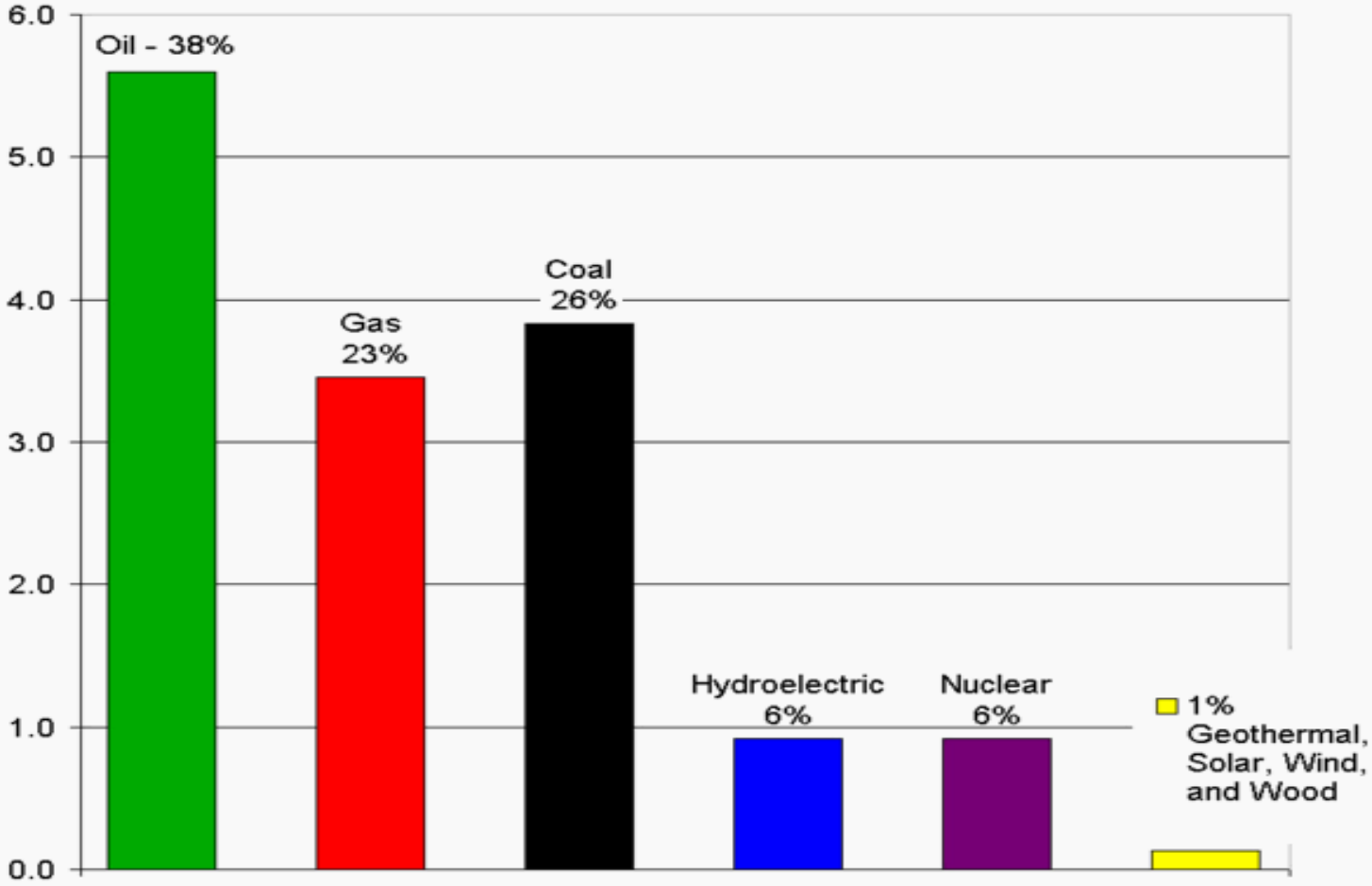
Environmental Education

Mgr. Jaromír Demek

World energy sources

- In the year 2007 primary sources of energy consisted of petroleum 36.0%, coal 27.4%, natural gas 23.0%, amounting to an 86.4% share for fossil fuels in primary energy consumption in the world. Non-fossil sources in 2006 included hydroelectric 6.3%, nuclear 8.5%, and others (geothermal, solar, tide, wind, wood, waste) amounting to 0.9 percent. World energy consumption was growing about 2.3% per year

World energy sources 2005



World energy sources

- Our economy is called “carbon economy“ because 86.4 percents of energy comes from fossil fuels
- Reserves of these fuels are limited, in case of some of them just to a few decades
- Recently is not available any solution of replacement of fossil fuels for another energy sources
- Renewable energy sources are still too expensive a ineffective

Energy sources in the Czech Republic

- Electricity is from 2/3 still produced in thermal power plants, one third is produced in two nuclear power plants
- Further construction of nuclear power blocks is planned to begin in the year 2017
- It is necessary because reserves of lignite, which is combusted in thermal power plants will be exhausted in next two decades
- Natural gas is available on almost all territory of the country and is the purest fuel. Gas is used for heating, cooking and industrial purposes
- Renewable energy sources are supported by government, but they are not able to compete with other power sources

Power plant combusting lignite (low quality brown coal)

Lignite mining in millions of tons

Country	1970	1980	1990	2000	2001
Germany	369.3	388.0	356.5	167.7	175.4
Russia	127.0	141.0	137.3	86.4	83.2
United States	5.4	42.3	82.6	83.5	80.5
Australia	24.2	32.9	46.0	65.0	67.8
Greece	8.1	23.2	51.7	63.3	67.0
Poland	32.8	36.9	67.6	61.3	59.5
Turkey	4.4	15.0	43.8	63.0	57.2
Czech Republic	67.0	87.0	71.0	50.1	50.7
People's Republic of China	13.0	22.0	38.0	40.0	47.0
SFR Yugoslavia	26.0	43.0	60.0	-	-
Serbia and Montenegro	-	-	-	35.5	35.5
Romania	14.1	27.1	33.5	17.9	29.8
North Korea	5.7	10.0	10.0	26.0	26.5
Total	804.0	1,028.0	1,214.0	877.4	894.8

Lignite mining in open mine destroys the landscape

Acid rains

- Lignite used in thermal power plants contains a lot of pollutants
- One of the most important pollutants is sulphur
- Combustion of sulphur causes following chemical reactions
- $S + O_2 = SO_2$
- $2\ SO_2 + O_2 = SO_3$
- $SO_3 + H_2O = H_2SO_4$
- Final product of these reactions is sulphuric acid, a very strong acid

Acid rains

- Almost all forests in Northern Bohemia were destroyed by acid rains
- It is not only local problem – it is a problem of all developed countries
- But also countries which do not mine and use lignite are affected, for example the Scandinavian countries
- Acid rains dissolve limestone and cause serious damages of historical buildings, marble statues etc.
- Acidification of water can cause extinction of some biological species
- Most of all are endangered water animals

Forests destroyed by acid rains in Northern Bohemia

The same problem in Germany

Badly damaged marble statue

Acid rains cause extinction of water animals

- Water animals are very sensitive to the acidity of water. They can not live in too acid water.

Solution of acid rains problem

- Use of fuels not containing sulphur
- Sulphur oxides can be neutralized in power stations and other industrial facilities. Limestone (calcium carbonate) is used for this purpose, final product is calcium sulphate (gypsum)
- Millions of tons of calcium sulphate are produced each year, but they cause another problems as calcium sulphate has limited use

Greenhouse effect
Global warming

- Since the beginning of industrial revolution in 1750 man started to combust fossil fuels, first coal, later petroleum and natural gas
- It caused primary slow, but later faster and faster increase of concentration of greenhouse gases in atmosphere, mostly of carbon dioxide

Greenhouse effect

- It is very important to consider that there are two types of greenhouse effect:
- Natural
- Artificial, caused by man (anthropogenic)

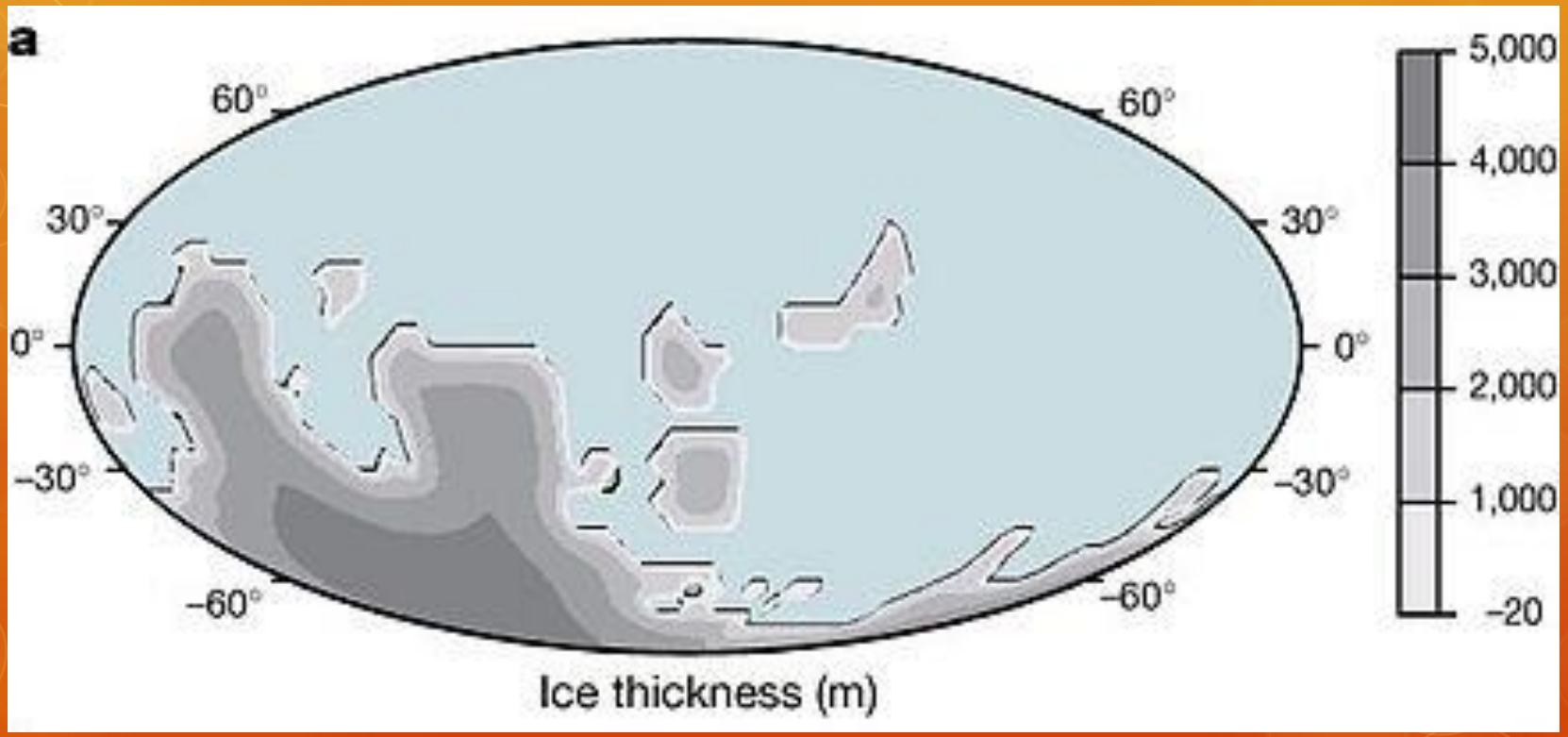
Natural greenhouse effect

- Natural greenhouse effect is essential for life on Earth.
- If there would not be natural concentration of greenhouse gases (carbon dioxide, methane) the average temperature would be about -18 degrees Celsius. But the average temperature is about +15^{o} C . This difference – 33 degrees is caused by greenhouse effect.
- Natural concentration of carbon dioxide, the most important of greenhouse gases is about 280 ppm

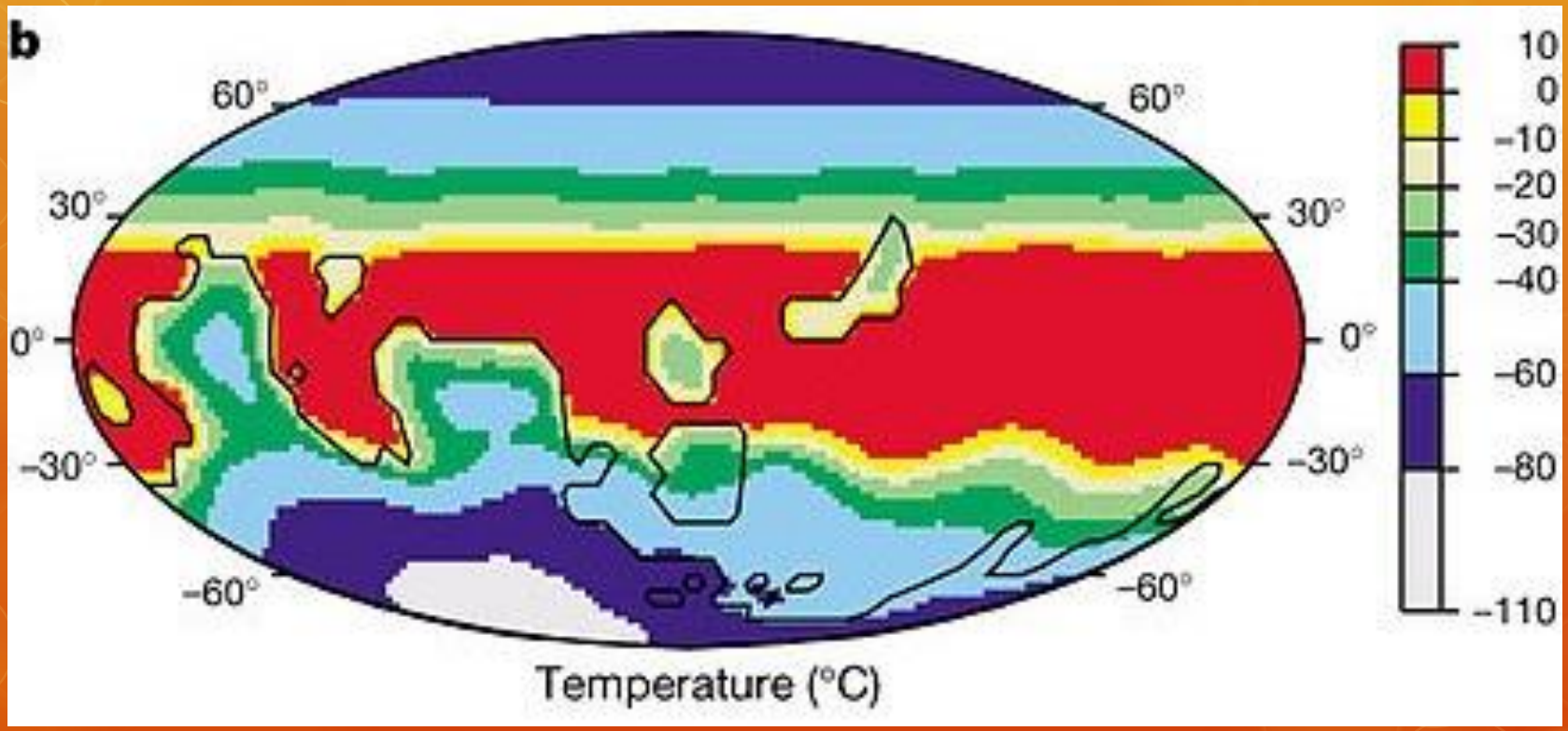
Snowball Earth

- About 700 million years ago concentration of CO_2 decreased (by chemical processes and photosynthesis)
- The result was that the Earth's surface became entirely or nearly entirely frozen
- Only seawater near Equator remained liquid and it probably saved the life on the Earth from extinction
- It is possible that there was not only one global glaciations

Snowball Earth



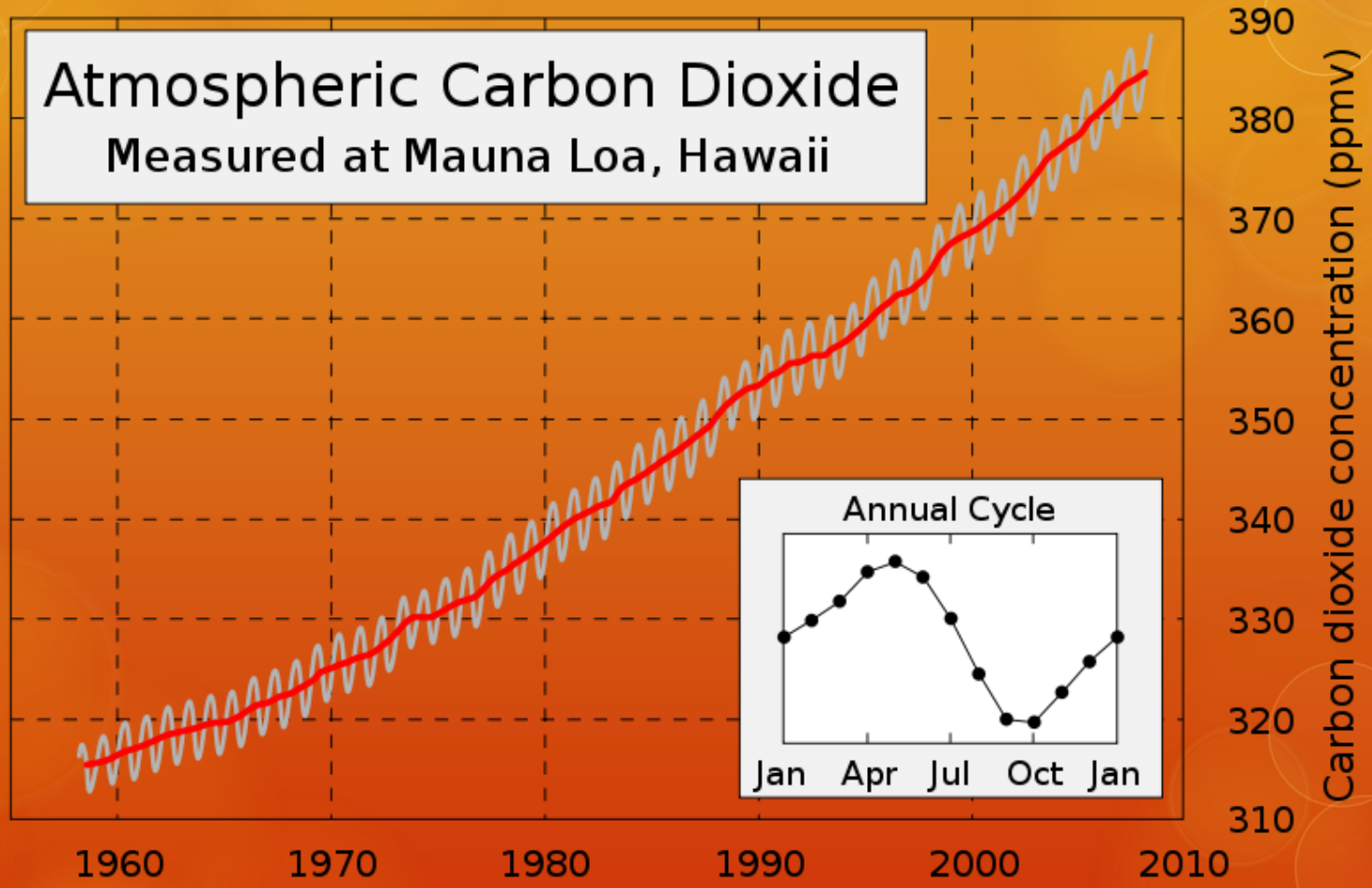
Snowball Earth



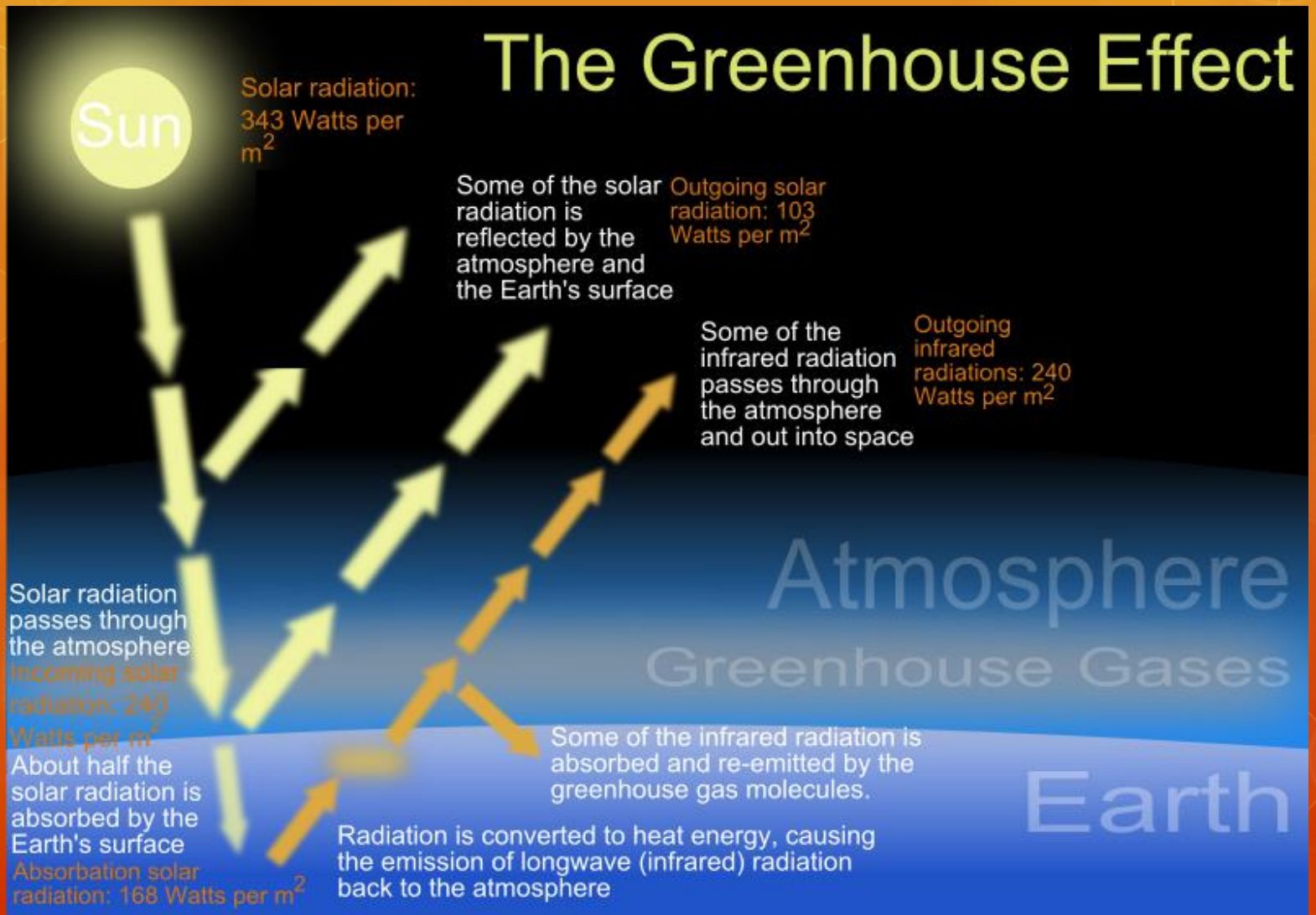
Artificial greenhouse effect

- Combustion of fossil fuel causes rapid increase of concentration of greenhouse gases, mostly of carbon dioxide. Fifty years ago the concentration of carbon dioxide was about 320 ppm, now it is 385 ppm. Average temperatures have increased for about 2 degrees Celsius since the year 1900
- Connection between increased concentration of greenhouse gases and temperature rise is known more than forty years.
- But only in the year 1997 was signed “Kyoto protocol“ aimed to achieve "stabilization of greenhouse gas concentrations in the atmosphere"

Carbon dioxide concentrations



The principle of the greenhouse effect



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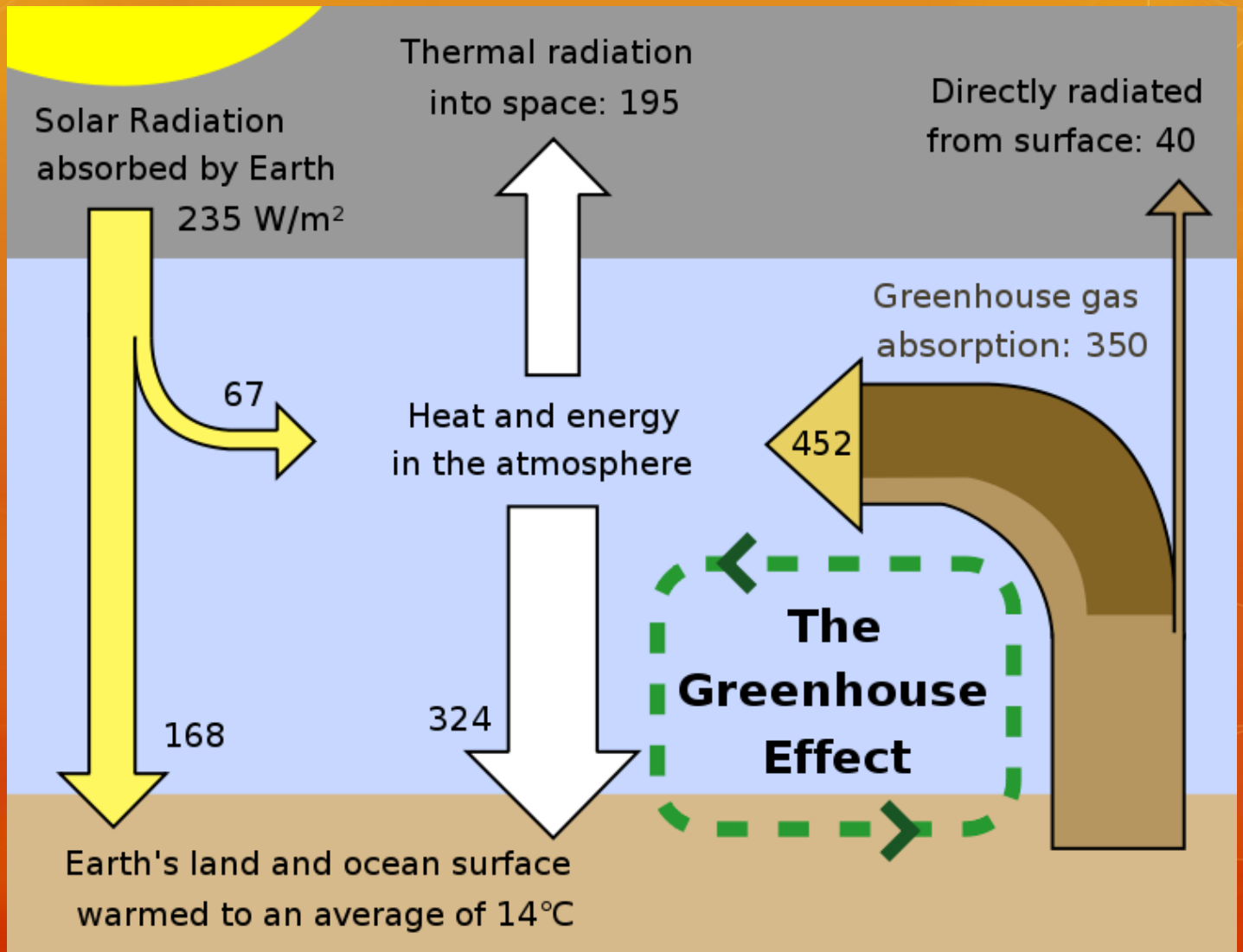
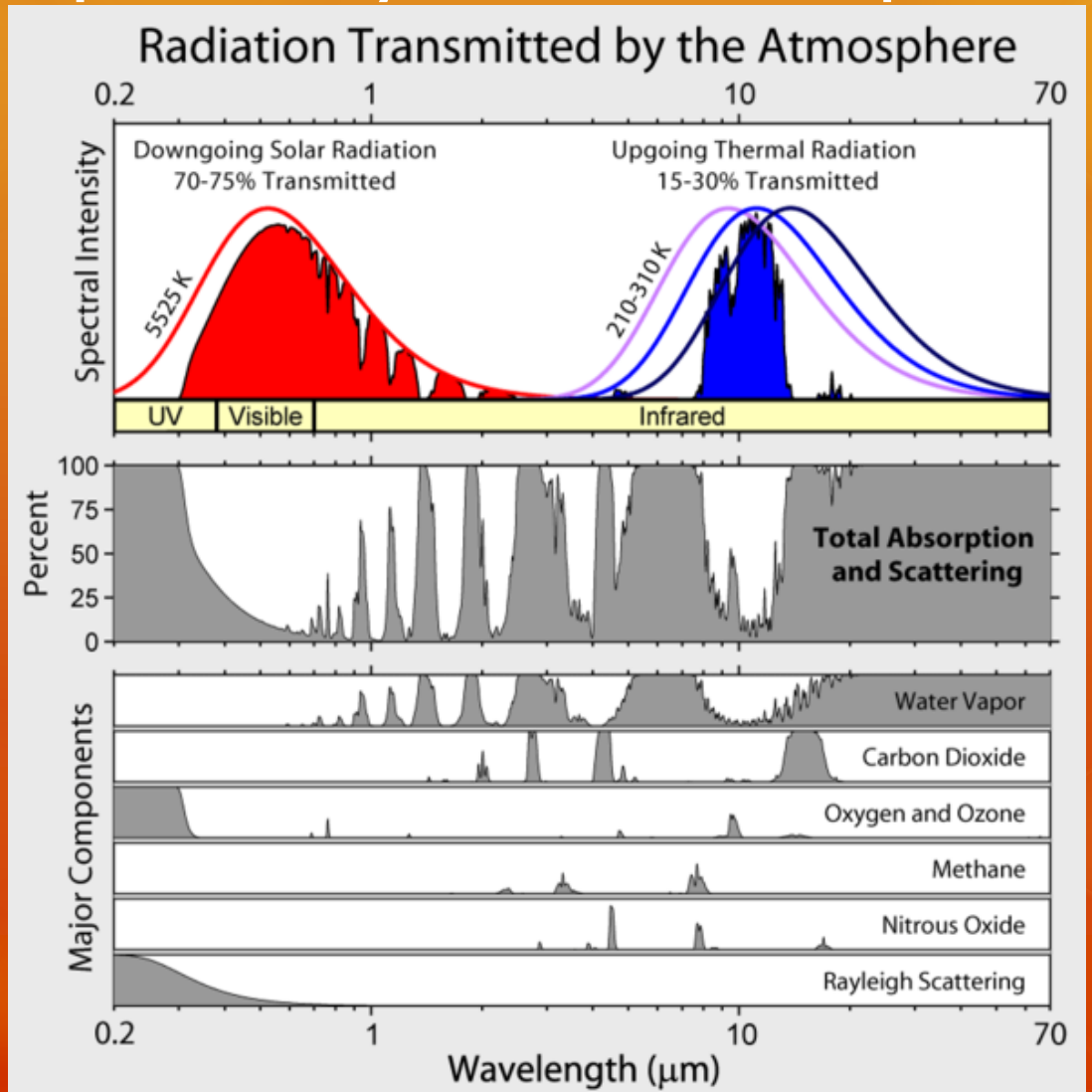


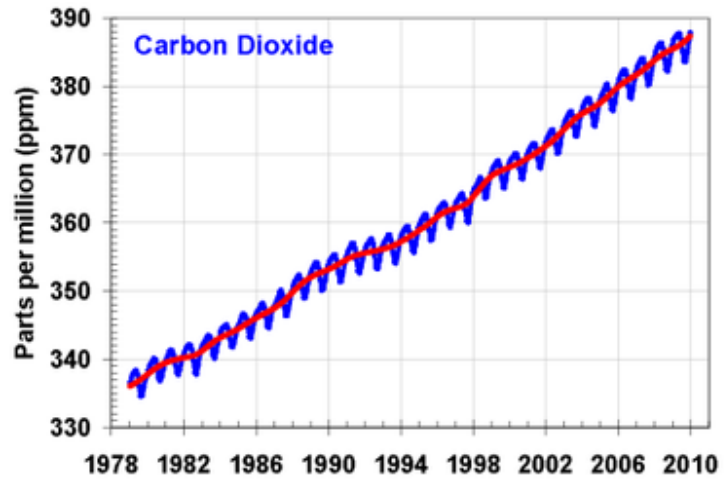
Solar radiation transmission and absorption by the atmosphere

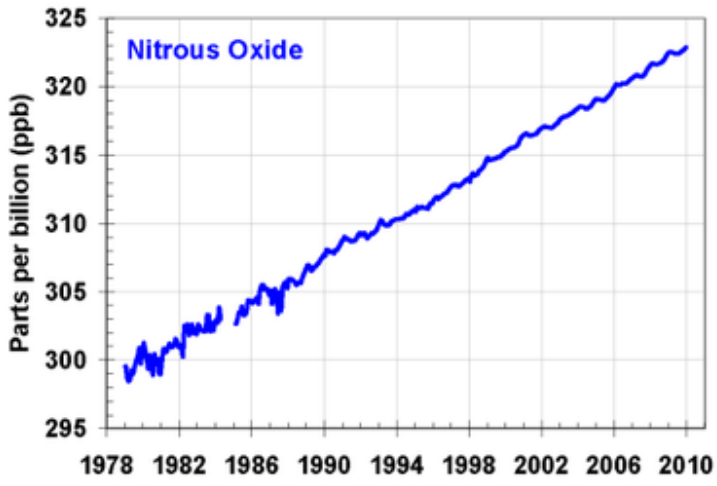


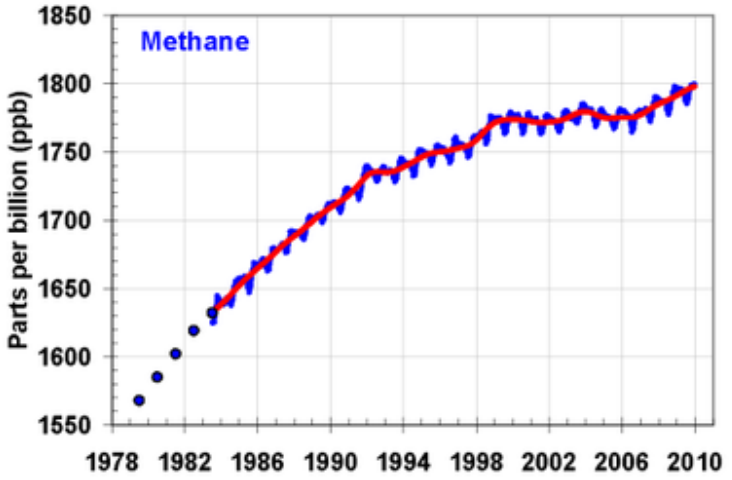
Greenhouse gases

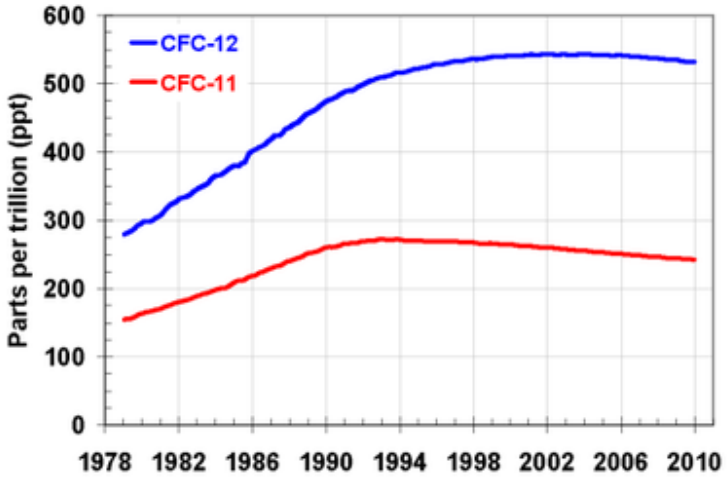
- Greenhouse effect in not only caused by carbon dioxide
- Other three – atom molecules also absorb long – wave infrared radiation – H_2O, N_2O, O_3
- Methane CH_4 is very important greenhouse gas, too
- Very high ”warming potential” also have the CFC gases – chlorofluorocarbons (freons). Their use was limited by Montreal protocol because they are very dangerous for ozone layer, which protects the surface of Earth from solar ultraviolet radiation

Major greenhouse gases trends

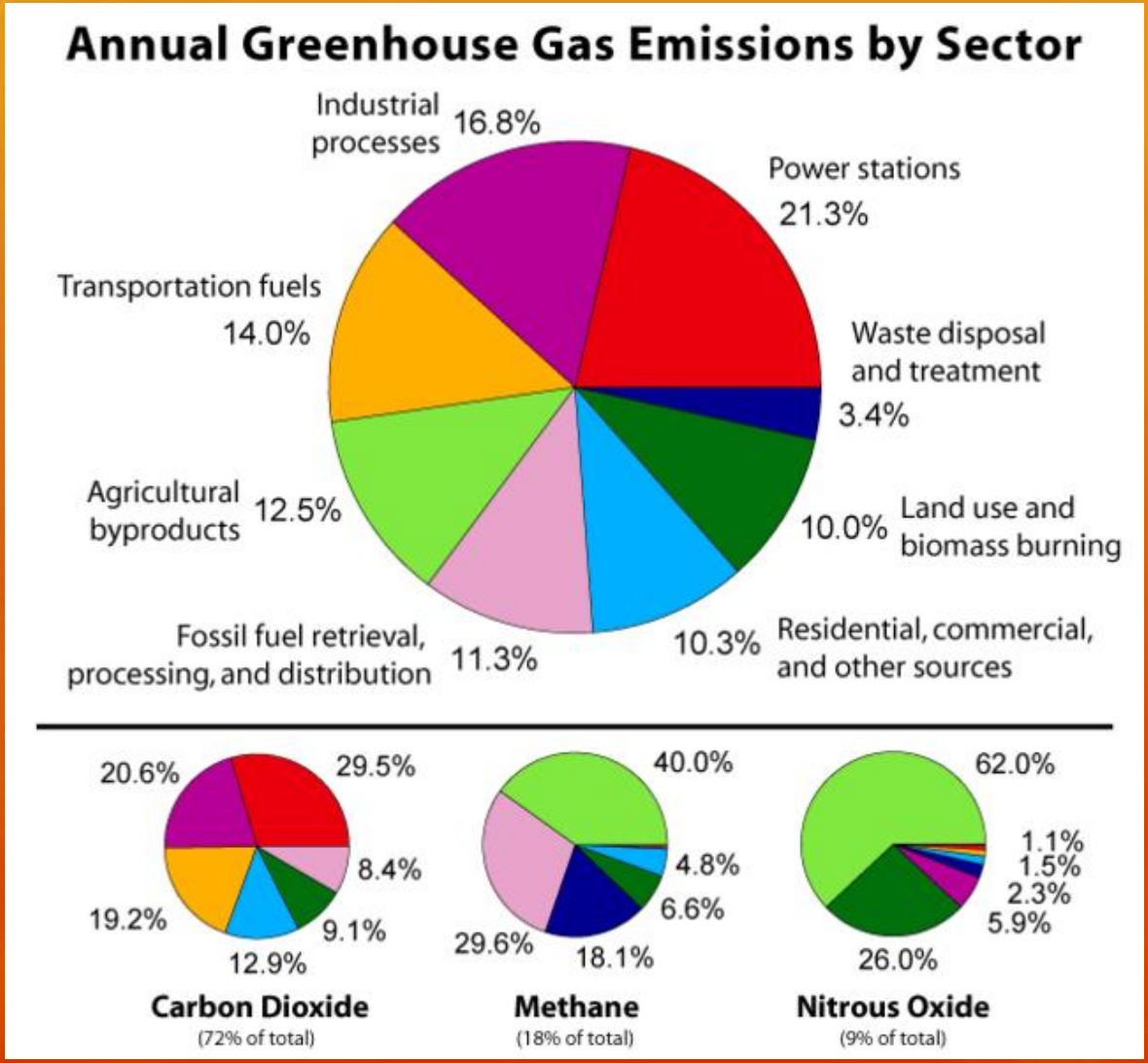








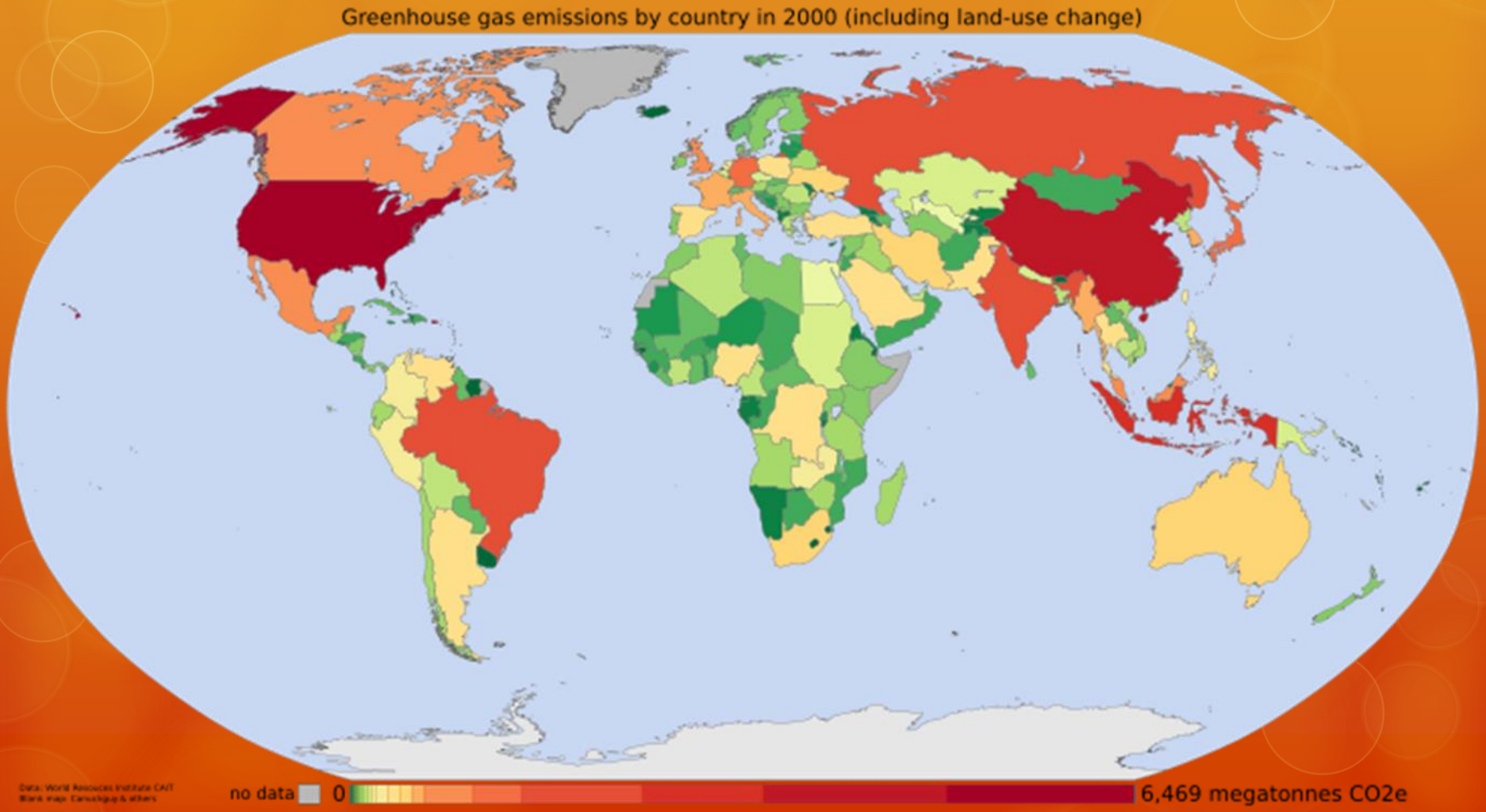
Greenhouse gases by sector



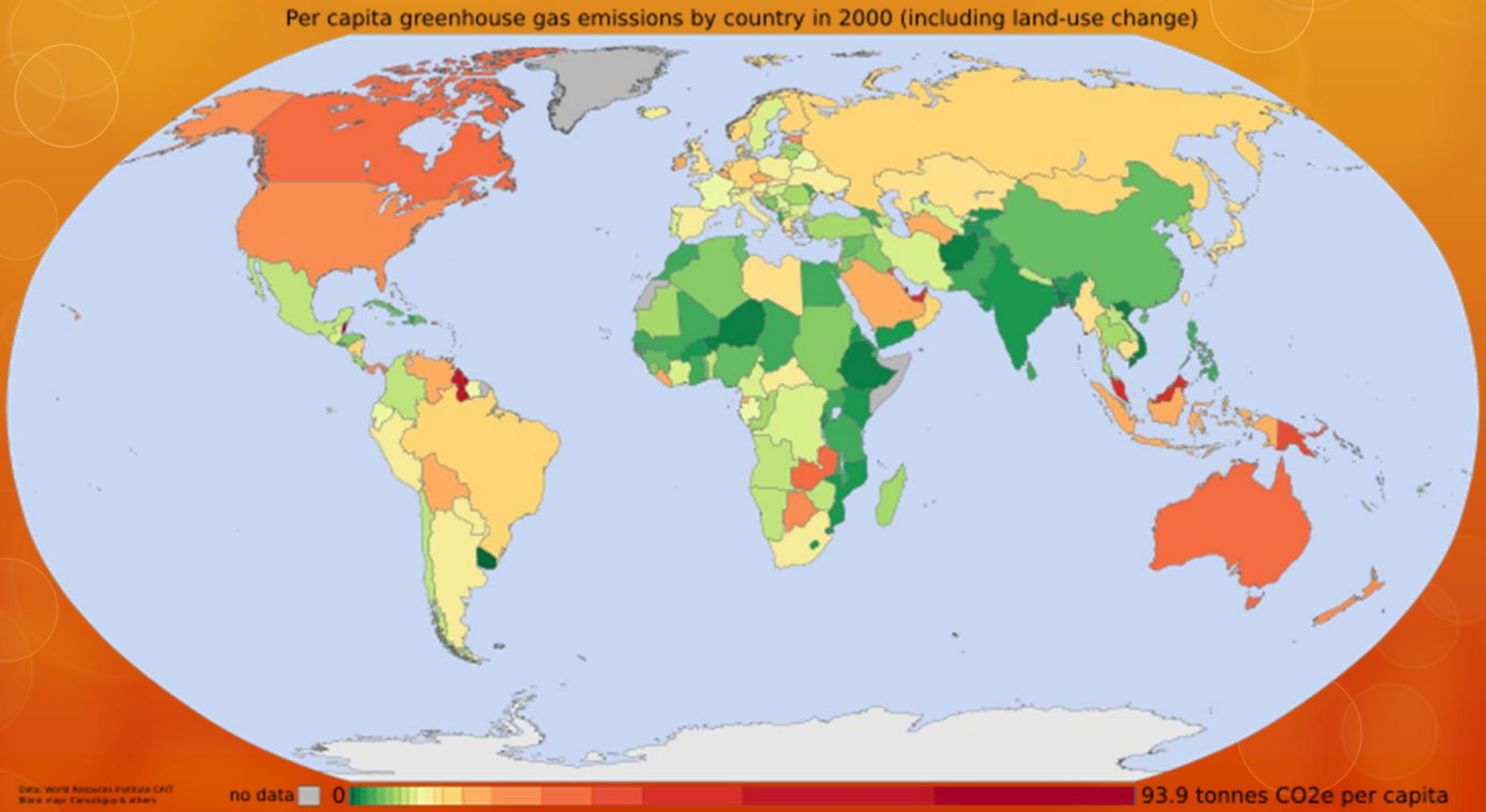
Problems with reduction of greenhouse gases emissions

- Kyoto protocol is valid only until 2012
- Negotiation in Copenhagen on United Nations Climate Change Conference 2009 were not successful
- Possible reason – world economical crisis
- Environmental – friendly technologies are available, but they are expensive
- Many countries are afraid of slowing of their economical growth, in some of them it is a very essential problem (China, India - not only economical, but political, too)
- In 2010, emissions of CO_2 increased of 6 %!

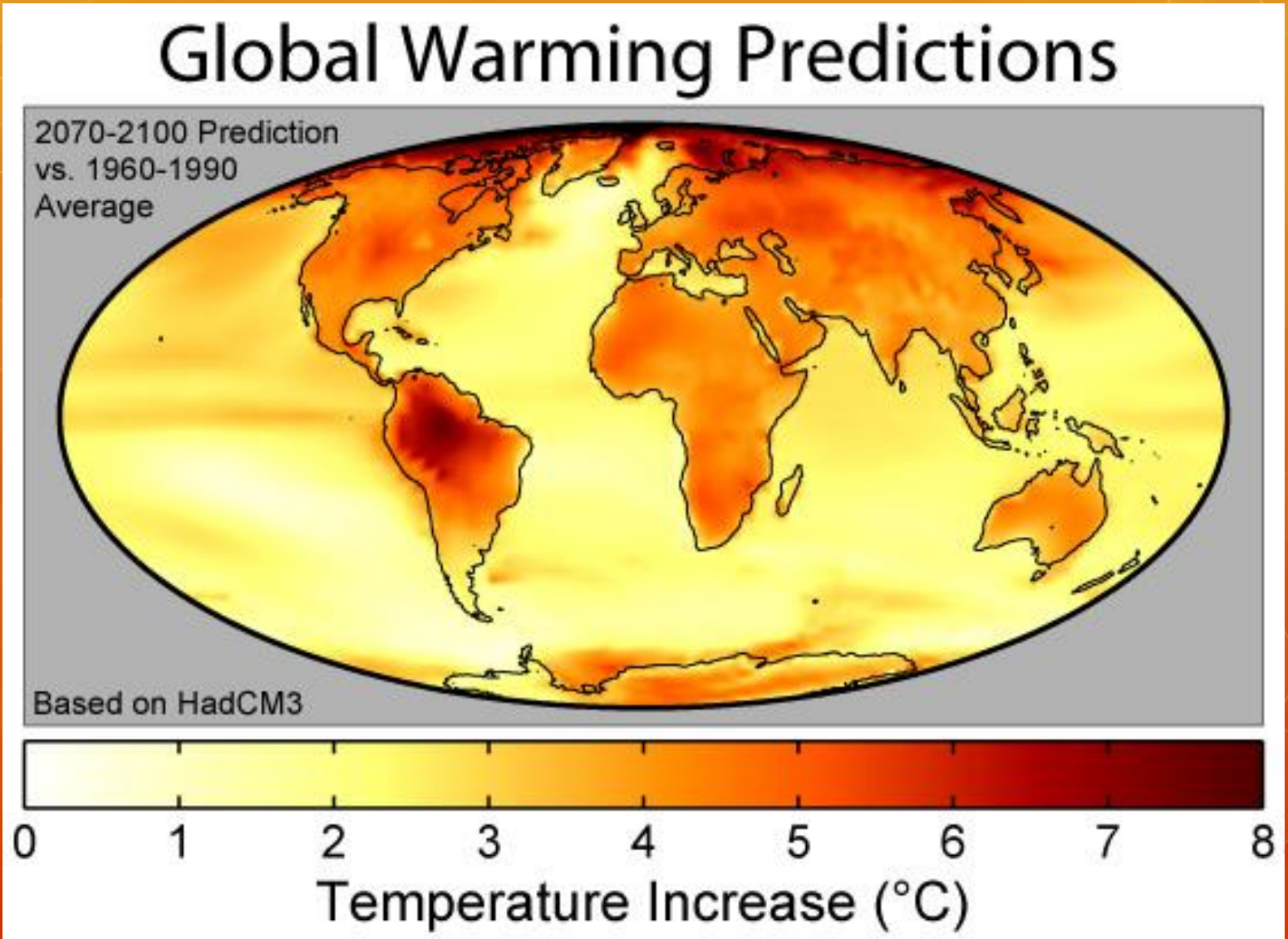
Greenhouse gas emissions by country in 2000



Greenhouse gas emissions per capita in 2000



Global warming predictions



How to solve the problems with global warming

- Emissions of greenhouse gases still increase, not decrease
- If the growth of the emissions will continue with ratio of 6 percent per year, even the worst predictions of IPCC (Intergovernmental Panel on Climate Change) will be exceeded
- According to recent predictions average temperature can rise of 2 degrees until the year 2100 (optimistic alternative), 4 degrees (average alternative) and 6 to 7 degrees (pessimistic alternative)

How to solve problems with global warming

- Reduction of greenhouse gases emissions is possible, but complex (economical, political reasons)
- Diversion from ”carbon economy” means very high costs
- Only available energy source non-producing greenhouse gases are water and nuclear energy
- Increase of energy production of water power stations is difficult and may cause serious ecological problems – for example Chinese Three Gorges or Rio Xingu water dam
- Recently only possible energy source which development is not limited is nuclear energy
- Other energy sources (photovoltaic, wind, biomass, biogas) are not able to compete with traditional ones

Dangers of temperature rise

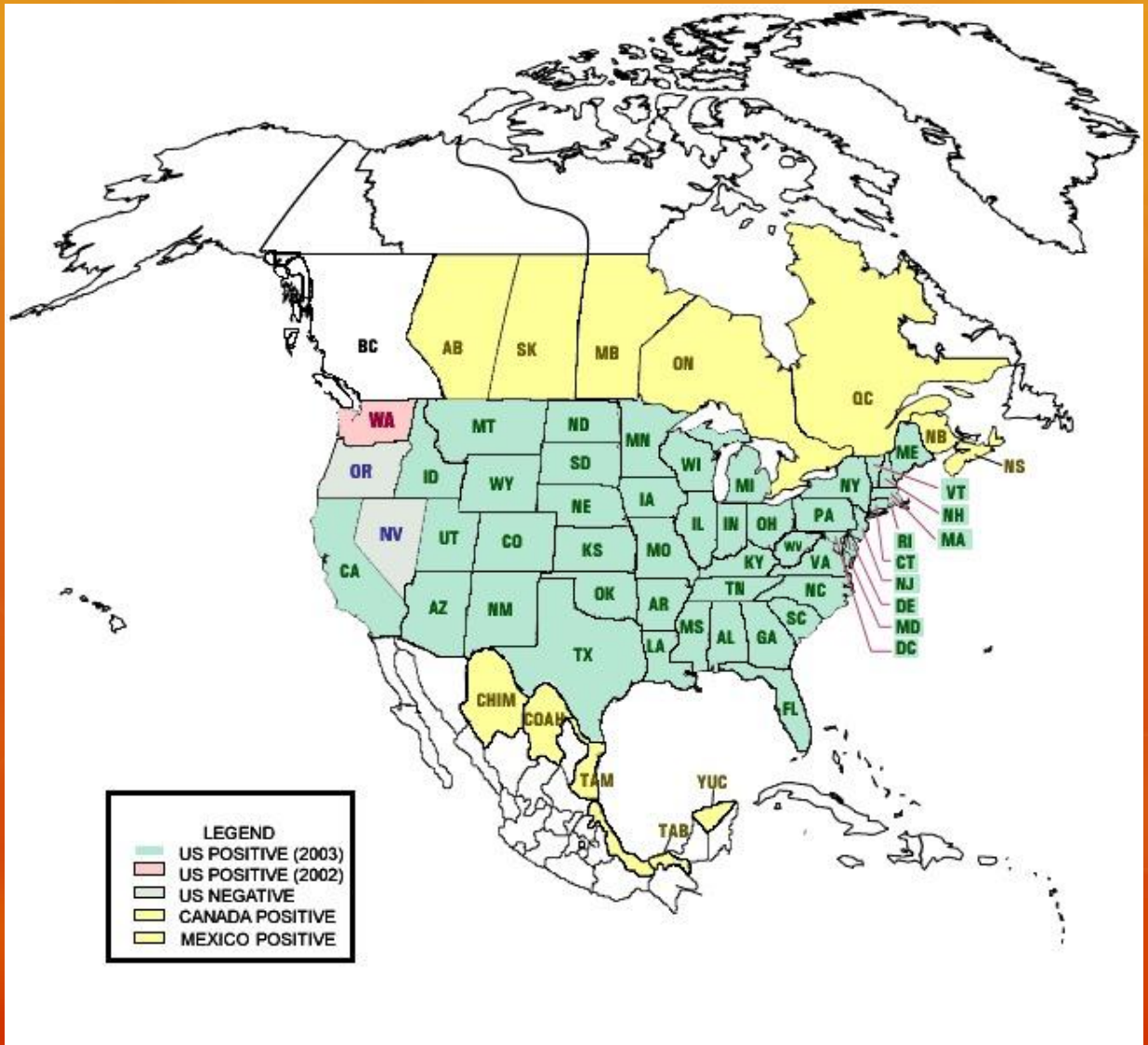
- Rise of sea level that can cause flooding of ports or countries which are recently situated only a few meters above sea (Bangladesh, Vanuatu, The Netherlands)
- Melting of mountain glaciers can cause serious problems with water supplies for billions of people
- Temperature rise can damage many ecosystems. Many species can live in a specific temperature range. They may be endangered with extinction, temperature rise is so fast that they are not able to adapt
- Higher temperatures cause higher atmosphere dynamics and higher evaporation of water. We can await strong storms, flooding, even hurricanes

Specific dangers for the Czech Republic

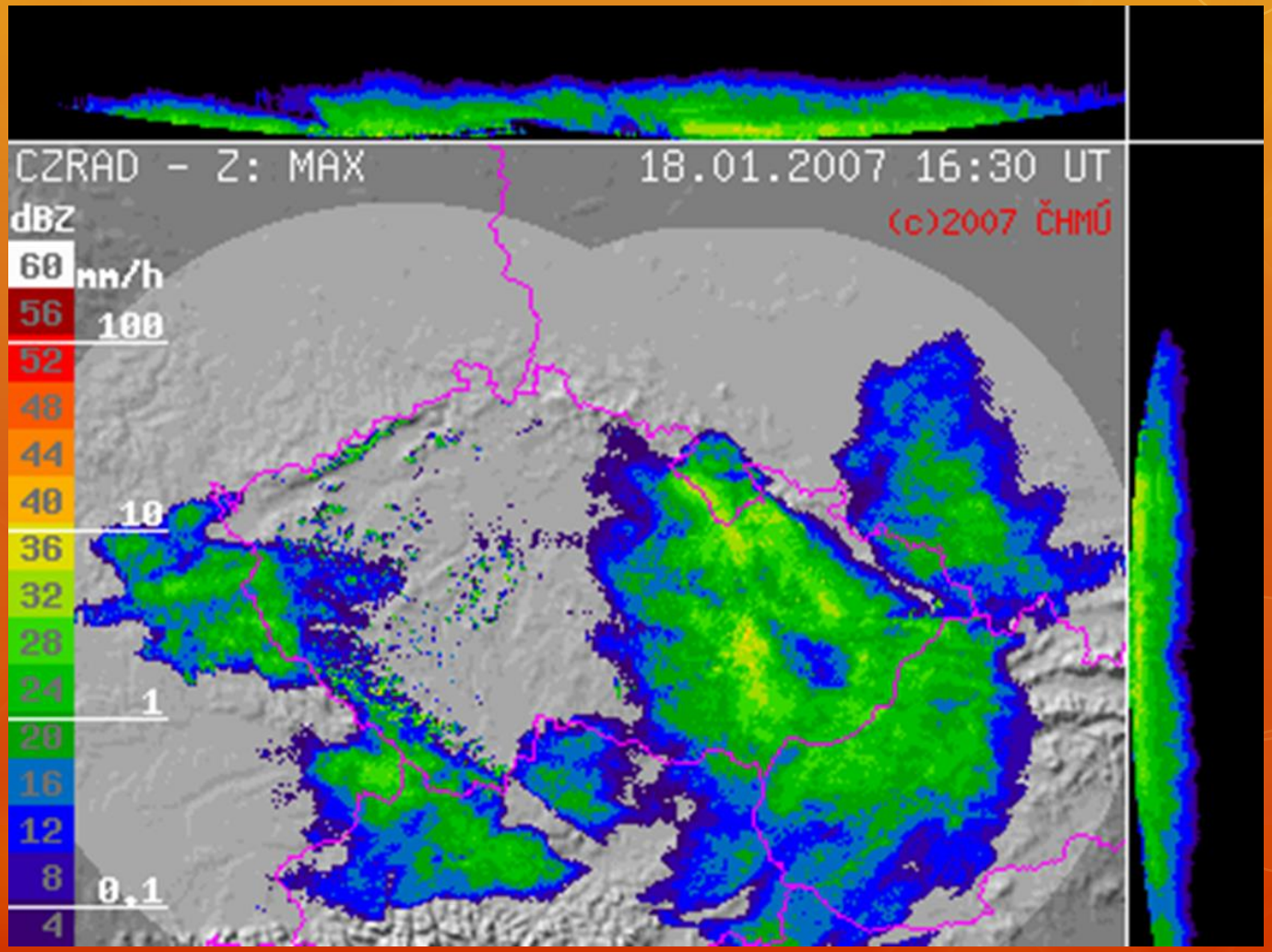
- Proliferation of subtropical diseases – malaria, West Nile fewer, Q – fever
- Serious damages of ecosystems, extinction of some species, damages of natural food chains
- Large – scale migration waves from Northern Africa and Near East
- Change of precipitation mode – there may be two maximums, one in winter a one in summer, the rest of the year can be very dry. It may cause very serious problems in agricultural production, water sources etc. On the other hand there may be summer flooding even exceeding disastrous one in the year 2002

Recent occurrence of malaria

Spreading of West Nile fewer in The USA



Kyrill storm 2007

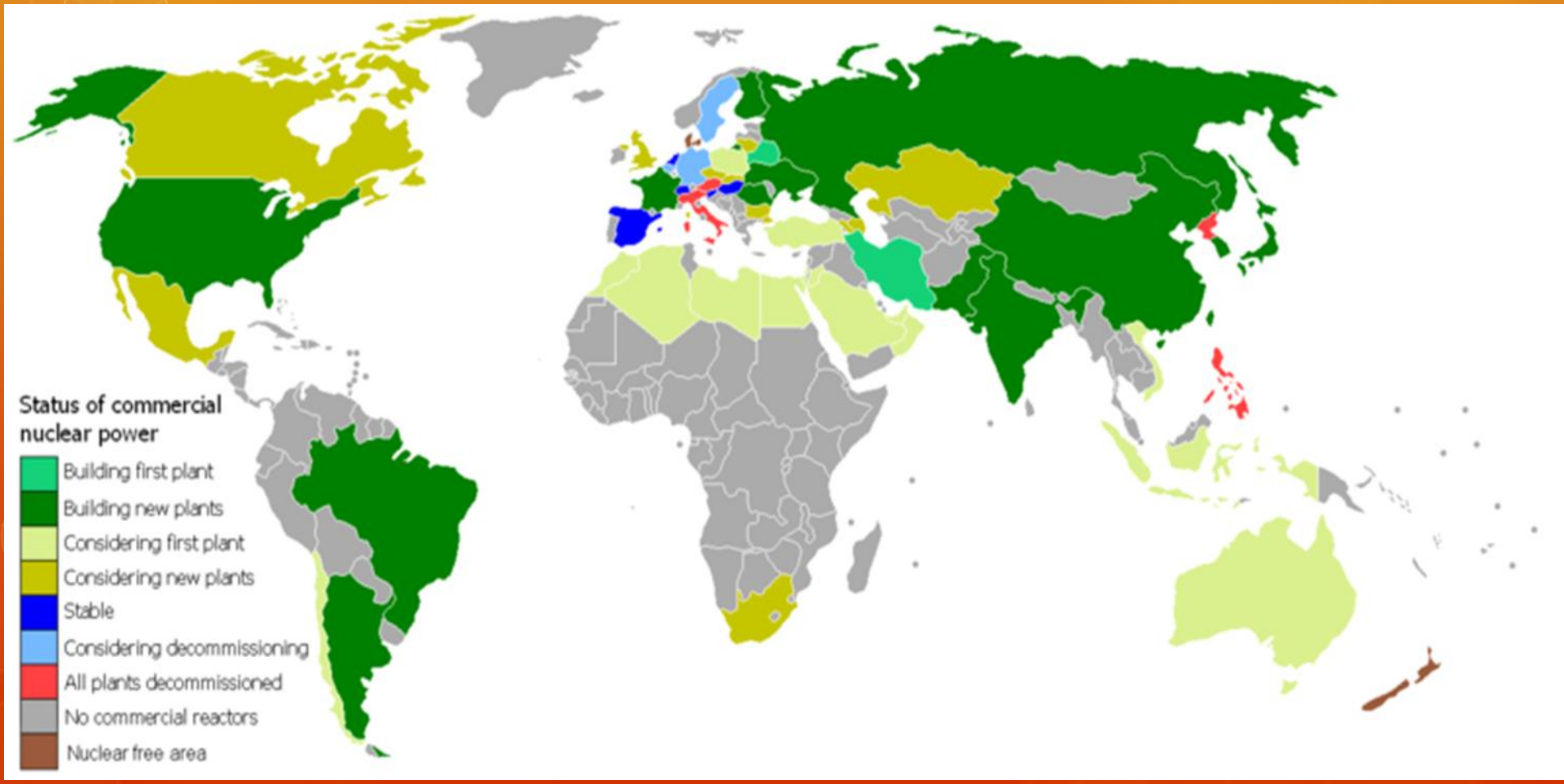


Losses caused by storms

ČR	**Škody** (miliard Kč)	**Evropa**	**Škody** (miliard eur)
Ema 2008	0,5 – 0,8 (odhad)	Ema 2008	0,6 (odhad)
Kyrill 2007	2,2	Kyrill 2007	1,4
Jeanett 2002	0,6	Jeanett 2002	0,9
Lothar 1999	0,8	Lothar 1999	1,1
Lore 1994	0,35	Lore 1994	0,7

Nuclear power plant Temelín

Nuclear energy in the world



Nuclear energy controversy

- Development of nuclear power plants begun in the half of fifties in last century
- First plants (experimental) were built in former USSR (1954) and USA (1956)
- In sixties started further development and construction of industrial nuclear power plants
- In sixties and seventies nuclear power plants were built in many developed countries and the use and further development of nuclear energy was fast
- Unfortunately, one serious accident and one catastrophe in eighties slowed the further development and recent catastrophe in Japan caused further discussions

Nuclear accidents

- First serious accident happened in 1979 in Nuclear power plant Three Mile island in Pennsylvania. The mistake of operators caused partial meltdown of reactor core. Leakage of radioactive elements was very low (mostly radioactive gases), but decontamination of water from reactor containment lasted three years and the costs were high
- The most ”damage” was done by media, which exaggerated the danger, caused panic and rapid runaway of inhabitants. No one was irradiated, only a few panicking aged people died of heart attacks.
- On International scale the accident was counted as level 4 – accident with local consequences

Nuclear disaster Chernobyl 1986

- The first serious nuclear disaster happened in 1986 in Chernobyl nuclear power plant on Ukraine
- The cause was not the technical failure of the equipment, but failure of human factor
- The operators tried some kind of an ”experiment” with reactor, removed control rods
- In a few seconds increased the reactor its output power for thousand times and was destroyed by two explosions
- The fission reaction continued, about one-third of fission products was released into environment
- Forty people died in a few weeks from high doses of radiation, many people have serious health problems
- 30 km zone around Chernobyl was evacuated and is uninhabitable by now

Nuclear disaster Fukushima 2011

- The earthquake in March 2011 created high tsunami wave, which hit Fukushima nuclear power plant (Fukushima prefecture, Japan) and destroyed the power supply of reactors (even backup diesel aggregates were destroyed).
- The cooling water in reactors stopped to circulate, the reactors started to overheat, nuclear fuel melted.
- Although Japanese engineers tried to cool the reactor with seawater, they had only partial success
- A lot of radioactive substances were released to environment, 30 km zone around the power plant had to be evacuated
- The worst problem was that one reactor contained MOX fuel, which contains plutonium, one of the most poisonous elements

Nuclear energy as renewable energy source

- Reaction in breeder reactors:
- $^{238}U_{92} + n \rightarrow {}^{239}Pu_{94}$
- Possible of use of thorium as nuclear fuel – world reserves of thorium are three times higher than of uranium :
- $^{232}Th_{90} + n \rightarrow {}^{233}Th_{90} \rightarrow {}^{233}U_{92}$

Discussion on future of nuclear energy

- Both disasters (Chernobyl and Fukushima) caused discussions and doubts about the security of nuclear energy
- But there are some important facts that should be considered:
- The Chernobyl disaster was caused by operator's error, not reactor equipment failure
- The reactors in Fukushima were built to withstand powerful earthquake. They withstand, but damages were caused by unpredictable tsunami wave
- As an aftermath of Fukushima disaster Germany decided to close all nuclear power plants

Nuclear wastes

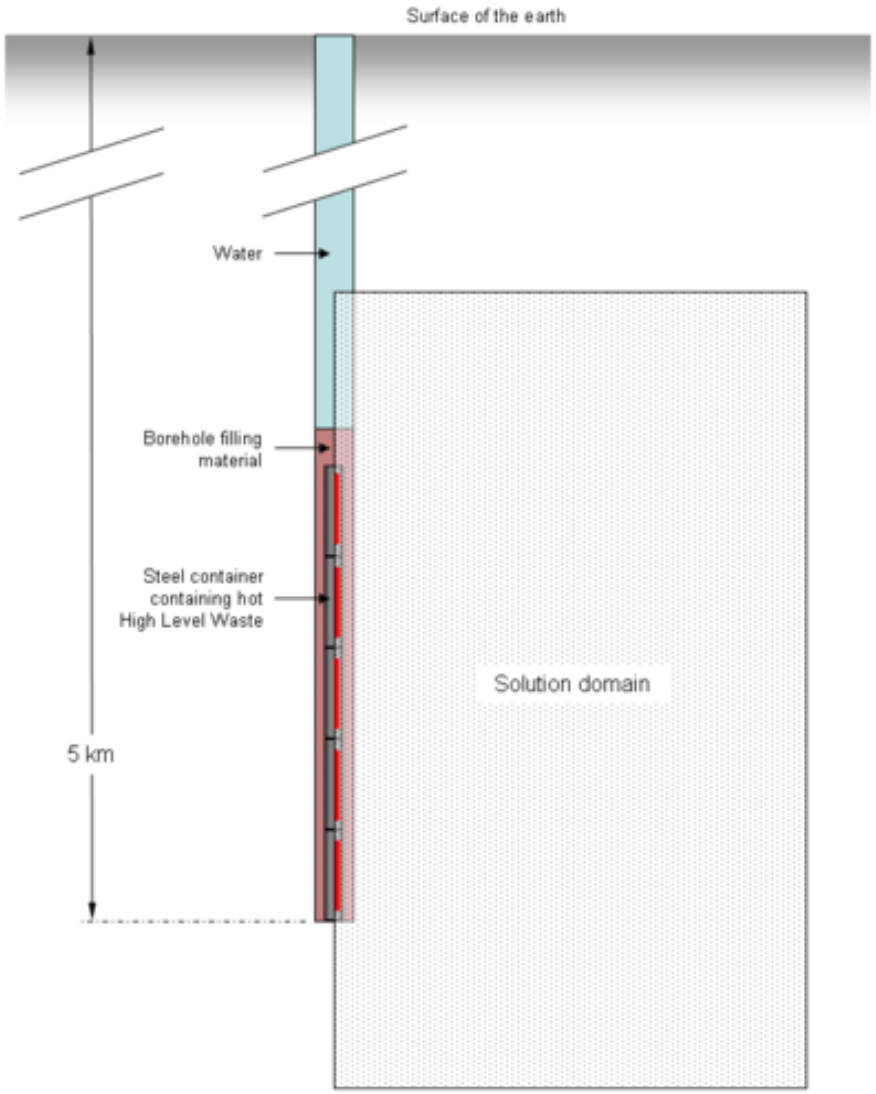
- Nuclear wastes are probably the most sensitive problem connected with the use of nuclear energy
- During the fission processes in the reactor are created new radioactive elements. Some directly by fission, some by absorption of neutron in other elements
- Radioactive wastes contain elements with short half-lives (days to years), medium half-lives (years to thousands years) and long half-lives (tenth of thousands to millions years)
- Most dangerous are radioactive isotopes of elements contained in human body (iodine, strontium)

Nuclear wastes

- The nuclear wastes can be handled in different ways
- Most effective is reprocessing of nuclear fuel. Most of ^{235}U and ^{238}U can be reused, the volume of wastes to be stored is about 95 % lower than if whole fuel rods are stored
- But the most commonly used process is storage of used fuel rods in nuclear power plant for about 30 years and then transferred in special containers to nuclear wastes deposits (for storage or possible future reprocessing)
- But of course, it is difficult to predict what can happen with the deposit in 10 000 or million years

Radioactive wastes

Deep borehole disposal



Container for transport of radioactive wastes

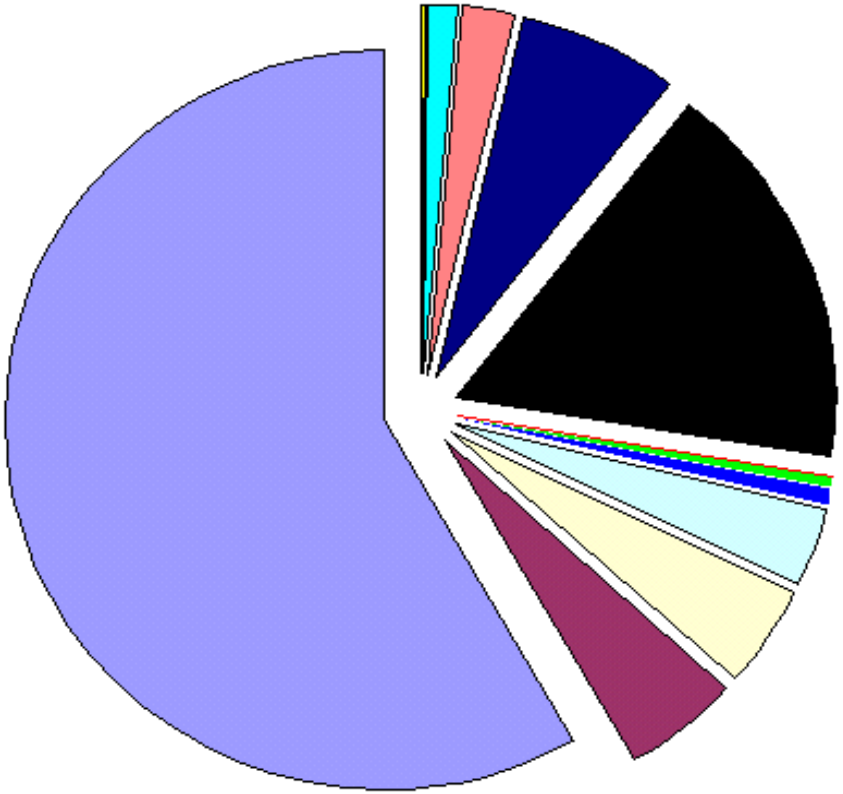
Solar power station

Wind power turbines in Germany on the coast of North Sea

Geothermal power station on Iceland

Biomass combustion, bioethanol production

World Renewable Energy 2005



Large hydro 58.23%	Small hydro 5.12%	Wind power 4.58%	Biomass elec 3.42%
Geothermal elec 0.72%	Photovoltaic 0.42%	Other elec** 0.05%	Biomass heat* 17.08%
Solar heat 6.83%	Geothermal heat 2.17%	Biodiesel fuel 1.21%	Bioethanol fuel 0.16%

Threat for ozone layer

- The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O_3).
- This layer absorbs 97–99% of the Sun's high frequency ultraviolet light, which is potentially dangerous to the life forms on the Earth
- The ozone layer can be damaged (ozone depletion) by some gases, most dangerous are CFC (Freons)
- The freons are very stable from chemical point of view. One molecule of CFC may destroy 30 000 molecules of ozone
- The production of CFCs was limited by Montreal protocol in 1987. But some countries violate this protocol

Threat for ozone layer

- Although the production of some chlorofluorocarbons gases was banned or strictly reduced, some of them are still used
- It takes about 30 years before the molecule of CFC disintegrates in atmosphere (sometimes even longer)
- Some developing countries continue the production of some CFCs which are banned in EU and US
- Possible solution of the problem
- Ban of all CFCs
- Recycling of all fridges, freezers, air-conditions where CFCs are used

Thank you for your attention!