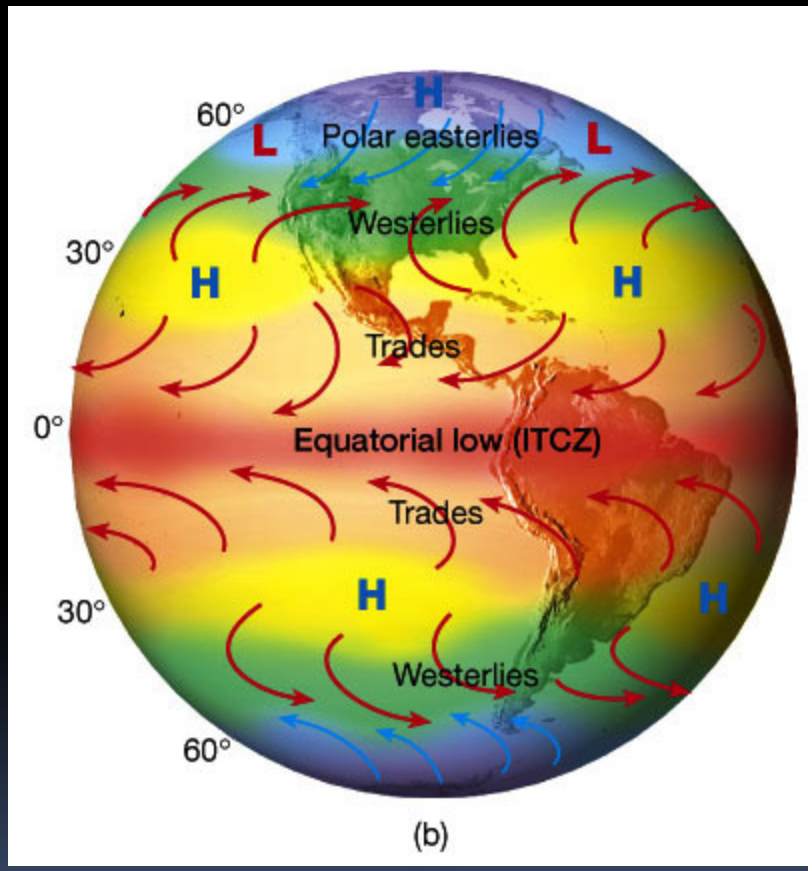
What brings about the change of seasons?

- ✓Seasonality of births
- ✓Seasonality of deaths

SEASONS and BIOMES: "The primary cause of the seasons is the 23.5 degree tilt of the Earth's rotation axis (with respect to the plane of the ecliptic). This means that as the Earth goes around its orbit the Northern hemisphere is at various times oriented more toward and more away from the Sun; and likewise for the Southern hemisphere……"



www.physicalgeography.net



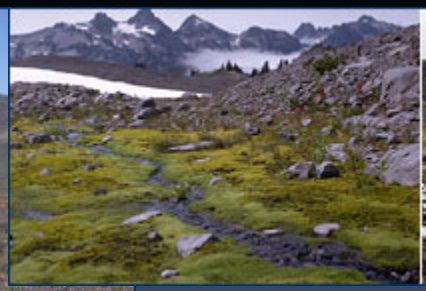
http://www.ux1.eiu.edu

Biomes: are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment". Each biome has its own triangle of human ecology and medical geography.

http://www.ucmp.berkeley.edu






Birth seasonality

- Seasonality of birth, found everywhere, has been much less studied than seasonality of death.
- The seasonal incidence of birth in Japan is quite different from that in European countries, and that of the United States is again distinct.

See text. figure 6.5 Page 225

- One possible reason for birth seasonality is that **high temperatures may have an effect on spermatogenesis** (the creation of sperm).
- High temperatures may also injure existing sperm.

Birth seasonality contd… •

As with other biometeorological effects, threshold and range are presently unknown.

How high a temperature over how long is necessary to affect fertility?

Birth seasonality has innumerable consequences for health and disease. For example, a strong peak of birth for individuals with schizophrenia seems to occur during late winter and early spring in many countries.

• These individuals would have been fetuses in their third month, when the central nervous system is forming, during the late summer heat that is associated (in the United States) with the minimum of conception.

The problem of separating environmental and cultural factors is complex. For example, seasonality in marriages would affect the number of women at risk of conception, and thus result in seasonal changes in birth rates.

Seasonality of Deaths

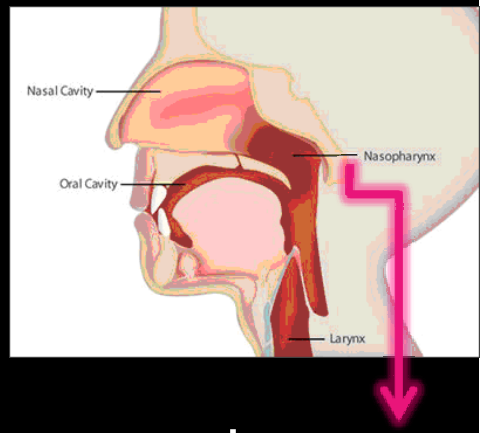
"It has been known for at least 2500 years that some causes of death occur more often in one season than in another. A century ago it was common knowledge in the Unites States that in summer people died of malaria, yellow fever, cholera, typhoid, gastroenteritis, and tuberculosis whereas in winter people died of influenza, stroke, and cold-related causes. The seasons have not much changed, but the former mortality patterns have been obliterated. How have people caused this?"
http://www.aihw.gov.au

A few facts about death seasonality:

- ✓ **Diseases of the circulatory system, pneumonia and influenza and sudden infant death syndrome are all highly seasonal causes of death, occurring more often in winter.**
- ✓ **Common causes of death among young adults such as from motor vehicle accidents, suicide, drowning and assault are more likely to occur in warmer months.**

Death seasonality contd…..

Why is the flue more common in the winter?



Influenza continues to be a winter disease.

Speculation has blamed several factors:

- The biometereorological conditions cause the nasopharynx and trachea to be dry, and membranes to become more susceptible to virus penetration.
- The virus can survive in the air between hosts more easily when the air in relatively dry and cold than when it is hot and humid.
- The lower solar radiation, and hence lower ultraviolet radiation, promotes virus survival.
- The body's seasonal metabolic changes make it more susceptible.

Climate Change: Potential Effects on Health and Health Care

- ✓ Direct Temperature Events:
- ✓ Extreme Events
- ✓ Climate-Sensitive Diseases
- ✓ Air Quality

Definitions of climate change

Climate change in IPCC's (Intergovernmental Panel on Climate Change) usage refers to a **change in the state of the climate that can be identified** (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Current indicators:

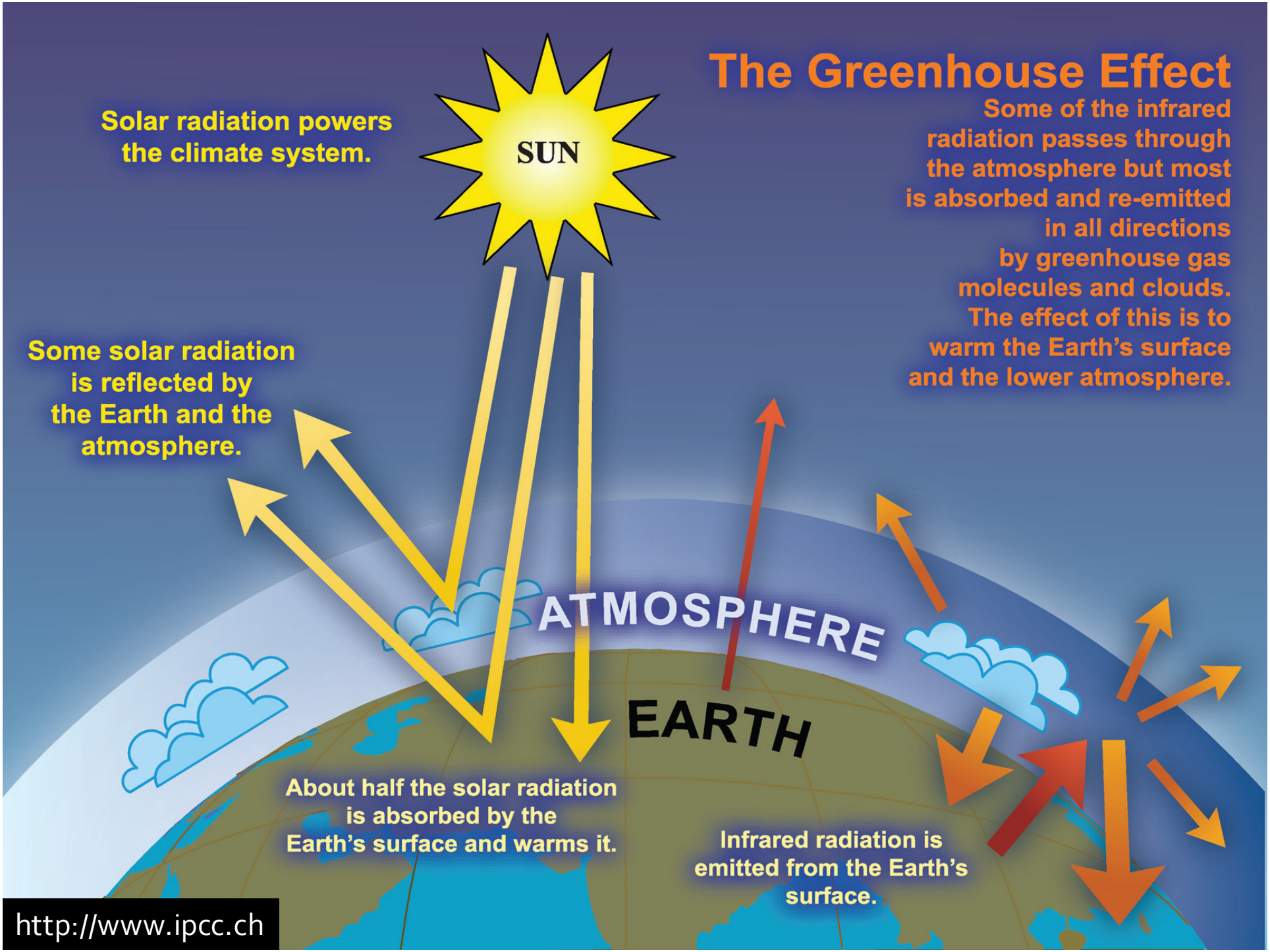
- ✓ Increases in global average air and ocean temperatures,
- ✓ Widespread melting of snow and ice and
- ✓ Rising global average sea level

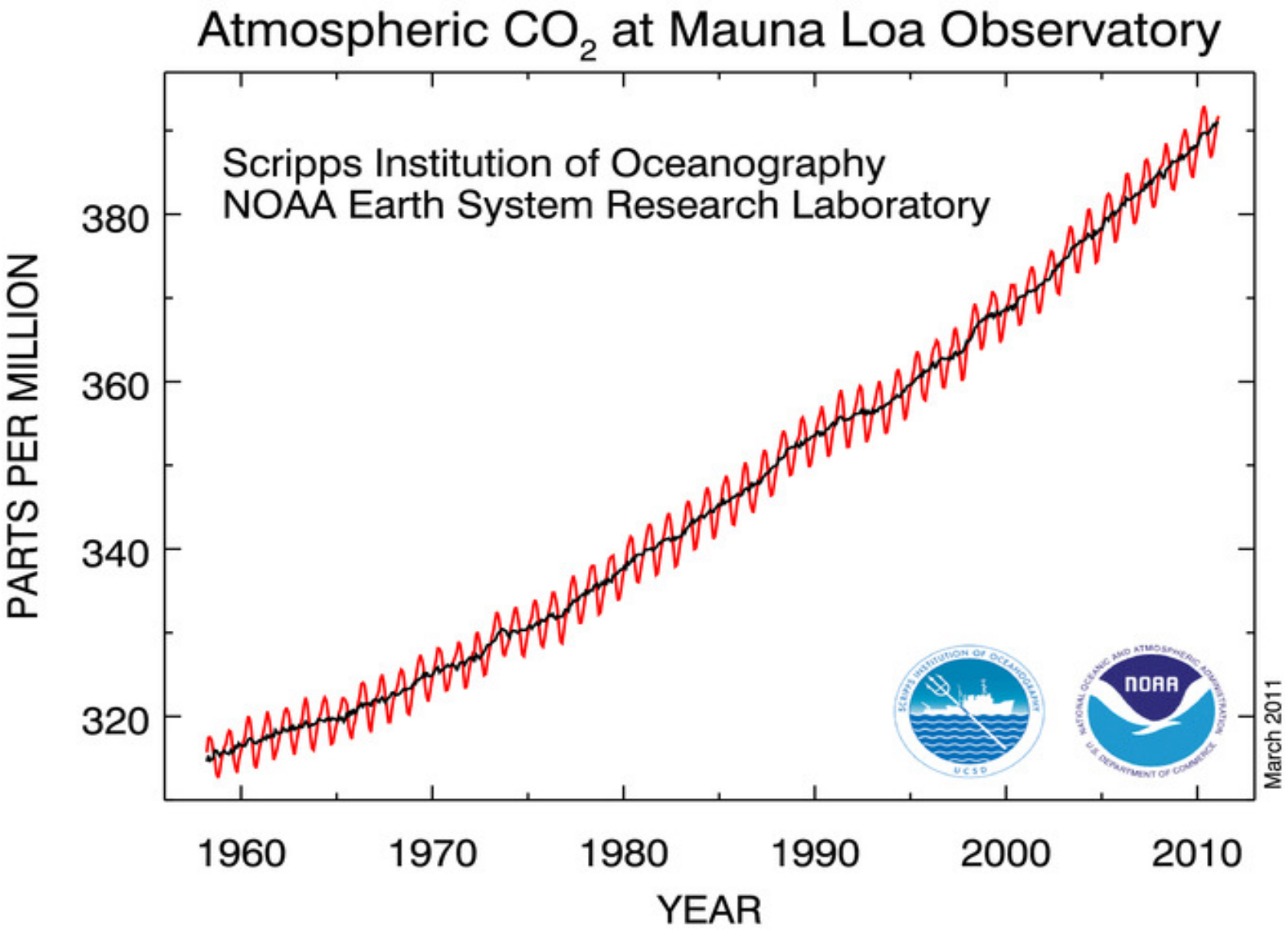
Well documented facts about climate change:

- ✓Eleven of the twelve years between 1995 and 2006 rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850).
- ✓The temperature increase is widespread over the globe and is greater at higher northern latitudes .
- ✓Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years.
- ✓Land regions have warmed faster than the oceans.
- ✓Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000m and that the ocean has been taking up over 80% of the heat being added to the climate system.

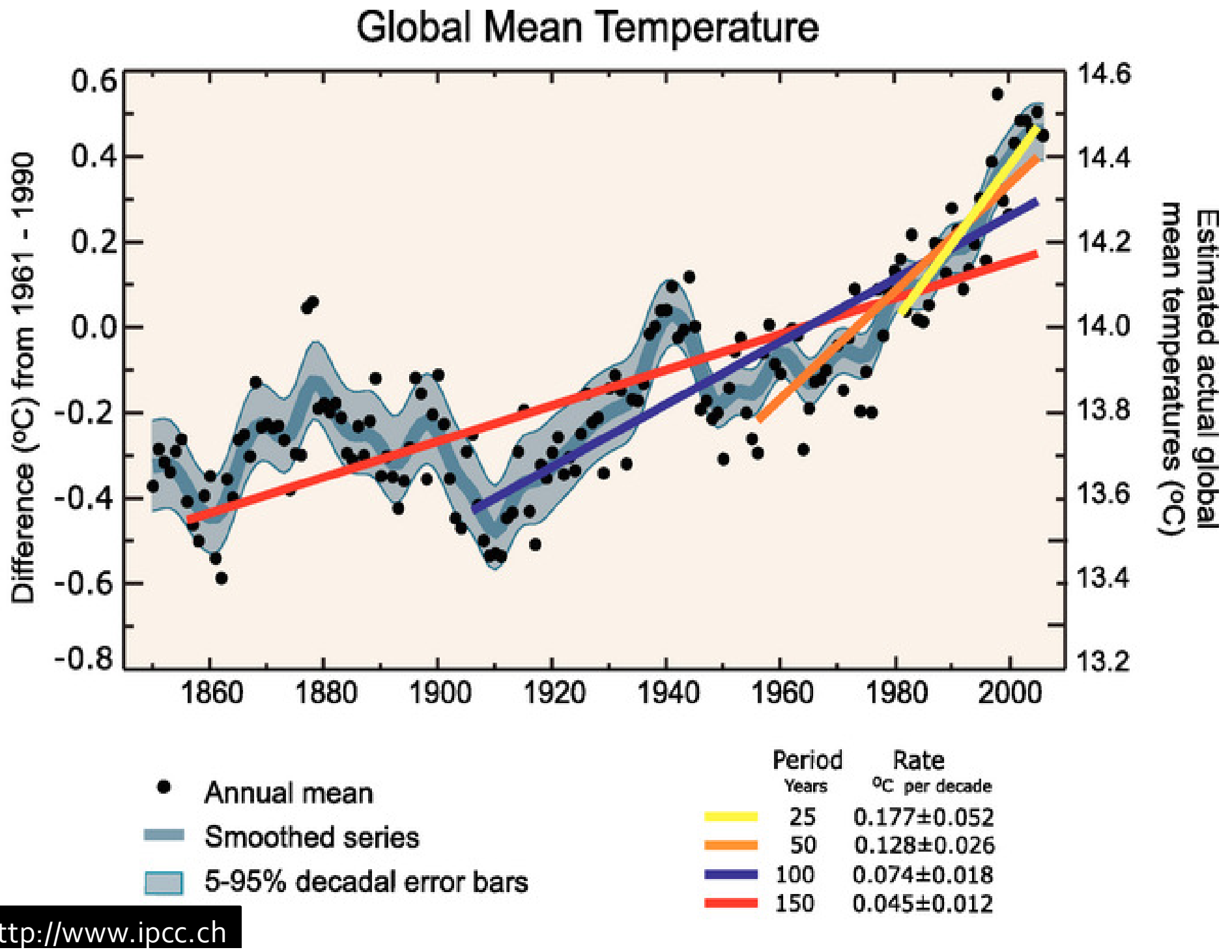
Facts contd.....

- ✓New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates similar to those observed in surface temperature.
- ✓Increases in sea level are consistent with warming.
- ✓Global average sea level rose at an average rate of about 3.1 [2.4 to 3.8]mm per year from 1993 to 2003.
- ✓Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer - 7.4 [5.0 to 9.8]% per decade.
- ✓The maximum areal extent of seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with decreases in spring of up to 15%.


The Greenhouse Effect
Solar radiation powers the climate system.
SUN
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
EARTH
About half the solar radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.
http://www.ipcc.ch

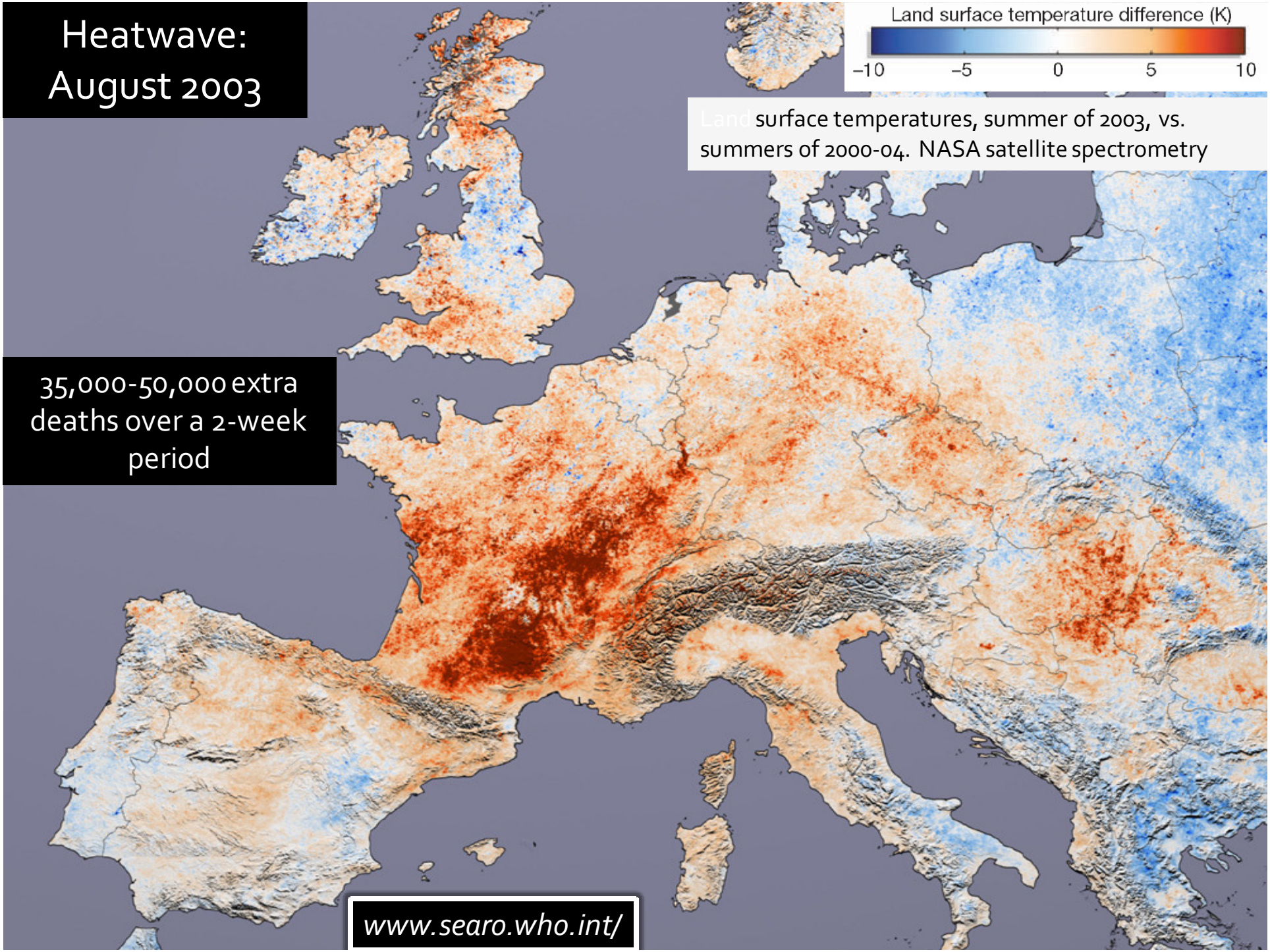


http://www.esrl.noaa.gov



http://www.ipcc.ch

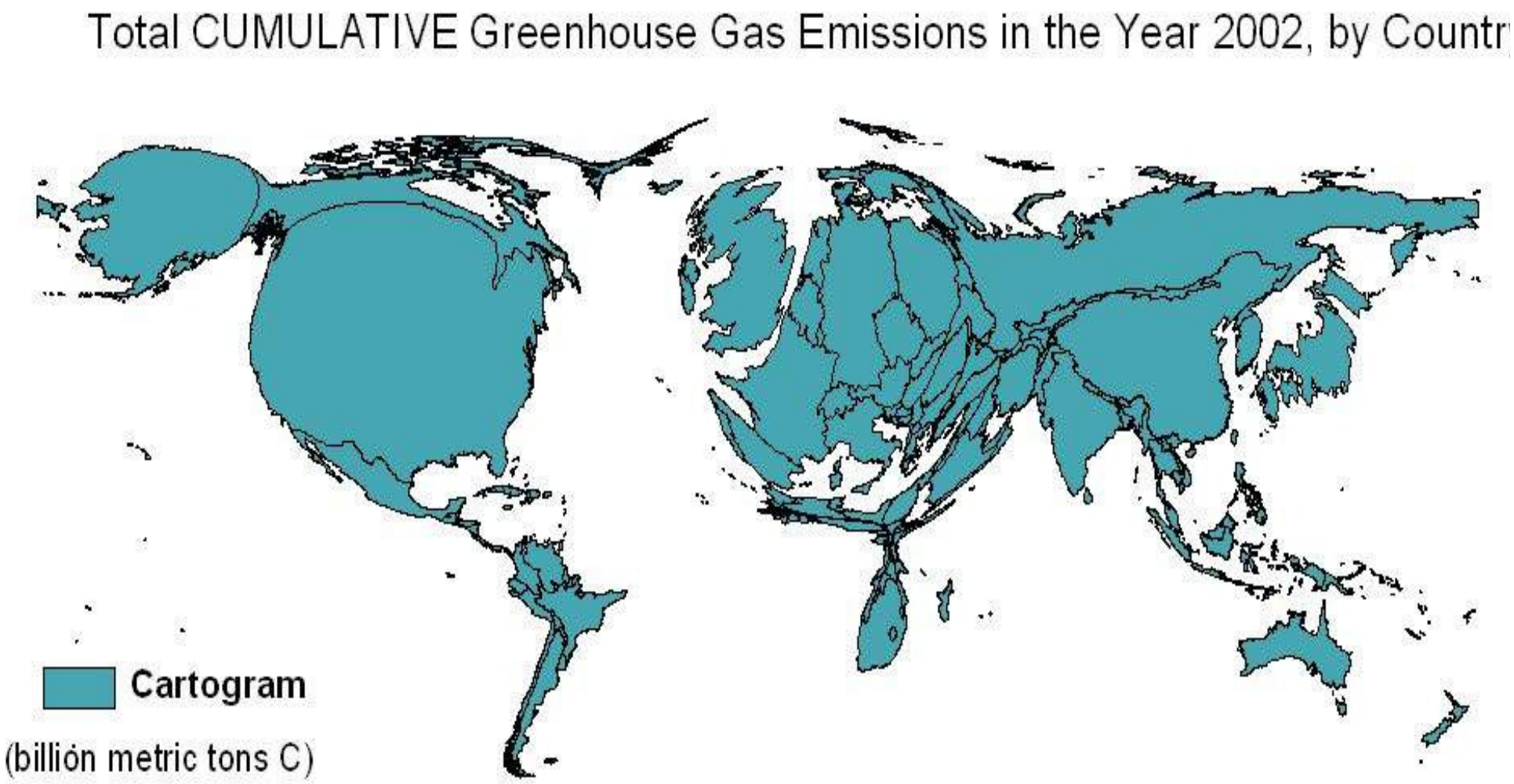
Heatwave: August 2003



Land surface temperatures, summer of 2003, vs. summers of 2000-04. NASA satellite spectrometry

35,000-50,000 extra deaths over a 2-week period

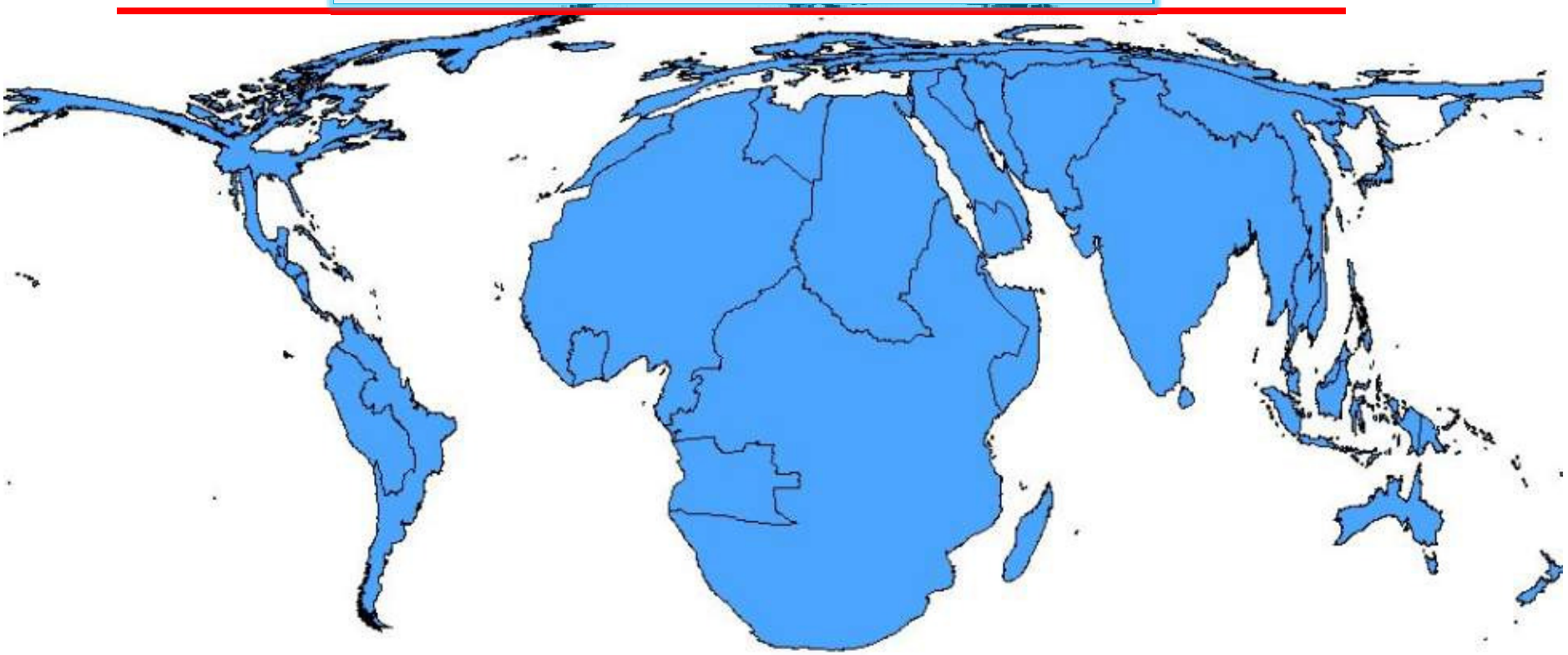
www.searo.who.int/



Density-equalling cartogram. Countries scaled according to cumulative emissions in billion tonnes carbon equivalent in 2002. Patz, Gibbs, et al, 2007

Cartogram: (Selected) health impacts of climate change

Malnutrition > diarrhoea > malaria > floods



Density-equalling cartogram. Countries scaled according to cumulative emissions in billion tonnes carbon equivalent in 2002. Patz, Gibbs, et al, 2007

DIRECT Health Impacts www.epa.org

"Climate-related disturbances in ecological systems, such as changes in the range of infective parasites, can indirectly impact the incidence of serious infectious diseases. In addition, warm temperatures can increase air and water pollution, which in turn harm human health."

Direct Temperature Events:

- ✓Climate change may directly affect human health through increases in average temperature.
- ✓Such increases may lead to more extreme heat- waves during the summer while producing less extreme cold spells during the winter.
- ✓Rising average temperatures are predicted to increase the incidence of heat waves and hot extremes.

Health effects….contd

- ✓ Increases in malnutrition
- ✓Increased deaths
- ✓Increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas
- ✓Altered spatial distribution of some infectious diseases.

Climate change is projected to bring some benefits

- ✓Fewer deaths from cold exposure in temperate areas
- ✓Changes in range and transmission potential of malaria in Africa.

Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.

www.epa.org contd....

Climate-Sensitive Diseases

Important facts

- ✓Climate change may increase the risk of some infectious diseases.
- ✓Particularly worrisome are those diseases that appear in warm areas and are spread by mosquitoes and other insects.
- ✓These "vector-borne" diseases include malaria, dengue fever, yellow fever, and encephalitis.
- ✓Also, algal blooms could occur more frequently as temperatures warm — particularly in areas with polluted waters — in which case diseases (such as cholera) that tend to accompany algal blooms could become more frequent.

Some of the diseases transmitted by mosquitoes (a recap.)

Encephalitis
West Nile virus
Dengue Fever
Malaria
Rift Valley Fever
Yellow Fever

www.epa.org contd….

Air quality

Climate change is expected to contribute to some air quality problems (IPCC, 2007).

Respiratory disorders may be exacerbated by warming-induced increases in the frequency of smog (ground-level ozone).

Particulate matter (PM). Facts:

✓Particulate matter is a complex mixture of extremely small particles and liquid droplets in the lower atmostphere.

✓When breathed in, these particles can reach the deepest regions of the lungs.

✓Exposure to particle pollution is linked to a variety of significant health problems.

✓Climate change may indirectly affect the concentration of PM pollution in the air by affecting natural or "biogenic" sources of PM such as wildfires and dust from dry soils.

Potential impacts of climate change

Example 1 Malaria in Africa

✓There are six major mosquito vectors of malaria, they differ greatly in their biology, breeding habitats and distribution. …….

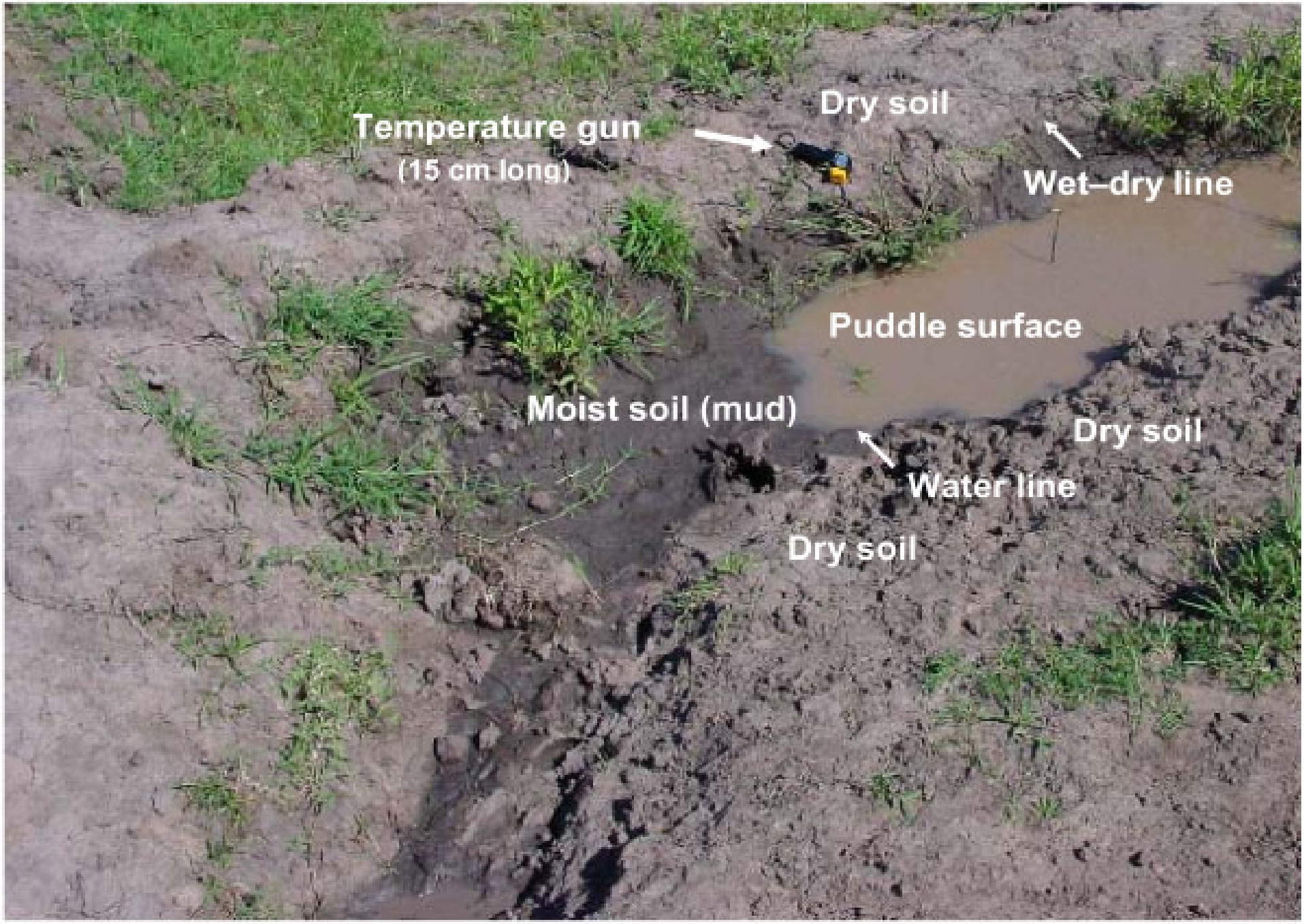
✓Different vector species establish their population at different heights where ecology is suited for their survival.

✓Longevity of vectors and the process of parasite development are sensitive to temperature. Vector species adapts to different temperature threshold depending on the area it occurs.

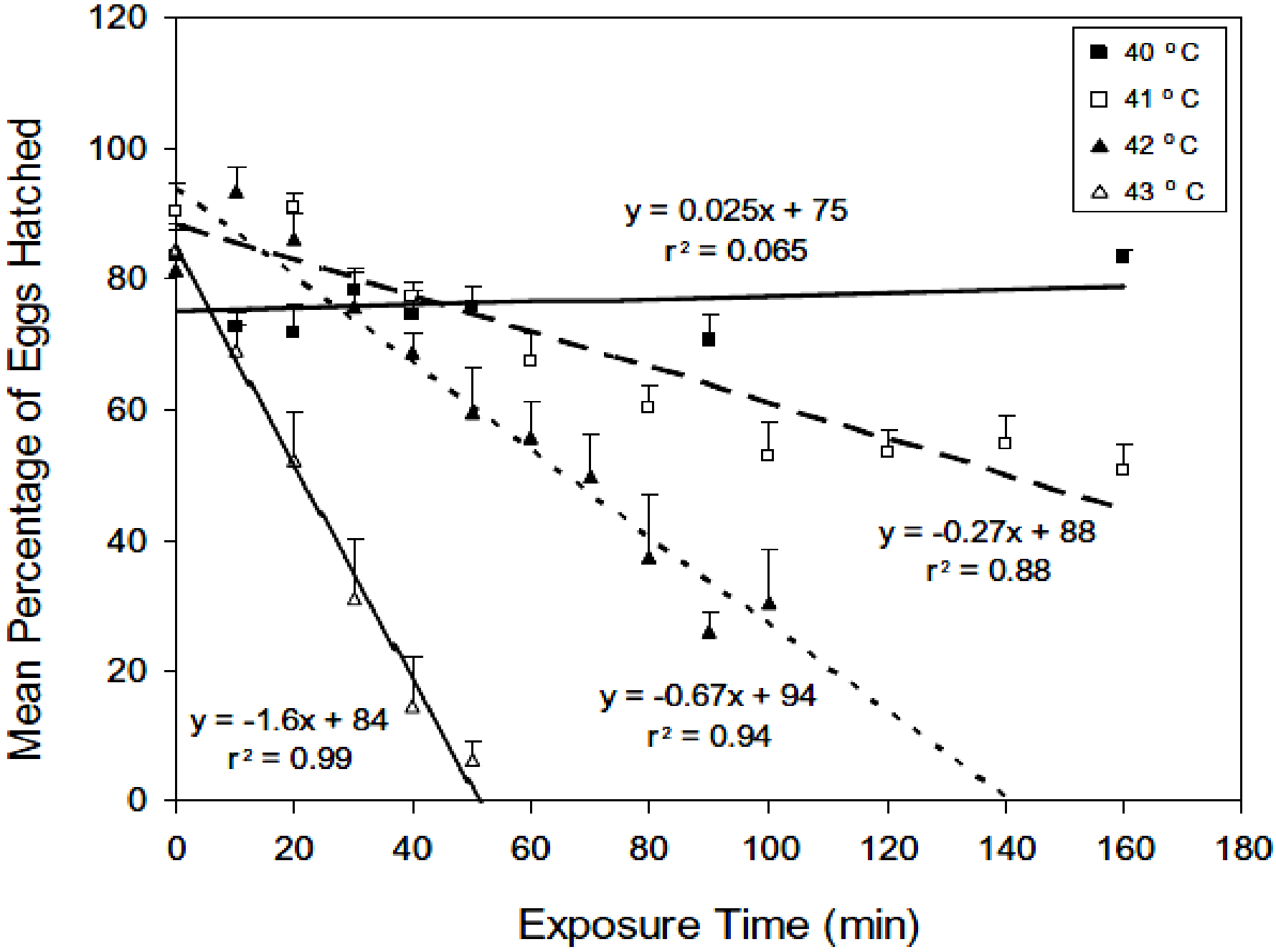
✓Low temperature limits active malaria transmission.

✓At higher temperatures the longevity of mosquitoes is exponentially reduced.

✓The number of breeding sites is generally related to the amount of rainfall for most of the vector species but excessive rains cause flushing, thus killing immature stages.

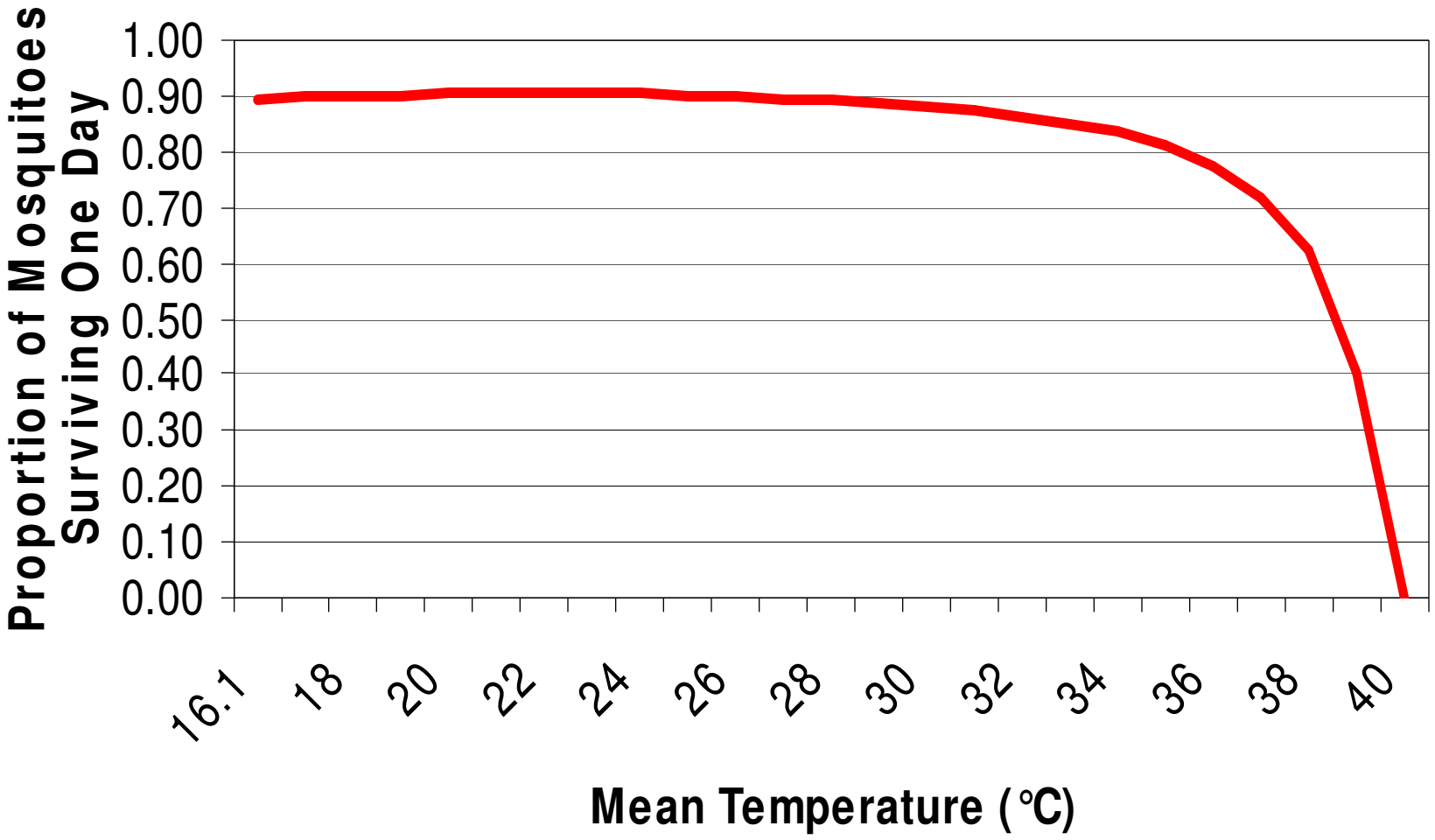


Juan Huang1, Edward D Walker1,2, John Vulule3 and James R Miller*1

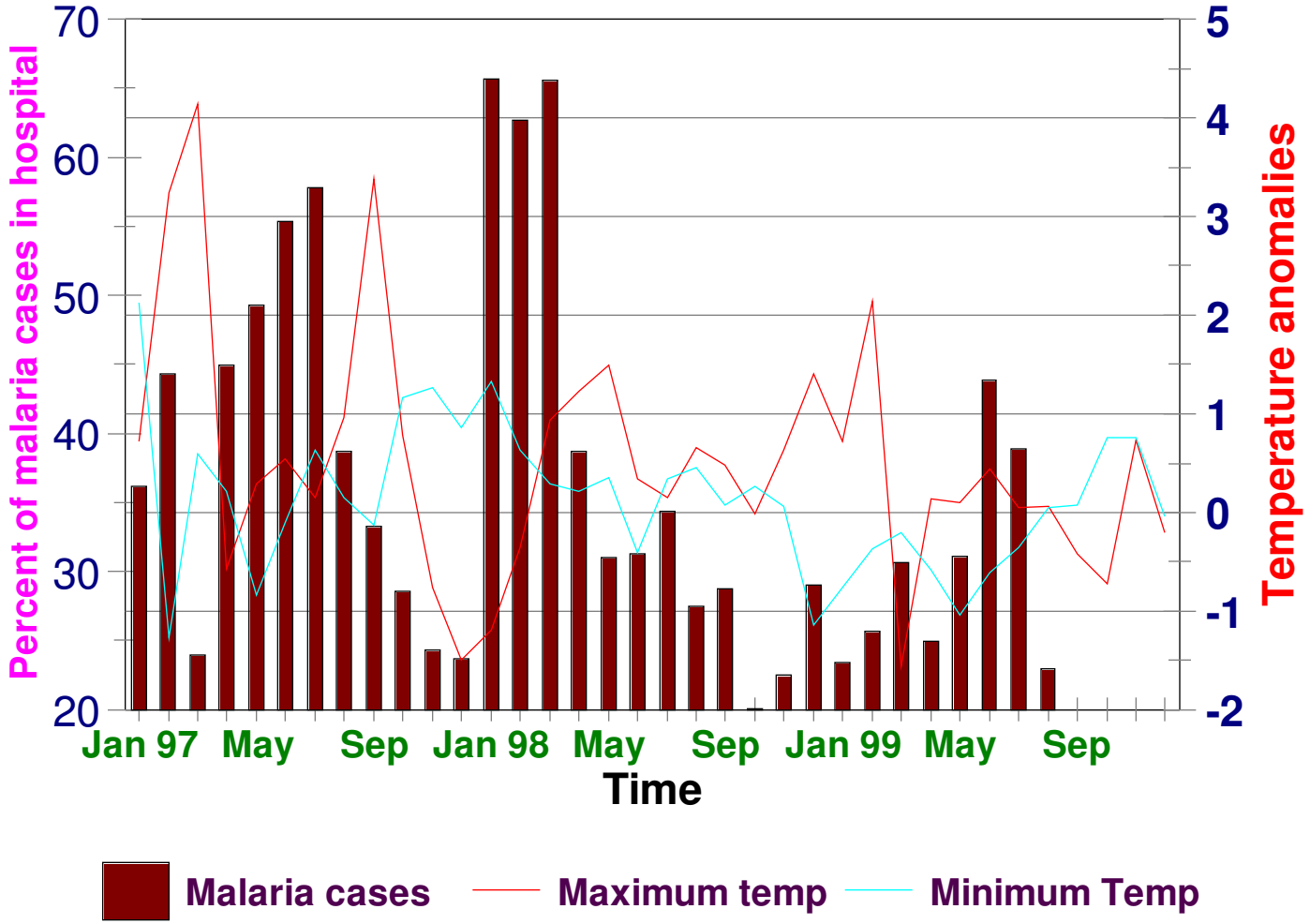


Juan Huang, Edward D Walker1, John Vulule and James R Miller, 2006 http://www.ncbi.nlm.nih.gov

Relationship between Temperature and Daily Survivorship of Anopheles Mosquito



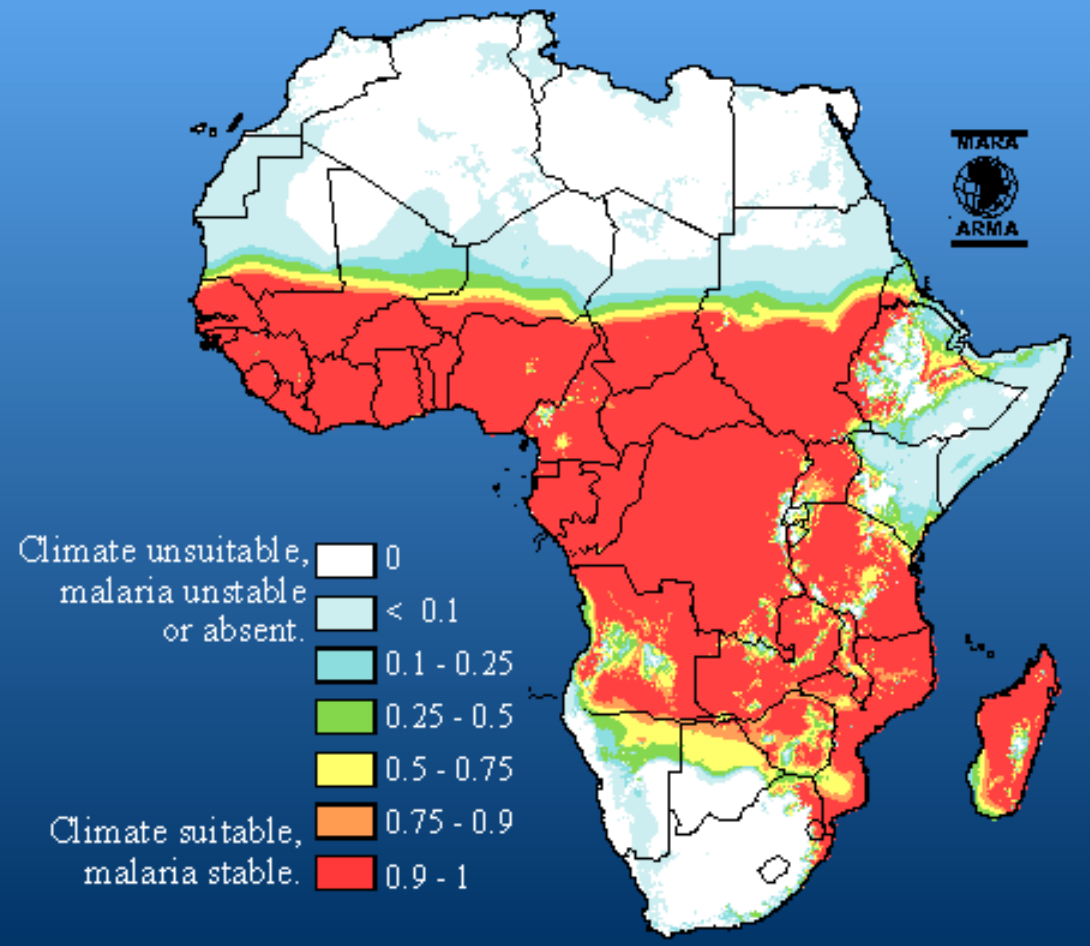
Proportion of malaria cases and anomalies in maximum temperture: Kenya



Source is Dr. Andrew Githeko, Kenya Medical Research Institute.

Malaria distribution model

This model defines the theoretical distribution of endemic malaria, based on the biological constraints placed on the parasite and the vector by temperature and rainfall, as outlined before. The particular temperature-rainfall combination is rated as either suitable or unsuitable for transmission in the average year.



Indirect Health Impacts: Food Production

- ✓ Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions.
- ✓ At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger.
- ✓ Globally, the potential for food production is projected to increase with increases in local average temperature over a range. http://www.ipcc.ch

Indirect Health Impacts: Water

✓Water impacts are key for all sectors and regions.
✓Climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change, including urbanization.
✓On a regional scale, mountain snow pack, glaciers and small ice caps play a crucial role in freshwater availability.
✓Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and changing seasonality of flows in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world population currently lives.

http://www.ipcc.ch

Indirect Impacts: Water ....contd

✓Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease. The resulting increased flood risk poses challenges to society, physical infrastructure and water quality.

✓It is likely that up to 20% of the world population will live in areas where river flood potential could increase by the 2080s.

✓Increases in the frequency and severity of floods and droughts are projected to adversely affect sustainable development. Increased temperatures will further affect the physical, chemical and biological properties of freshwater lakes and rivers, with predominantly adverse impacts on many individual freshwater species, community composition and water quality. In coastal areas, sea level rise will exacerbate water resource constraints due to increased salinisation of groundwater supplies.