Weather More

Unit 3
Biometeorology

During certain weather conditions many people complain about problems in their well-being or even illness. For example, we talk about the effect of overbearing humidity. The weather can exacerbate certain illnesses and elderly people and young children can be especially susceptible to health effects related to the weather conditions.

It has been proven statistically that weather events can have a strong influence on the life of humans and animals. During the heat wave in summer 2003 the mortality rate in some countries increased to many times its normal value.

Biometeorology is a scientific branch, which can be seen as the link between meteorology, biology and medical sciences. It investigates the direct and indirect influence of the atmosphere on humans and other living organisms. In this unit we will look at what these influences are.

Weather makes us shiver, sweat or can stress the heart.

Part 1: Environment and health

More about environmental changes and human health.

In industrialised countries, the phrase "Environmental Health" conventionally refers to the adverse effect on human health caused by exposure to specific physical and chemical agents in the local environment. The emphasis so far has been on contaminants in air, water, soil and food.

Epidemiologists and toxicologists try to quantify the effects of this exposure, either by studying human populations or by using animal experimentation.

Global environmental hazards to health include:

- climate change resulting from an increase in greenhouse gases in the lower atmosphere.

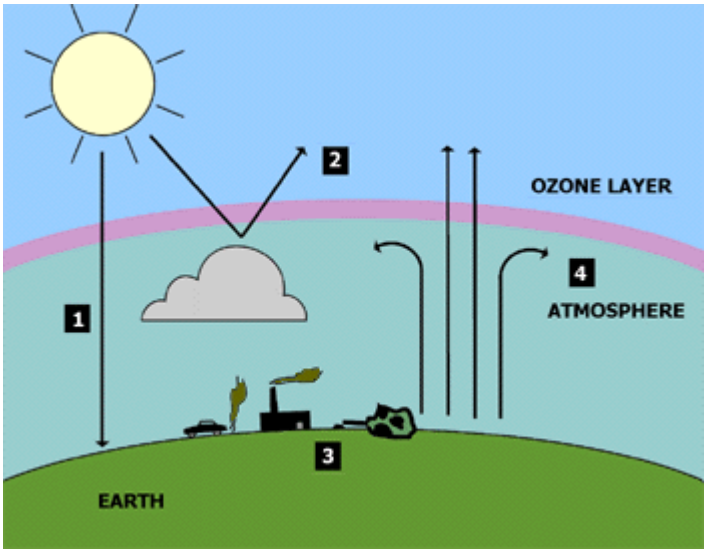


Figure. 1.
1. Energy from the Sun reaches the Earth. The ozone layer shields the Earth from the Sun's harmful ultraviolet radiation.
2. About 30 percent of the solar energy is reflected back into space.
3. Burning fossil fuels and deforestation increase carbon dioxide levels in the atmosphere. Other greenhouse gases such as methane are also added to the atmosphere as a result of human activity.
4. These greenhouse gases form a "blanket" which traps heat energy coming from the surface of the Earth, thus warming the Earth.
source:http://www.texasep.org

- stratospheric ozone depletion.

Effects of solar ultraviolet radiation on human health include:
skin damage - malignant melanoma, non-melanocytic cancer, sunburn
eye damage - lens opacity, acute solar retinopathy, cancer of the cornea and conjunctiva
reduction in immunity to disease and increased susceptibility to infection
direct effects - vitamin D production: prevention of rickets, possible benefit for hypertension, altered general well-being: sleep/wake cycles, mood
indirect effects - on climate, food supply, infectious disease vectors, air pollution.

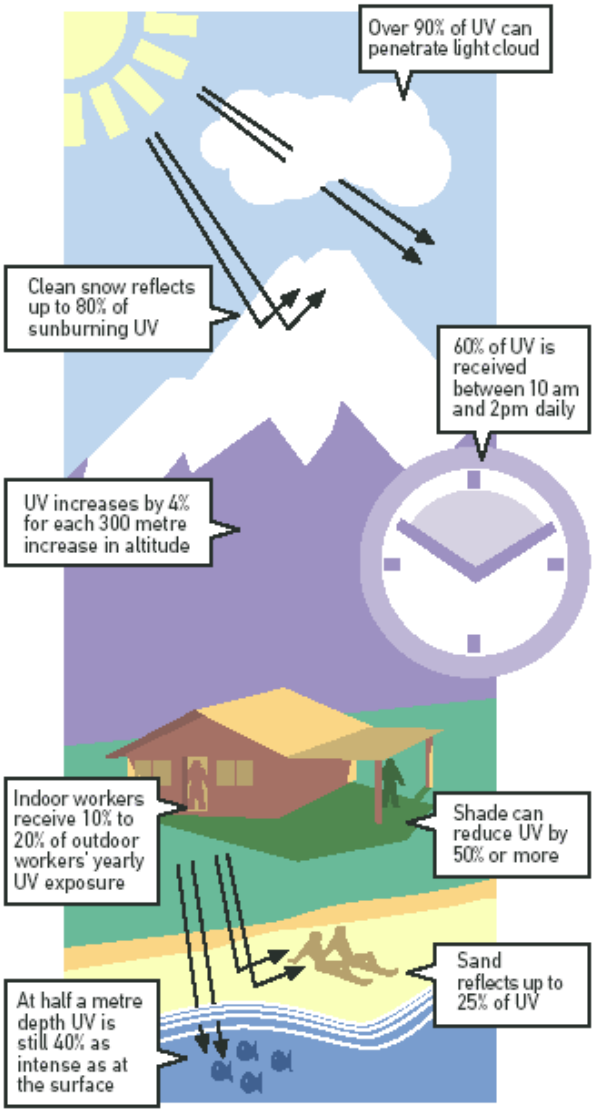
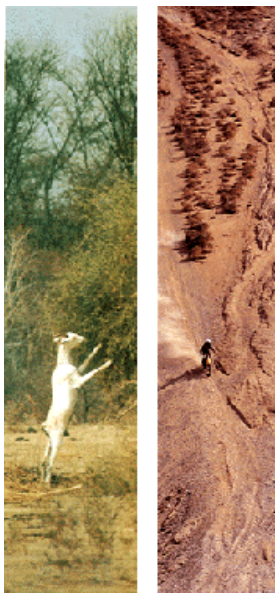


Figure 2. UV radiation levels are influenced by: sun elevation, latitude, cloud cover, altitude, ozone, ground reflection.
source:www.who.int

- loss of biodiversity.

Loss of biodiversity is occurring at a rapid rate and involves both the disappearance of useful species and genes and the weakening of various ecosystems thereby reducing the flow of nature's life-supporting "goods and services".

Figure 3. Even the remaining North American forests are still being cleared for new development.
source: library.thinkquest.org



- desertification, depletion of fertile soil, groundwater and natural fisheries. This reduces the amount of food which can be grown and offsets any expected gains from genetically modified organisms, precision farming and aquaculture.

Figure 4. Left: A goat seeks food in the sparsely vegetated Sahel of Africa.
Right: Off-road vehicles significantly increase soil loss in the delicate desert environment.
source: pubs.usgs.gov

- various common chemical pollutants are now recognised as persistent and globally pervasive. Some appear to affect neurological, immune and reproductive systems and can no longer be considered to have specific and limited toxicity.

Figure 5. Humans emit more and more greenhouse gases into the atmosphere Cars, trucks, home and business heating and power factories are responsible for about 98% of US carbon dioxide emissions and 18% of nitrous oxide missions.
source: www.wrh.noaa.gov

In addition to large-scale environmental changes, global trends within human societies have also had significant effects on human health. The prime determinant of population health in the medium-to-long term is the life-supporting capacity of the environment. Much work still needs to be done to improve our understanding of the fundamental ecological relationship between environmental conditions, climatic conditions and human health.

Measurement of population health

We need a measure to describe the health of population. The disease burden comprises the total amount of disease or premature death within the population. To compare burden-fractions attributable to different risk factors requires, firstly, the knowledge of the severity/disability and duration of the health deficit, and, secondly, the use of standard units of health deficit. The widely-used Disability-Adjusted Life Year (DALY) is the sum of

- years of life lost due to premature death (YLL)
- years of life lived with disability (YLD).

YLL takes into account the age at death, and YLD takes into account disease duration, age at onset, and a disability weight reflecting the severity of disease. Based on this measure, the estimated impacts of climate change in 2000 were the following in different regions.

Region	Total DALYs (1000's)	DALY's per million population
Africa region	1894	3071.5
Eastern Mediterranean region	768	1586.5
Latin America and Caribbean region	92	188.5
South-East Asian region	2572	1703.5
Western Pacific region (without developed countries)	169	111.4
Developed countries (and Cuba)	8	8.9
WORLD	5517	920.3

Examples of how diverse environmental changes affect the occurrence of various infectious diseases in humans.

Environmental changes	Examples diseases	Pathway of effect
Dams, canals, irrigation	Schistosomiasis	Δ Snail host habitat, human contact
	Malaria	Δ Breeding sites for mosquitoes
	Helminthiasies	Δ Larval contact due to moist soil
	River blindness	∇ Blackfly breeding, ∇ disease
Agricultural intensification	Malaria	Crop insecticides and Δ vector resistance
	Venezuelan haemorraghic fever	Δ rodent abundance, contact
Urbanization, urban crowding	Cholera	∇ sanitation, hygiene; Δ water contamination
	Dengue	Water-collecting trash, Δ Aedes aegypti mosquito breeding sites
	Cutaneous leishmaniasis	Δ proximity, sandfly vectors
Deforestation and new habitation	Malaria	Δ breeding sites and vectors, immigration of susceptible people
	Oropouche	Δ contact, breeding of vectors
	Visceral leishmaniasis	Δ contact with sandfly vectors
Reforestation	Lyme cliease	Δ tick hosts, outdoor exposure
Ocean warming	red tide	Δ toxic algal blooms
Elevated precipitation	Rift valley fever	Δ Pools for mosquito breeding
	Hantavirus pulmonary syndrome	Δ Rodent food, habitat, abundance

Δ increase ∇ reduction

Part 2: Weather and health

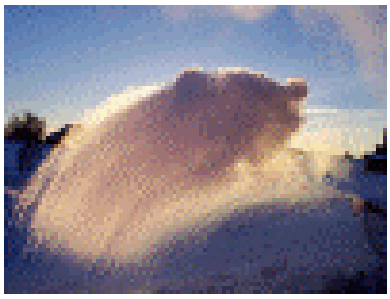
1. source: http://www.es.mq.edu.au/ISB/

People have, since ancient times, associated certain weather conditions with ill health. The connection between weather and health is made especially clear when skin cancer rates increase and during heat waves or extreme cold snaps when old people are much more at risk of death.

Illness resulting from temperature extremes and solar ultra-violet radiation are obvious effects of weather on health. Effects which are not so obvious include the influence of weather on our mood, behaviour and general well-being.

Researchers realised that medical conditions alone could not explain all illnesses and a new science called **Biometeorology** was created. This is a combination of many science disciplines, mainly meteorology, medicine and biology. Our gradual detachment from nature and our modern lifestyle, with air conditioners, humidifiers and heaters has made us more sensitive to environmental influences. This is particularly valid when the body is weakened by illness or old age.

Our bodies react to cold by constricting the blood vessels in our skin and around the edges of our body. As a result, our heart has to work harder to squeeze blood through the narrow vessels. This puts alot of strain on a damaged or weakened heart. A significant drop in air pressure causes the air in our isolated body cavities and our membrane fluids to expand. This puts pressure on inflammed or injured tissues in joints or muscles and causes us increased pain. Some people experience this phenomenon when they travel by aeroplane when the cabin pressure drops during take off. Many of us are sensitive to changes in weather and the pain we feel may be caused by the irritation of nerve endings as a result of rapid changes in conditions. Bones and muscles have different densities and unequal expansion and contraction during temperature and humidity variations may increase the pain we feel in inflamed or injured joints and muscles.

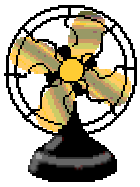


2. Boiling water tossed into air at a temperature of -18 oC on December 25 2000. Photo by Dan Lipinski. Source: http://www.crh.noaa.gov/ with permission.

3. source:
http://johnson.senate.gov/drought.html

Heat waves appear to have a greater impact on mortality than cold episodes. In the summer of 2003, 180 people died in Paris, France on one day alone as a result of the abnormally high temperatures. Several thousand people died during the heat wave that summer.

Humidity has an important impact on mortality. The more humid it is, the harder it is for our bodies to loose heat by sweating, and this results in further overheating.



4. source:
http://www.petsit.com/data/publications/html/world/ROOT-2001_6_27_145155.asp

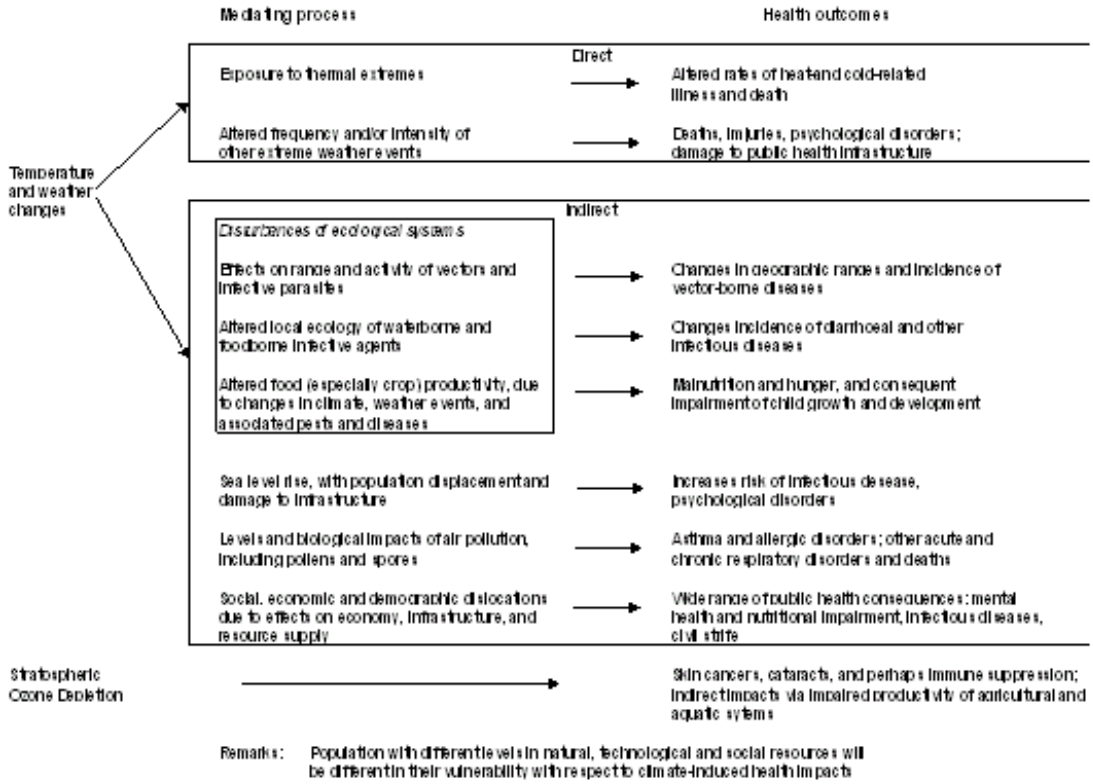
5. Dust storm over Edwards Air Force Base Photo by TSgt Matthew Kelpis
source:
http://www.crh.noaa.gov/
with permission

Weather-sensitive people often become irritated a day or two before a change in weather and are often miserable when a weather front arrives. Hospital records in the USA show that a greater number of babies are born during this time and headaches and migraines increase. People suffering from rheumatism dread the arrival of cold and damp weather and the dry and dusty inland wind prior to the arrival of a front triggers asthma or aggravates the symptoms and worsens hayfever.

Inland dry winds before fronts are called **Foehn** in the Alpine regions of Central Europe and **Chinook** and **Santa Ana** in the Rocky mountain regions of Canada and the USA. Some Swiss courts even allow the negative effects of these winds to be used as a mitigating factor in some crimes. The University of Calgary in Canada has substantiated the claims of many migraine sufferers that the Chinook is their main trigger.

6. Dry Santa Ana wind
source: http://www.usatoday.com/weather/wsanta.htm

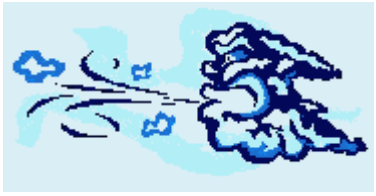
Electrical storms also have an impact on our health. A lightning bolt announces its presence by sending out electromagnetic signals, **sferics** (short for atmospherics), at the speed of light. Instruments can measure these hundreds of kilometres away.



7. Major types of impact change and stratospheric ozone depletion on human health (WHO/WMO/UNEP-Task Group, 1996).

Part 3: Wind chill

One of the principal modes of heat transfer from an object is convection of heat to the surrounding air. Convective heat transfer increases significantly with increasing air velocity. As a result, a person is cooled at a faster rate under windy conditions than under calm conditions, given equal air temperature.



1. source: http://www.erh.noaa.gov/er/iln/tables.htm

Wind chill is a concept that relates the rate of heat loss from humans under windy conditions to an equivalent air temperature for calm conditions. The wind chill temperature (WCT) is an equivalent air temperature equal to the air temperature needed to produce the same cooling effect under calm conditions. So the wind chill temperature is not actually a temperature, but rather an index that helps relate the cooling effect of the wind to the air temperature under calm conditions.

It is important to remember that the wind does not cause an exposed object to become colder than the ambient air temperature. Higher wind speeds simply cause the object to cool to the ambient air temperature more quickly.

2. Parched Yugoslav Lake
source:
http://dsc.discovery.com/news/
afp/20030804/euroheat.html

An extreme heat event or heat wave is a period of excessive daytime and night time heat and high humidity relative to the geographic location and time of year.

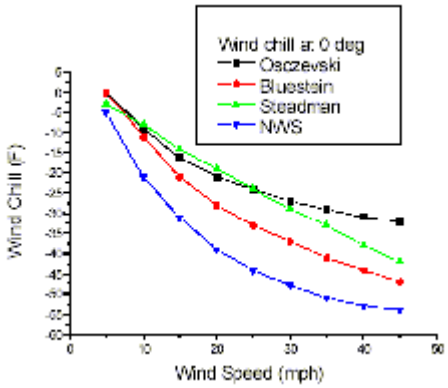
Human bodies loose heat by changing the rate and depth at which the blood is circulated and by water loss through the skin and sweat glands. To cool the body, the heart begins to pump more blood, blood vessels dilate (expand) to accomodate the increased flow and the bundles of tiny capillaries threading through the upper layers of skin are put into operation. The blood is circulated closer to the skin's surface, and excess heat drains off into the cooler atmosphere. At the same time, water diffuses through the skin as perspiration. The skin is responsible for about 90 percent of the body's heat loss function. Sweating alone does nothing to cool the body. For cooling to occur, the sweat must be lost by evaporation from the surface of the skin. High humidity conditions retard this process of evaporation.

Under conditions of high temperature and high relative humidity, the body aims to maintain an internal temperature of 37°C. To do this, the heart pumps more blood through dilated blood vessels and sweat glands pour liquid, which includes essential dissolved chemicals like sodium and chloride, onto the surface of the skin.

When more heat enters the body than the body can remove or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illnesses may develop.

Death rates can increase markedly as a result of heat waves and the peaks correlate with maximum daily temperature 1-2 days before death; that is, there is a 1-2 day lag between the hottest temperatures and the peak in death rate. Illnesses such as heat stroke and heat exhaustion can occur in healthy people who are overexposed to, or are overactive in the heat. However, the majority of excess deaths that occur during heat waves are actually the result of other illnesses, which are exacerbated by heat stress. Children, the elderly and people who are already ill, particularly those with circulatory problems, are most at risk during excessive heat.

Many indices have been developed to measure the influence of meteorological parameters on the human body. A comparison of formulations used to determine the effect of wind speed on wind chill is shown here.



3. Differences in the various wind chill equivalent formulations at an air temperature of 0°F (adapted from Quayle et al. 2000).

The **Heat Index** (HI) is the temperature the body feels when heat and humidity are combined. The chart below shows the HI that corresponds to the actual air temperature and relative humidity. This chart is based upon shady, light wind conditions. **Exposure to direct sunlight can increase the HI by up to 15°F.** To convert temperatures in Fahrenheit (TF) to temperatures on the Celsius scale (TC) use the following equation:

$$TC = (5/9)*(TF-32)$$

°F	90%	80%	70%	60%	50%	40%	30%	20%	10%
65	65.6	64.7	63.8	62.8	61.9	60.9	60.	59.1	58.1
70	71.6	70.7	69.8	68.8	67.9	66.9	66.	65.1	64.1
75	79.7	76.7	75.8	74.8	73.9	72.9	72.	71.1	70.1
80	88.2	85.9	84.2	82.8	81.6	80.4	79.	77.4	76.1
85	101.4	97.	93.3	90.3	87.7	85.5	83.5	81.6	79.6
90	119.3	112	105.8	100.5	96.1	92.3	89.2	86.5	84.2
95	141.8	131.1	121.7	113.6	106.7	100.9	96.1	92.2	89.2
100	168.7	154.	140.9	129.5	119.6	111.2	104.2	98.7	94.4
105	200	180.7	163.4	148.1	134.7	123.2	113.6	105.8	100.
110	235.	211.2	189.1	169.4	151.9	136.8	124.1	113.7	105.8
115	275.3	245.4	218.	193.3	171.3	152.1	135.8	122.3	111.9
120	319.1	283.1	250.	219.9	192.9	169.1	148.7	131.6	118.2

4. Temperature (F) versus Relative Humidity (%)

HI	Possible Heat Disorder:
80°F - 90°F	Fatigue possible with prolonged exposure and physical activity.
90°F - 105°F	Sunstroke, heat cramps and heat exhaustion possible.
105°F - 130°F	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
130°F or greater	Heat stroke highly likely with continued exposure.

5. Possible heat disorder

Temperature (Down) versus Dewpoint (across)

°F	50	55	60	65	70	75	80	85
65	62.7	63.8	65.0	66.6				
70	67.8	68.7	69.8	71.1	72.6			
75	73.1	73.9	74.8	75.9	79.2	80.7		
80	79.8	80.6	81.6	82.8	84.4	86.9	90.9	
85	83.5	84.7	86.1	88.0	90.5	94	99	106.6
90	87.9	89.4	91.2	93.6	96.9	101.2	107.2	115.6
95	92.9	94.5	96.7	99.6	103.4	108.4	115.2	124.3
100	98.1	99.9	102.4	105.6	109.8	115.3	122.7	132.3
105	103.4	105.4	108.1	111.6	116.1	122.0	129.7	139.7
110	108.7	110.9	113.8	117.5	122.3	128.4	136.3	146.5

6. This table compares Temperature and Dewpoint. The different colours show the disorders which are possible (see above).