MEMO ON ENERGY REQUIREMENTS, ENVIRONMENTAL CHANGES AND POLLUTION

Dr Michel P. R. Boisson
Editor

This document is based on scientific information and data of which the documents and information are available at Internet, the Monegasque Scientific Centre, the Oceanographic Museum, the laboratory of the AIEA in Monaco, at the Departments of Environment, Urbanism and Construction (DEUC) of Monaco and among the Fire Brigade of Monaco. The conclusions only represent the opinion of the authors and not necessarily those of any official Monegasque, European or international authority.

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ESSENTIAL POINTS

- *The oil driven world economy will expire in the 21st Century, without that viable primary substitute resources are already in place, even not nuclear energy.*
- *One must therefore within some decades expect an increase of economical and political tensions.*
- *The increase of the Carbon Dioxide (CO_2) in the atmosphere will continue during this Century, Kyoto or not Kyoto.*
- *Exploitation, if executed, of the large reserves of tar shales will **seriously** increase the Greenhouse effects!*
- *Currently one must take in consideration a **Double Greenhouse Effect** with a global warming of the total atmosphere of 0.3% per Century with an average increase of the temperature of + 1.4 ^oC per Century. These changes of temperature vary according to the height (cooling of the stratosphere) and the region between -1.7 and + 5 ^oC per Century.*
- *The Double Greenhouse Effect causes locally a chronic increase of climate extremes, which is already taken in account by insurances companies.*
- *These climate changes due to the Double Greenhouse Effect are **irreversible**.*
- *The increase of dissolved CO_2 in the sea will increase the acidity of the marine environment and will reduce the growth of the corals and other calcareous marine species.*
- *The regional changes of rainfall, which vary since the beginning of the 18th Century between -75% and +60% per Century, are rather **independent** of the greenhouse effect.*
- *The problems of drinking water resources, with a global increase of the demand of 80% per Century, will **hardly be solved**.*
- *The ozone holes (O_3) in the stratosphere and the presence of the polluting gazes in the troposphere will persist.*
- *One must still take in consideration the presence in the environment of radionuclides, chemical munitions, pesticides and PCB's.*
- *The Principality of Monaco signed and ratified most international Conventions and Protocols, which concern the environment.*

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INTRODUCTION

In signing and ratifying international environmental conventions and protocols, the concerned States and its diplomats are supposed to be aware of the responsibilities they have accepted as laid down in these conventions and protocols.
It is therefore essential, before entering into these conventions, to judge the interest of the proposed engagements for the improvement of the global environment but also of the constraints that weigh on the States by these conventions.
Monaco as a Member State of the UN, UNESCO, FAO, WHO, UNEP, became in 2004 also Member of the European Council and takes full part in many discussions which concern our global environment. It is therefore more and more committed in proceedings concerning the global environment.
The authors of this small book provide to decision-makers some clear and easily comprehensible answers, based on facts and on their consequences, to numerous questions encountered by the States and their diplomats on the problems of the world environment. It summarizes in the beginning the availability and requirement of primary and secondary energy resources and problems these sources can create to the environment.
This document is based on the knowledge available in Monaco, at the Scientific Centre, at the Oceanographic Museum, at the Laboratory of the marine environment of the AIEA, in the Department of the Environment of the Principality (DEUC) and the Fire Brigade of Monaco. It has as main objective to allow the Principality to adopt, based on known and recognized facts, a prudent and independent environmental policy.

ENERGY REQUIREMENTS OF THE 21st CENTURY

International conventions: *OPEC convention. Kyoto protocol, 1997, to reduce the world emissions of gases causing greenhouse effects,; entry into force February 16, 2005, (non ratified by the United States of America and China).*
Question: Are our near future demands for energy ensured?
Answer: Not really.

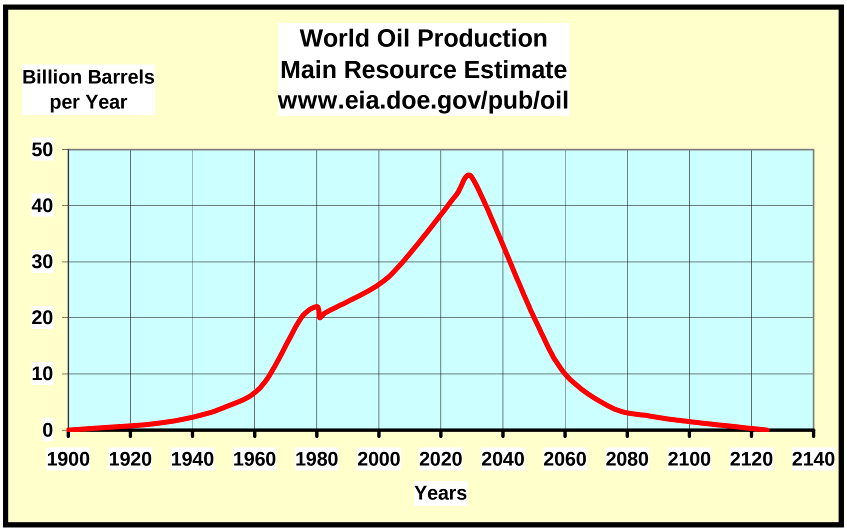

Fig. 1. Evolution of the world production of crude oil based on the official evaluation by the administration American of information on energy (EIA)[1]

[1] EIA, EI30, 1000 Independence Av, SW, Washington DC, 20585, USA, www.eia.doe.gov/pub/oil

Facts:

- Political-economical reasons are probably the cause that the general public is not always informed on the future global lack of fossil fuels and on the uncertainty on the reserves of uranium for nuclear power. Observing the curve on global oil production in **Fig. 1**, it becomes obvious that from 2030 on we will encounter great economical tensions due to the reduction in global oil production. The attitude of the USA not to ratify the Kyoto Protocol is not really illogical, knowing that the problem will anyhow be solved within the 21st Century when these fossil fuels become exhausted.[2]
- There are possibilities of using other energy resources **(Table 1),** but the question is whether research and development will produce results in time?

Consequences:

- It becomes **increasingly urgent to develop other energy sources**, since at present the global needs are mainly based on fossil fuels, hydropower and nuclear power.
- Oil shales could be the next fuel resources, because their reserves are larger than those of oil. The technology to recover organic matter from oil shales requires energy for blasting, crushing, heating to 450 ^{o}C, addition of hydrogen and safe disposal of huge quantities of waste. The several billion dollar attempts of one of the richest shale deposits in the USA was so far unsuccessful and make oil shale an "elusive" energy resource, although the amounts are beyond all known conventional oil reserves.

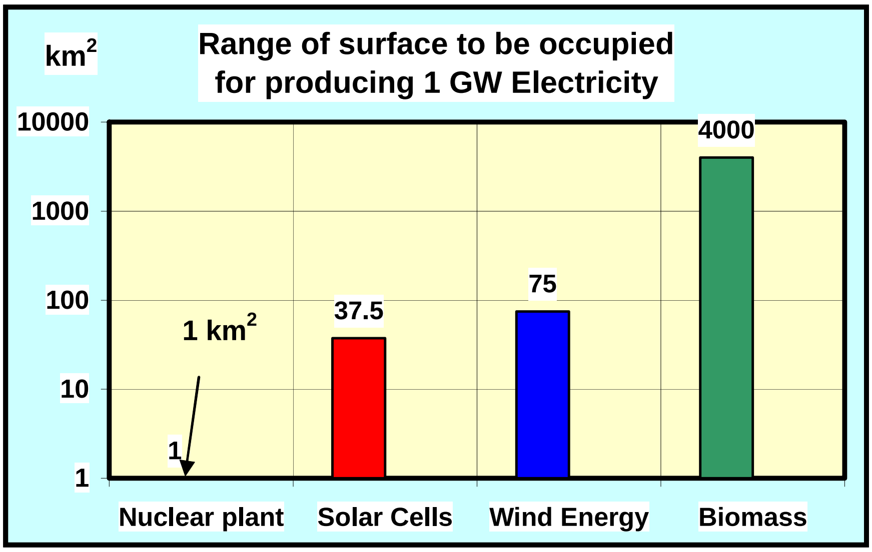

Fig. 2. Surface occupied by the producers of "green energy" in relation to a 1 GW Nuclear Power plant

- There does not yet exist **a breakthrough** for "green" energy resources such as based on, windmills, solar cells and biomass products. These have all their obstacles. For example one 1000 MWe (1 GWe) nuclear reactor produces **(Fig. 2)** the same energy as 25-50 km^2 of solar cells, 50-100 km^2 covered with windmills and 3000-5000 km^2 of biomass plantations[3]. The global need for energy of 20,000 TWh[4] in 2010 in the form of electricity would thus require 75 thousand km^2 of solar cells, 170 thousand km^2 of windmill parks or 9 million km^2 of biomass production. Supposing that windmill parks are composed of one to three lines of windmills with of width of 1 km, this would require a length of 200 thousand km, five times around the earth.

One speaks frequently of the use of hydrogen, of fuel batteries and hybrid systems that are marketed already **(Table 2)**. It is, however these are secondary energy resources, since these require primary energies to produce hydrogen or to nourish the batteries.

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[2] World Energy Council, www.worldenergy.org 2004, 5th floor Regency House, 1-4 Warwick Street, London.

[3] Hans Blix, 1999, Environment, nuclear energy and public perception. In: Environment and Nuclear Energy. Proc. Int. Conference on Environment and Nuclear Energy. Plenum Press, New York, p. 225-230.

[4] TWh = 10^{12} Watt hours

Table 1. Survey of primary energy resources.[5]

Energy Resources	% of World Energy Requirement in 2010[6]	Availability	Exploitation Possibilities and Problems
Coal	36%	Some centuries	Guaranteed but with many casualties and Green House Effects
Crude Oil	7%	End 21st Century	With increasing economic tensions
Oil Shale's, Bitumen and extra-heavy oil	<5% Estonia Canada	Several centuries	Too expensive (450 ^{o}C, Hydrogen, Water and much waste)
Natural Gas	25% Growing	Several Centuries	Many possibilities but also Green House Effects
Uranium		Questionable end 21st Century	Underground resources to exploit
Nuclear Power (Fig. 3)	17%	Stagnation at 441 NPS in 21st Century with about 357 GWe	Urgent need for new technologies and for waste disposal.
Nuclear fusion	In development	A joint project between China, Korea, Japan, Russia, Canada USA and the European Union called ITER[7] (The Way) will be set up in Cadarache, France.	The first 500 MW reactor is expected in 2015. There is no nuclear waste, except Helium at negligible level (< $6x10^{-6}$% per year) compared to Helium in the atmosphere.
Hydropower	16%	Still 30% of its global potential	Region problems to overcome of river ecosystems
Peat	Only in Arctic regions	Limited	Direct heating in few regions
Wood	Limited	Limited	Danger of over-exploitation without renewable foresting
Biomass	In progress	Great potential for engine fuels when fossil fuels are extinct	However requires large surfaces (Fig, 2).
Solar Energy	In progress	Possibilities without limit	However requires large surfaces and new technologies (Fig. 2)
Geothermal Energy	Island	Limited to certain regions	Only in volcanic regions
Wind Energy	up to 20%	Growing rapidly until limits	Requires large surfaces and storage of electricity
Tidal Energy	France	Limited to certain regions	Limited to a few regions with large tidal movements
Wave Energy	None	Not yet well developed	Technically difficult to realize

[5] After World Energy Council, 2004, see note 2.
[6] IAEA, 2004. Energising the future. IAEA Bull. 46, No. 1, p. 10.
[7] ITER was initiated in 1985 by the USA, the Soviet Union, Japan and the EU. The USA left the group in 1998, but signed up again with the other partners in 28 June 2005.

Ocean Thermal Energy	None	Questionable	Technically difficult to realize
Marine Current Energy	None	Questionable	Technically difficult to realize

Table 2. Examples of secondary energy resources [8]

Energy Resources	Availability (depending on primary resources)	Exploitation, Possibilities and Problems
Hydrogen as fuel	In development. Objective: to use renewable resources such as water (electrolysis between 700 et 900 ^{o}C)	Storage at high pressure, as cryogenic liquid hydrogen and in solid materials.
Fuel cells: ❖ hydrogen ❖ biomass ❖ methanol ❖ solid oxides	Can replace the actual combustion systems Direct conversion of "green" hydrocarbons into electricity	Electro-catalyzing materials
Hybrids electrical systems	Use of super capacitors and fuel cells	Applied already for traction

[8] European Commission, 2004. European hydrogen and fuel cell projects. DG Research, EUR 21241, 72 pp.

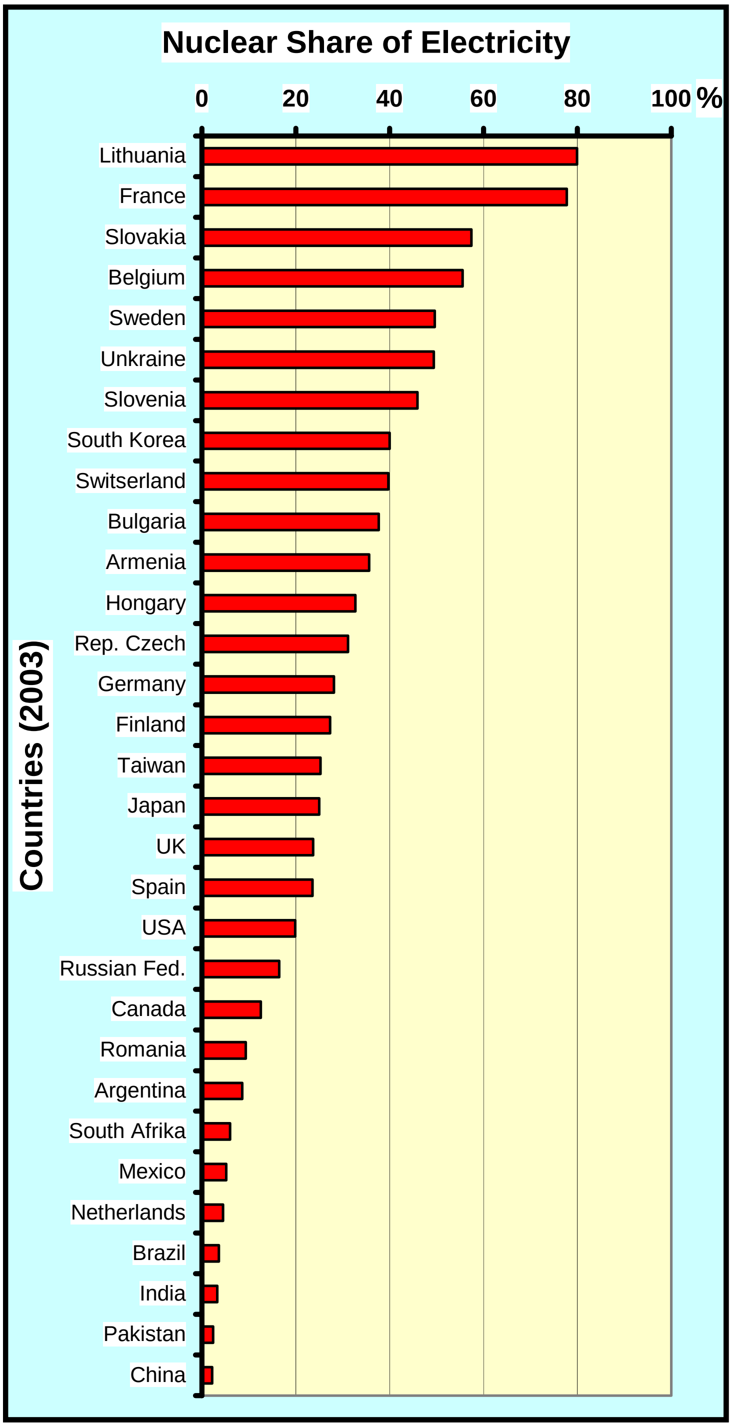

Fig. 3. Percentage of electricity produced by nuclear power in different countries.[9]

[9] IAEA, 2004. Energising the future; the power of innovation. IAEA Bull., 46, No. 1, p. 7.

ATMOSPHERIC CHANGES

❖ **World reserves in Oxygen**[10]

International conventions: None

Question: Will the atmospheric oxygen stock be able to be exhausted by the consumption of the fossil fuels?

Answer: No

Facts:

- The atmosphere contains 1.2 x 10^{15} tons of oxygen (O_2).
- The 20.946 volume % content of oxygen is of an astonishing stability. For example in a closed room of 50 m^3, oxygen is still available at 18 volume %, when 10 persons breathe normally for 10 hours. However, the problem concerns the Carbon dioxide (CO_2) which will increase by a factor of **110** and cause hyperventilation.
- Burning of all terrestrial biomass and humus, will potentially reduce the atmospheric oxygen to only 20.846 volume %, while combustion of all known fossil fuel reserves (estimated in 2000 between 4 and 6x 10^{11} tons of oil[11] will reduce oxygen to only 20 volume %.

Consequences: No problems, at least not for oxygen (see CO_2).

❖ **Carbon Dioxide**

International conventions: *Kyoto Protocol, Into force 16 February 2005.*

Question: Is Carbon dioxide (CO_2) increasing in the atmosphere with dramatic consequences?

Answer: Yes, with some **irreversible** consequences.

Facts:

- Carbon dioxide (CO_2) in the atmosphere has risen from 1930 to 2000 from 0.028 volume % to 0.036 volume %. An increase to rise to 0.4 volume % after exhaustion of fossil fuels.
- Combustion of fossil fuel and vegetation fires contribute for 39% to the increase of (CO_2) in the atmosphere, 31 % is recovered by vegetation growth and 30 % is absorbed by the oceans.[12]
- It will take at least a thousand years before the atmospheric CO_2 is equilibrated with the deep ocean due to its slow internal circulation. This will, however, not reduce the atmospheric CO_2 to less that 0.3 volume %.
- Storage of fossil duel CO_2 is **only** possible by increased **deposition** of calcareous skeletons and humus on land and in ocean sediments. This is impossible to realize, since it would require a similar increased fertilization by nitrates and phosphates of land and oceans.

Consequences:

- **Greenhouse.** A **Double Greenhouse effect** due to an increased capture of infrared light continues to develop (see Climate Changes), which will remain **irreversible** during the next millennia.
- **Acidity of oceans.** An increase of the acidity (decrease of pH = degree of acidity) of the oceans is to be expected, where the pH will decrease from 8.1 to 7.1 until all fossil fuels are burnt **(Fig. 4)**.
- **Reduced calcification in the oceans.** The acidification of the oceans will increasingly hamper the growth of coral reefs and calcareous phytoplankton **(Fig. 5 & 6)**.

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[10] Duursma, E.K. and M. Boisson, 1994. Global oceanic and atmospheric oxygen stability considered in relation to the carbon cycle and to different time scales. Oceanologica Acta, 17, 117-141.

[11] John Wood & Gar Long, 2000. Long term World Oil supply. www.eia.doe.gov

[12] Ibid, note 10.

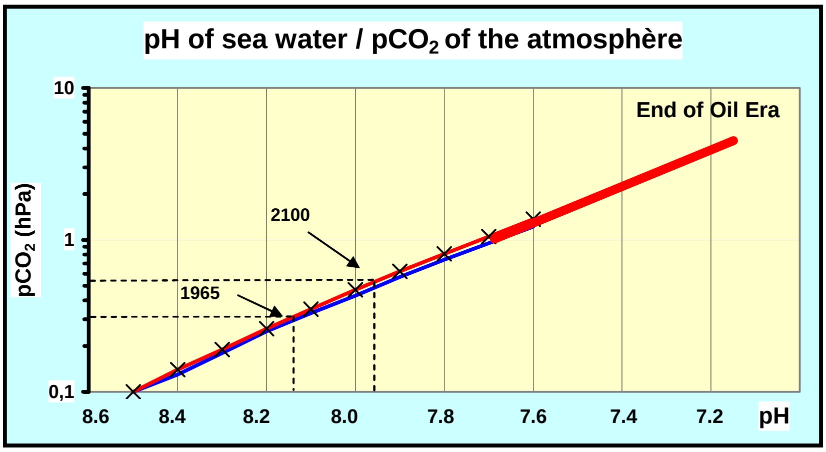

Fig. 4. Correlation of atmospheric pCO_2 and pH in sea water for 4 different temperatures of 0 to 15 °C. The 1965 figure is based on a pCO_2 = 0.3 hPa (mBar), where for the year 2100 the pCO_2 will be raised to about 0.6 hPa and the pH reduced to 7.9.[13]

- **Acidification of the oceans.** An increase of the acidity (decrease of pH[14]) of the oceans is expected. If all reserves of fossil fuels are burnt the pH will decrease from 8.1 to 7.1 **(Fig.4)**.
- **Reduction of the calcification in the oceans.** The acidification of the oceans will increasingly retard the calcification speed of coralline reefs and the calcareous plankton **(Fig. 5 & 6)**.

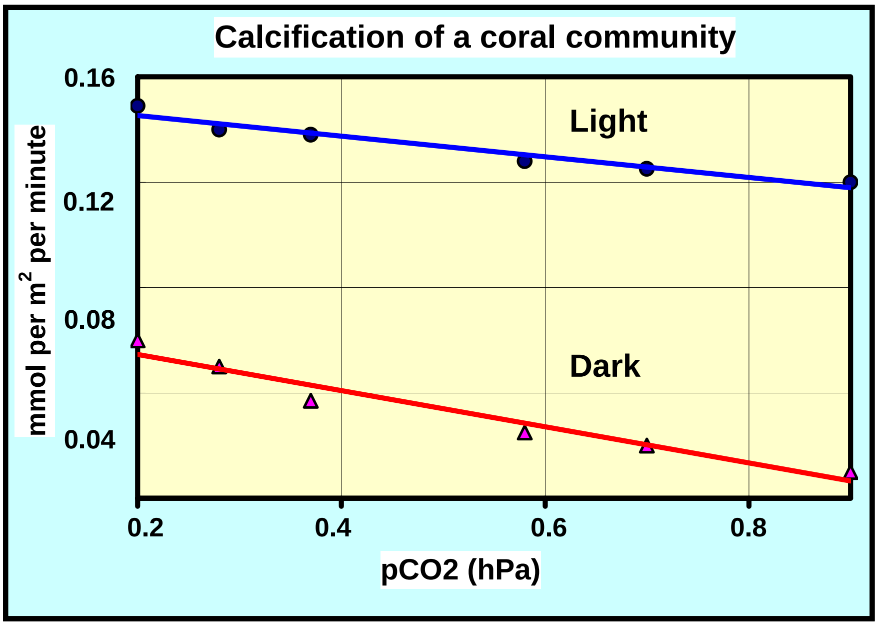

Fig. 5. Due to increased CO_2 in the atmosphere and oceans a reduced calcification of reefs to be expected Leclerq et al., 200). In light: -14% per 100 µatm. In dark: -2.8% per 100 µatm (1 µatm = 10^{-3} hPa = hectoPascal).[15]

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[13] Duursma E.K. and Carroll, J., 1996, Environmental Compartments; equilibria and assessment of processes between air, water, sediments and biota. Springer Verlag, Heidelberg, 277 pp.
[14] Degree of acidity, (pH = 7 is neutral)
[15] Leclerq, N., Gattuso, J-P., & Jaubert J., 2000. CO_2 partial pressure controles the calcification rate of a coral community. Global Change Biology, 6, 329-334. Gattuso, J-P., Allemand, D. & Frankignoulle, M. 1999. Photosynthesis and calicification at celluar, organismal and community levels in coral reefs: A review. Amer. Zool., 39, 160-183.

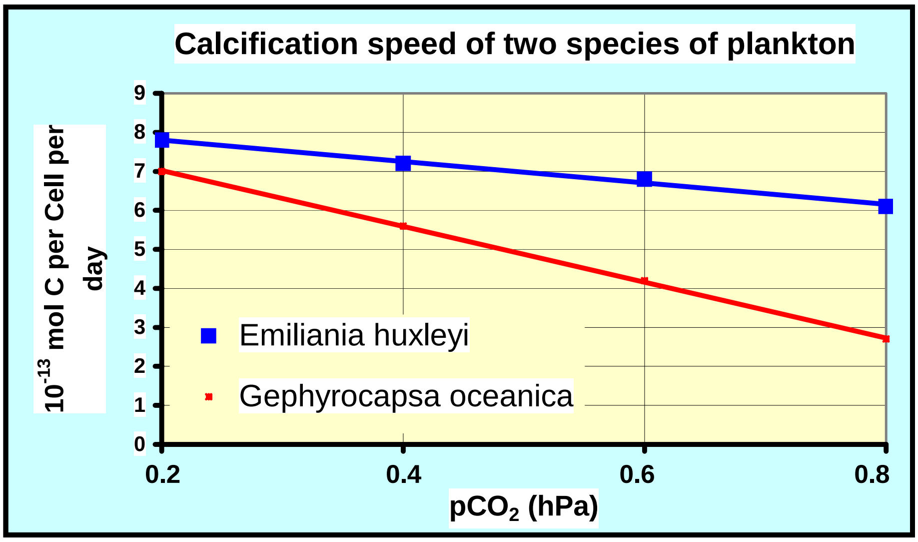

Fig. 6. Ibid for calcareous phytoplankton (Rebesell et al., 2000). *Emiliani huxleyi*: -3.5% per 100 µatm. *Heophyrocapsa oceanica*: -10.7% per 100 µatm.[16]

CLIMATE CHANGES

❖ **Double Greenhouse effect**[17]

Question: Will the greenhouse effect persist?

Answer: Yes, in particular as a **double** greenhouse effect on climate extremes and a possible change of climate in Western Europe.

Facts:

- There exists in the atmosphere a **double greenhouse effect**. One in the lower atmosphere, caused by increased capture of reflected infrared radiation from the earth surface and one above the stratosphere by increased capture of sun infrared radiation. Since the sun radiation is rather stable over the centuries, warming at the earth surface and above the stratosphere causes a cooling in the stratosphere.
- **Global warming** based on temperature data collected for 75 stations up to an altitude of 27 km between Svalbard (Spitsberg) and Antarctica from 1948 on is in average 0.34 ^oC per Century. Compared to the average solar radiation of about 300 W/m^2 received by the earth, + 0.3% of the average received solar radiation of 300 Watt per m^2.is additionally retained per Century by the Greenhouse Effect **(Fig, 7).**
- **Regional warming** ranges for the **total** atmosphere between -3.5 to +35 ^oC per Century (uncorrected) - the last above the stratosphere above Antarctica - or between **-1.7 and +5 ^oC per Century** (corrected to earth surface). The corrected ^oC per Century corresponds to a temperature in/decrease for warming an equal volume of air of 1000 hPa pressure[18]. In general warming is in the troposphere is highest at an altitude of 500 - 1000 m above earth surface and cooling highest in the stratosphere between 16 and 24 km with an average increase of the difference of 1.4 ^oC/Century, standardized at sea level.

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[16] Rebesell, U., Zondervan, I., Rost, B., Tortell, P.D., Zeebe, R.E. & Morel, F.M.M., 2000. Reduced calcification of marine plankton in response to increased atmospheric CO_2. Nature, 407, 364-367.

[17] Duursma, E.K., 2003: Rainfall, River Flow and Temperature profile trends; consequences for water resources. 3rd World Water Forum, Kyoto, Japan. 32 pp + CD-Rom.

[18] Example: The same amount of calories are required to warm 1 m^3 of air of 10 hPa (hectoPascal at 27 km height) **by 35 ^oC** as 1 m^3 of air of 1000 hPa (at earth surface) by **0.35 ^oC**.

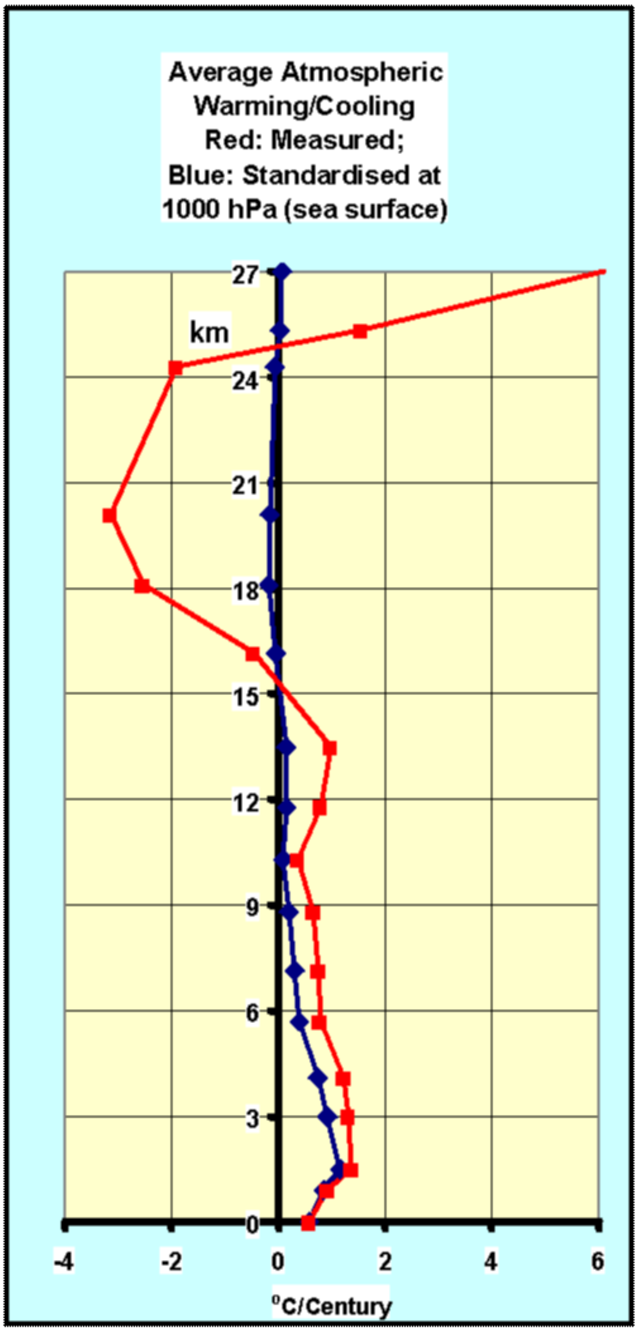

Fig. 7. Average global warming (cooling) trends in °C/Century of the total atmosphere between sea level and 27 km altitude, as determined at 75 locations on all continents and between Spitsberg (Svalbard) and Antarctica since 1948. **Total average** (standardized) is: + 0.34 °C/Century

Consequences:

- ❖ Cooling in the stratosphere and warming of the troposphere will increase the density instability of the atmosphere which will have consequences for those geographical locations **(Fig. 8)** already at risk for natural hazards of storms and hurricanes.
- ❖ A **paradox** of global warming concerns the European climate which might change from a maritime to a more continental one, a situation already experienced during the so-called small ice-ages from 1450 to the end of the 18th Century. Additional warming of the surface waters of polar seas and melting of ice from Greenland will decrease the density of the surface waters and hamper the winter vertical descent of these cooled surface waters which feed the deep-sea counter currents far into the southern oceans. Thus the northern branch of the Gulfstream weakens, resulting in a stagnation of the Great Conveyor Belt. This will reduce its warming effect on the climate of Western Europe.

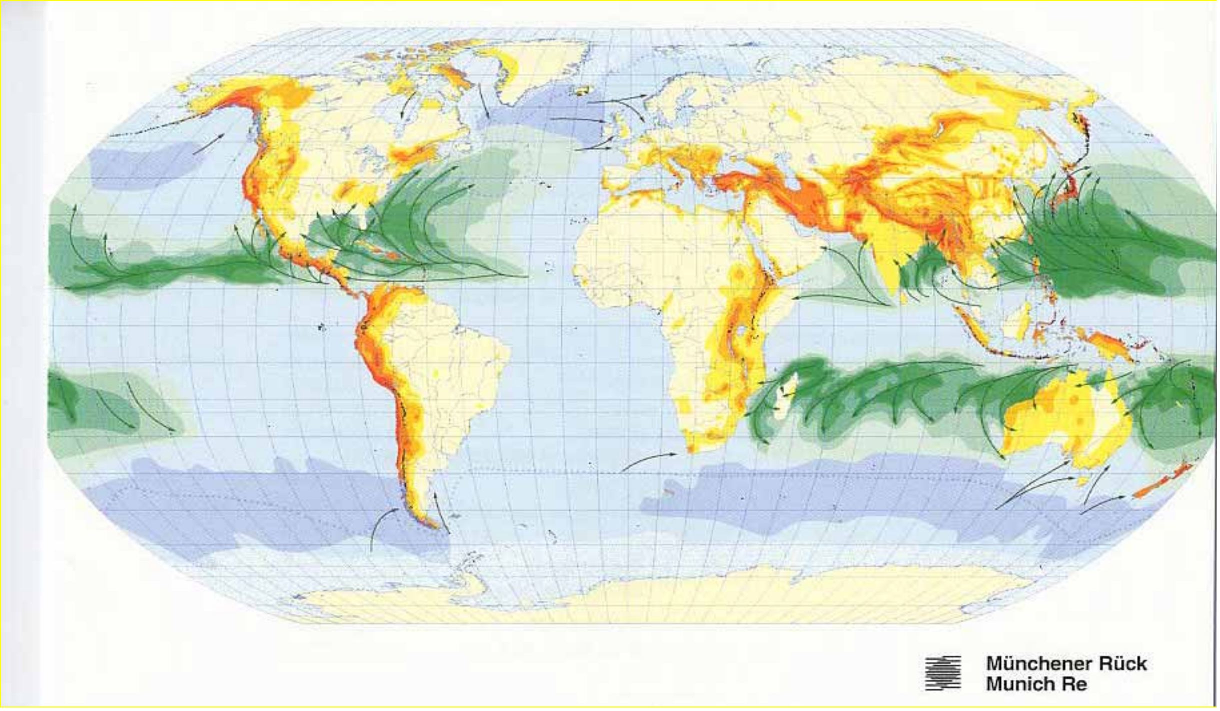

Fig. 8. Regions at risk (**green areas** and **black arrows**) with increased extreme climate conditions. Figure reproduced with permission of Re Munich.

❖ **Rainfall and River flow trends**

Question: Are rainfall and river flow trends related to the Greenhouse Effects?
Answer: Yes, where it concerns local rainfall extremes. **No,** for the existing historical annual rainfall and river flow trends.
Facts:

- Large regional differences in historical rainfall and river flow records, some over three Centuries, demonstrate rainfall trends between +100%/Century to -100%/Century, as observed for 186 geographical locations on the five continents **(Fig. 9)**.[19]

Consequences:

- **Trends.** In general these trends remained the same when the Greenhouse effect started (± 1900)**,** thus showing that desertification and increased flooding are **not** in all cases due to the global warming. Even for the dry period of 2003 in France, dry periods from July to September decreased in frequency from the 18th Century to the 20th Century for Marseille **(Fig. 10)**.
- **Water resources.** The forecast until 2030 of global water withdrawal is estimated at + 80% per Century, whereas the global rainfall for the continents increases less than 8%[20], which is higher than the data from 186 continental stations which gave only a rainfall increase of 1.2% per Century. Therefore, the concern of the 3rd World Water Forum of Kyoto, 2003 was quite justified.[21]

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[19] Duursma, E.K., 2003. Rainfall, River Flow and Temperature profile trends; consequences for water resources. 3rd World Water Forum, Kyoto, Japan. (Eds: P.W. van Oeveren,Th. A. de Man, S.W. Montijn) 32 pp + CD-Rom.
[20] Semenov, V. and Bengtson, L., 2000. Secular trends in daily precipitation characteristics: greenhouse gas simulation with a coupled AOGCM. Report 131. Max Planck-Institut für Meteorologie, Hamburg.
[21] Source: Zebedi, H., (ed.), 1998. Water, a looming crisis. UNESCO-IHP-V, No. 18, p. 10.

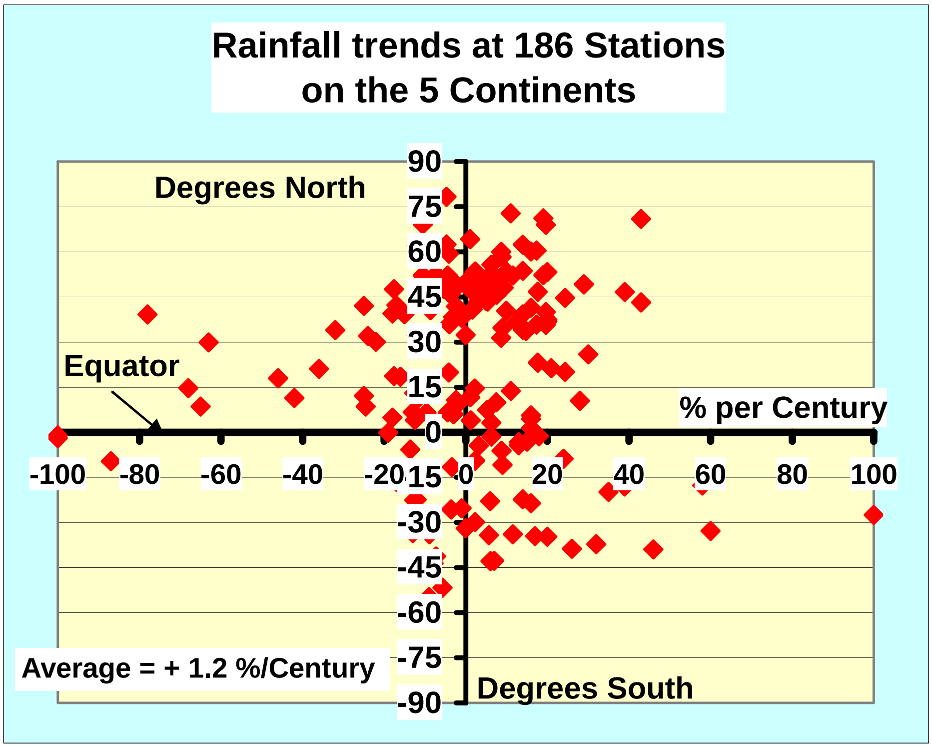

Fig. 9. South-north rainfall trends in percentage per Century for the continents America, Europe, Africa, Asia and Australia, based on rainfall records from 186 stations, the oldest from 1707 on (Note 19).

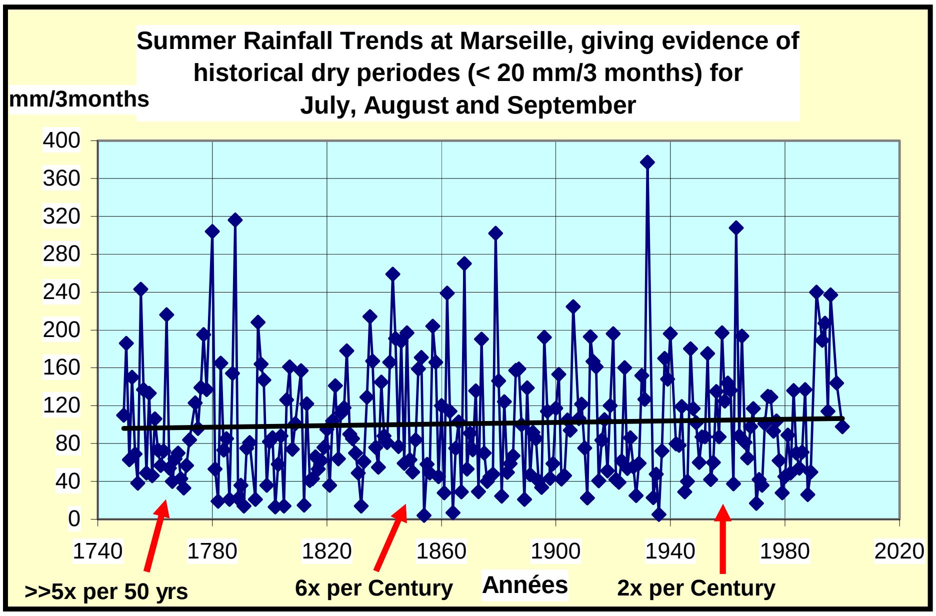

Fig. 10. One cannot conclude from the heatwave of 2003 that the greenhouse effect will give more heatwaves in the 21st Century, because since the time of King Louis XV (1740) the number of heatwaves (with rain << 20 mm) in summer decreased.

❖ **Glacial periods**

Question: Will there be a new glacial period?

Answer: No, not for the next millennium[22].

Facts:

- In the last million years, glacial periods of 90,000 years have interchanged with warmer interglacial periods of 10,000 years.
- Our actual interglacial period *(Holocene)* has lasted already more than 10,000 years. However, the change from the present interglacial warm period to a new glacial period is less evident.

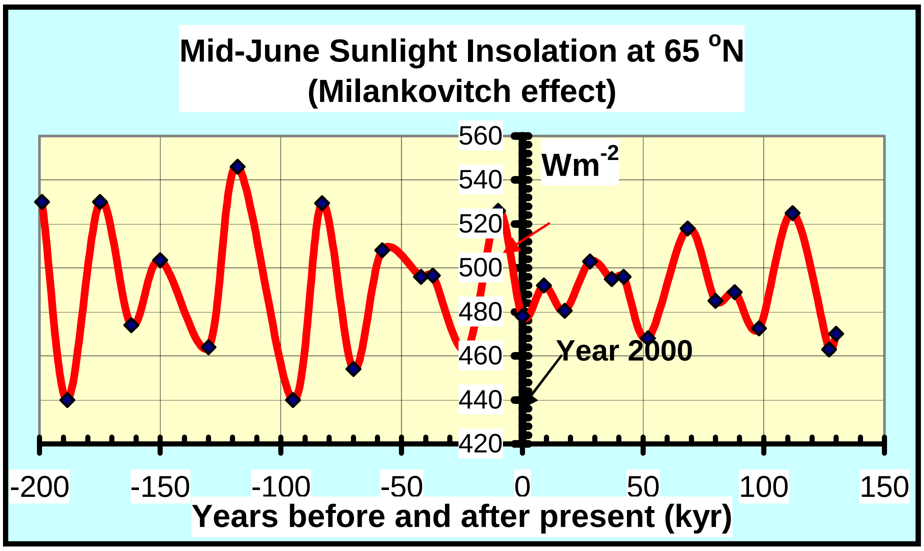

Fig. 11. Mid June solar insolation received by the atmosphere at 65 °N.

Consequences:

- The forecast for the next 50,000 years shows less variation in sunlight than during the previous 50,000 years **(Fig. 11).**
- Thus with the changes to be expected by the greenhouse effect in the next millennium, any change due to glacial-interglacial cycle can be noticed.

GLOBAL AND REGIONAL POLLUTANTS

❖ **Stratospheric Ozone holes**

International conventions: *Montreal Protocol 1987: international agreement on prohibition of the production and use of ozone-depleting halogenated chemicals (ODPs), mostly Freon-like halogenated compounds (CFCs). Into force 1 January 1989.*[23]

Question: Will ozone depletion in the stratosphere continue?

Answer: Yes, at least during this century with consequences for increased UV irradiation.

[22] Loutre, M.F. and Berger, A., 2000. Future climatic changes: are we entering an exceptionally long interglacial? Climatic Change, 46, 61-90.

[23] The Montreal Protocol requires that globally these substances should be substituted by carbon-fluorine-chlorine compounds containing less chlorine and more fluorine. Cessation of the CFC production is accepted for developed countries, with a delay is given up to the early 21st century for lesser developed countries.

Facts:

- Ozone holes are caused by 8 million tons of ozone-depleting halogenated chemicals (ODPs), mainly chlorine-fluorine-carbons (CFCs). They were released into the atmosphere since 1940, mainly from old cooling equipment compressors and spray bombs.
- At altitudes of between 15 and 20 km, the ozone hole may reach a size comparable to that of Australia. Since 1 chlorine atom of CFC can catalyze the destruction of as many as 500,000 ozone molecules, the ozone layer is depleted in spring.
- Since 1980 an increase of the UV-B radiance has been observed at the "Junfraujoch" 3576 m[24] in relation with a decrease of the total ozone in Arosa, Switzerland (1850 m) between 1926 and 1997.[25] Since this date the level of the UV-B has stabilized.[26]

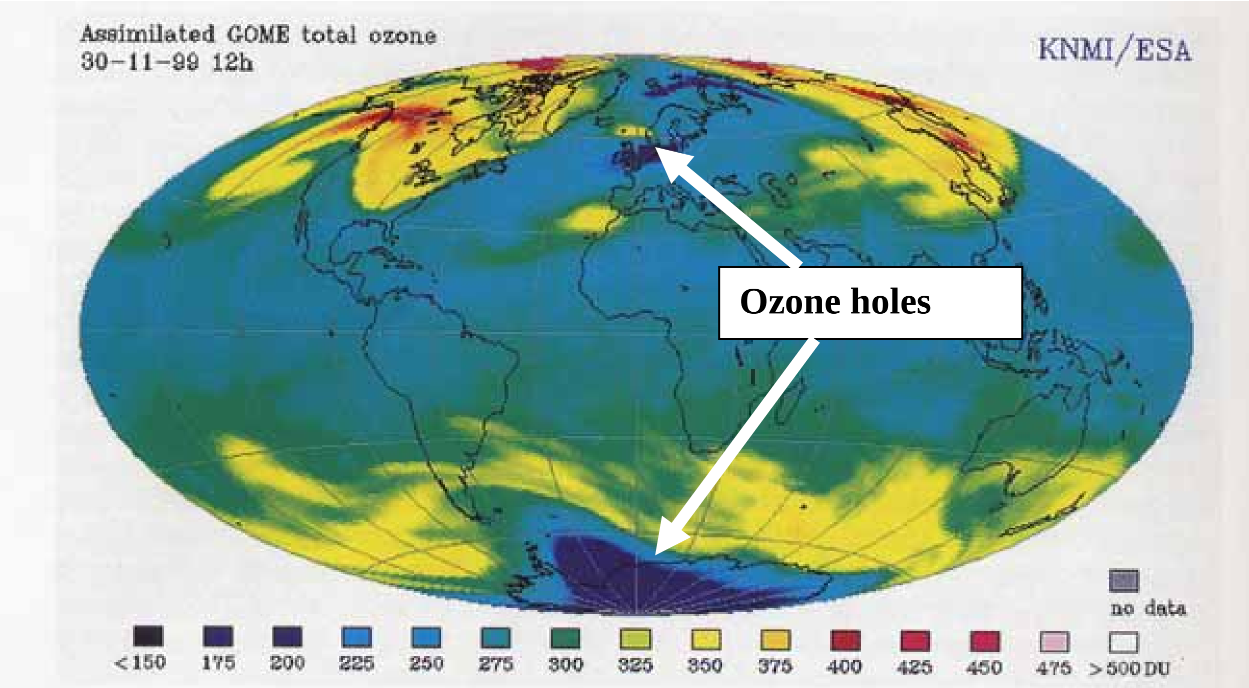

Fig. 12. GOME (Global Ozone Monitoring Experiment) total ozone values for 30th November 1999. Note the ozone depletion (dark-blue colour) above NW Europe and Antarctica. Figure reproduced by courtesy of the European Space Agency (ESA).

- The CFCs in the atmosphere will gradually disappear in the 21st and 22nd Century.
- The stratospheric ozone holes happen to take place in spring above Antarctica and sometimes above the Artic and Europe **(Fig. 12).**

Consequences:

- **UV irradiation and human health**

Although dermatologists have noticed an increase of *melanoma* skin cancers during the last decade(s), with a higher figure for people living in temperate climates, it is difficult to obtain concrete data to relate these figures to the increased doses of UV-B due to ozone depletion only, due to increased tourism, sun bathing and the better application of sun-protecting crèmes. In North America skin cancer is increasing (110 % between 1972 and 1988), far more than would be expected from increased exposure to solar UV-B **(Fig. 13**).

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[24] Ambach, W. and Blumthaler, 1991. Further increase in Ultraviolet B. The lancet, 388 & 393.
[25] After Dr. J. Staehelin, Institute of Atmospheric Sciences, Zurich, Switzerland.
[26] Blumthaler, M., 2005, personal communication.

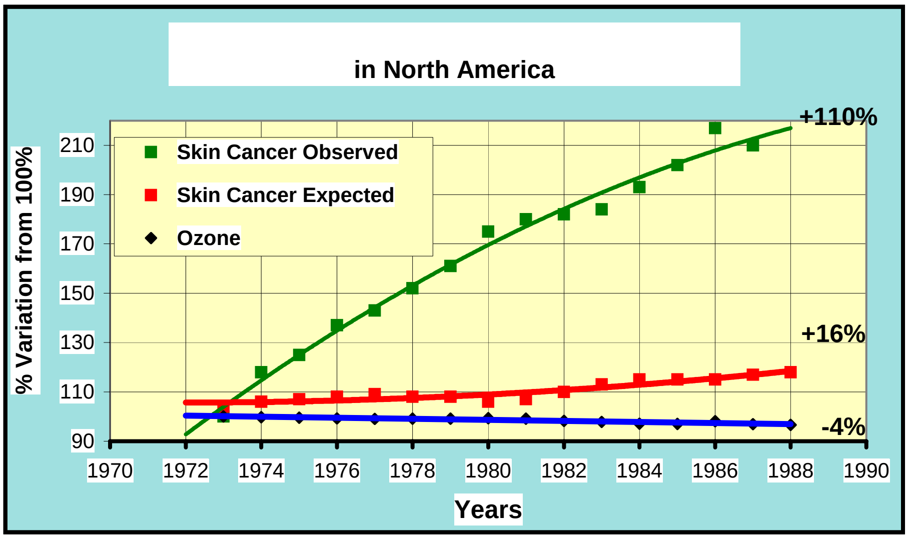

Fig. 13. Evolution of the number of skin cancer cases observed **(green)** in relation to those foreseen **(red)** based on the reduction of the ozone layer **(blue)**.[27]

❖ **Tropospheric Ozone and air pollution**

International Conventions: *Stockholm Convention on Persistent Organic Pollutants: Into Force 17 May 2001.*

Question: Is our lower troposphere increasingly contaminated?

Answer: Yes, atmospheric pollution is still of large concern. Many measures have been taken, but persistent high levels of pollution exist under special climate conditions in heavy populated regions.

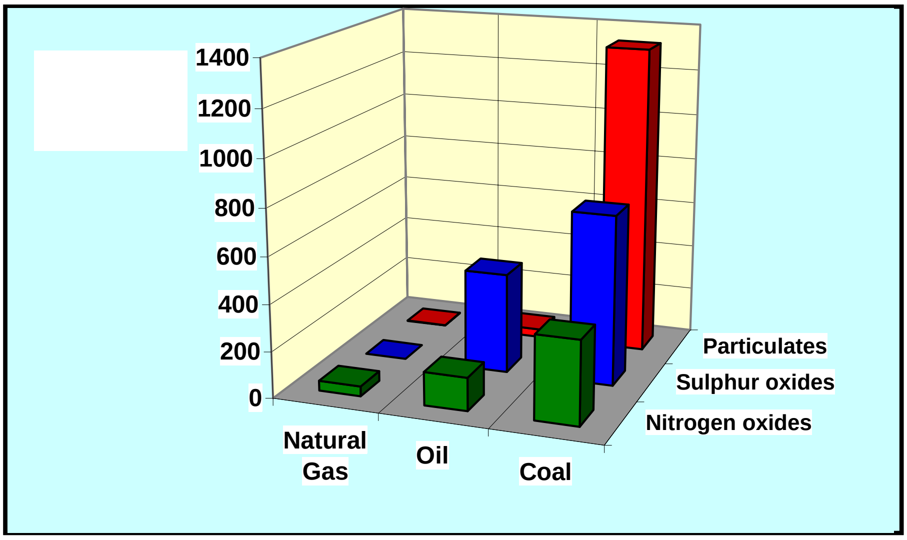

Fig. 15. Air pollution with Nitrogen oxides, Sulfur oxides and particulates by three conventional fossil energy resources. [28] (TJ = Tetra Joules)

Facts:

Under low wind conditions major large towns in the world are suffering from several degrees of air pollution, caused by releases of gases from industrial and traffic burning of fossil fuels **(Fig. 14)**, such as:

- Nitrogen oxides usually given as NO_x
- Sulfur oxides, in particular SO_2
- Carbon mono-oxide (CO), produced by incomplete burning

[27] Kane, R.P., 1998. Ozone depletion, related UV-B changes and increased skin cancer incidence. Int. J. Climatol., 18, 457-472

[28] Marmentauc, C., 2004. Conférence du Service de l'Environnement de Monaco.

- Due to these gases and under the influence of ultra violet light and catalyzed by the NO_x molecules Ozone (O_3) is formed, and
- Dust.

Consequences:

- The effects are for ozone, nitrogen oxides and sulfur oxides of reparatory nature, such as coughing, migraine, ocular irritation (O_3), oedema pulmonary (SO_2), chronical respiratory illnesses (NO_x), poisoning (CO**) (Table 3).**

Table 3. Results of epidemiological studies in Paris (ADEME and ESPAC (ERPURS), 2005):[29]

NO_2 mounts from 22 to 122 µg/m^3	**O_3 mounts from 3 to 103 µg/m^3**
+ 17% hospitalization for Asthma + 63 % medical visits for Asthma |+ 20% reduced working	+ 20% hospitalization of aged people for chronic respiratory illnesses + 25% visits at home for respiratory illness with children
SO_2 mounts from 7 to 106 µg/m^3	**Dust mounts from 11 to 111 µg/m^3**
+ 10% death due to cardio-vascular causes +15% hospitalization of children for Asthma + 22% stop of work	+ 6% death due to cardio-vascular causes + 17% doctors visits for head aches + 20% doctors visits for Asthma

❖ **Radioelements (Radionuclides)**

Conventions: *Non-Proliferation Treaty (NTP): Into force 5 March 1970. OSPAR Convention. Into Force: 25 March 1998.*

➢ **Fallout**

The largest global contamination with radionuclides of the atmosphere, oceans and land, occurred between 1946 and 1963 due to bomb tests in the atmosphere **(Fig. 15).** In total about 175 megatons of nuclear devices contaminated the complete atmosphere much larger than the Chernobyl accident of 1986. Since each nuclear fission explosion produces a spectrum of radioactive nuclides, human contamination by radionuclides with short half-lives such as iodide-131 are most dangerous in the neighborhood of the explosions. Contamination at distance occurs from fallout from the atmospheric with medium half-life radionuclides such as Cesium (^{137}Cs) and Strontium (^{90}Sr). In total we receive about 2000 µSv (200 mrem) radiation per year from different sources **(Table 4).**

[29] Source: ADEME et ESPAC (ERPURS).

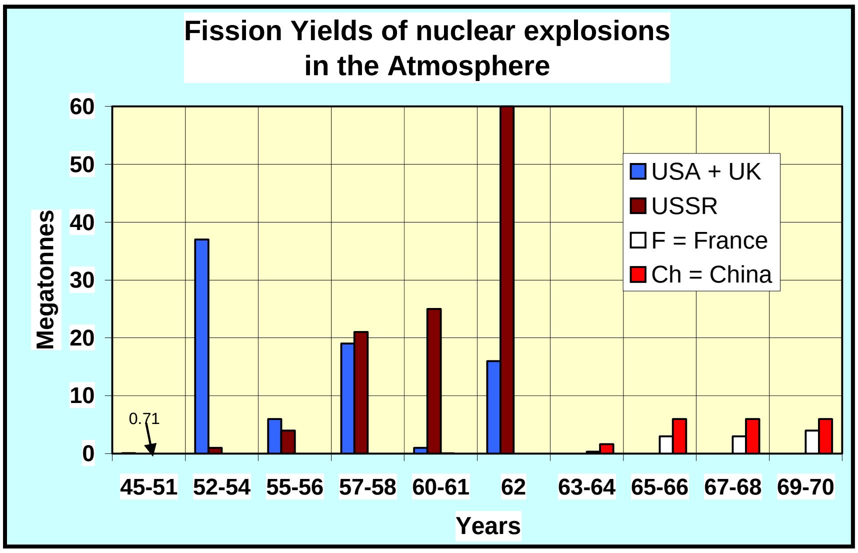

Fig. 16. Fission yields of nuclear explosions in the atmosphere by different countries.[30]

Table 4. Human received natural and ingested radiation in Western Europe. In comparison, 2 weeks after Chernobyl about 3 mrem (30 µSv) was received.[31]

Cosmic rays	**Housing**	**Inhalation and ingestion**	**Air traffic (as passenger)**	**Roentgen control**	**Colour TV**
300µSv /year	**350 µSv/year**	**1350 µSv/year**	**5 µSv/year**	**300-600 µSv/ test**	**10 µSv/year**

- Globally man receives from ^{137}Cs 0.03 µSv from fish and 0.002 µSv from shellfish. This is negligible as compared to the natural radionuclide ^{210}Po, which is 2.1 µSv for fish and between 2.8 and 7.2 µSv for shellfish.[32]

➢ **Ultimate storage of radioactive waste**

- The use of the nuclear energy by fission, requires an ultimate storage of high level radioactive waste for centuries to come. The best solution is the storage in rocky formations proposed by Sweden **(Fig. 15)**.

➢ **Radioactive effluents**

- Low-level liquid waste of reprocessing plants is usually discharged into the sea under controlled conditions. The data about the distribution of the nuclides in the sea have to be monitored continuously and should never mount higher than the levels authorized. These levels are based on the ICRP (International Commission on Radio Protection) rules. This is the case for the two European reprocessing plants in La Hague, France and Sellafield, UK. All information is available (IAEA, 2004) and through the French and UK atomic energy agencies.

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[30] Duursma, E.K., 1972. Geochemical aspects and applications of radionuclides in the sea. Oceanogr. Mar. Biol. Ann. Rev. 10, 137-223 (revue extensive de littérature).
[31] Modern dosage of radiation is given in Sievert (Sv) where 1Sv = 100 rem (radiation effect man).
[32] IAEA, 1995. Sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity (MARDOS). IAEA-Tecdoc-838, 54 pp.

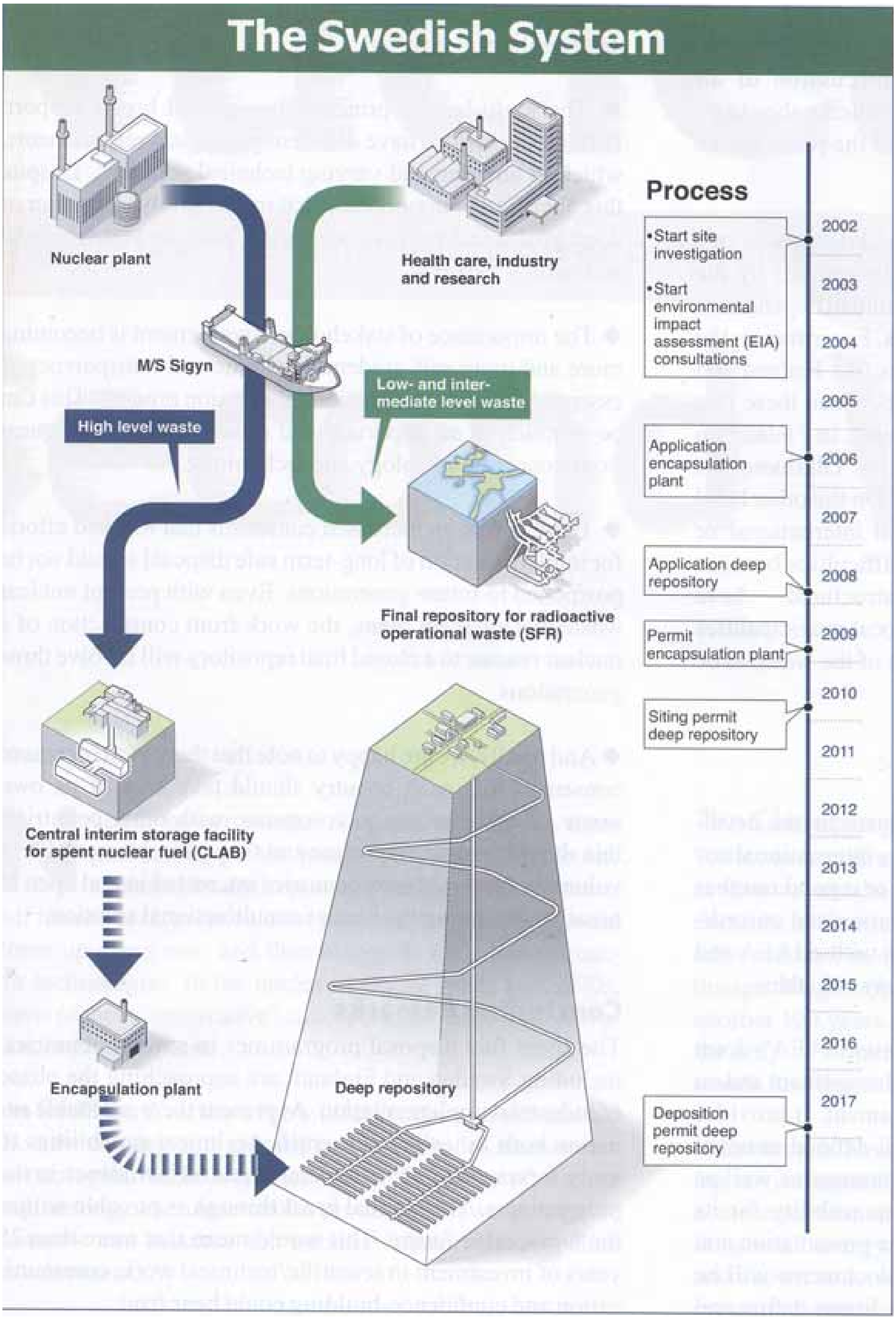

Fig. 16. The Swedish plan of storage of low and high level radioactive waste Reproduced with permission of the AIEA.[33]

[33] Thegerström, C., 2004. Down to earth and below. Sweden's plan for nuclear waste. IAEA Bulletin, 46/1, 36-38.

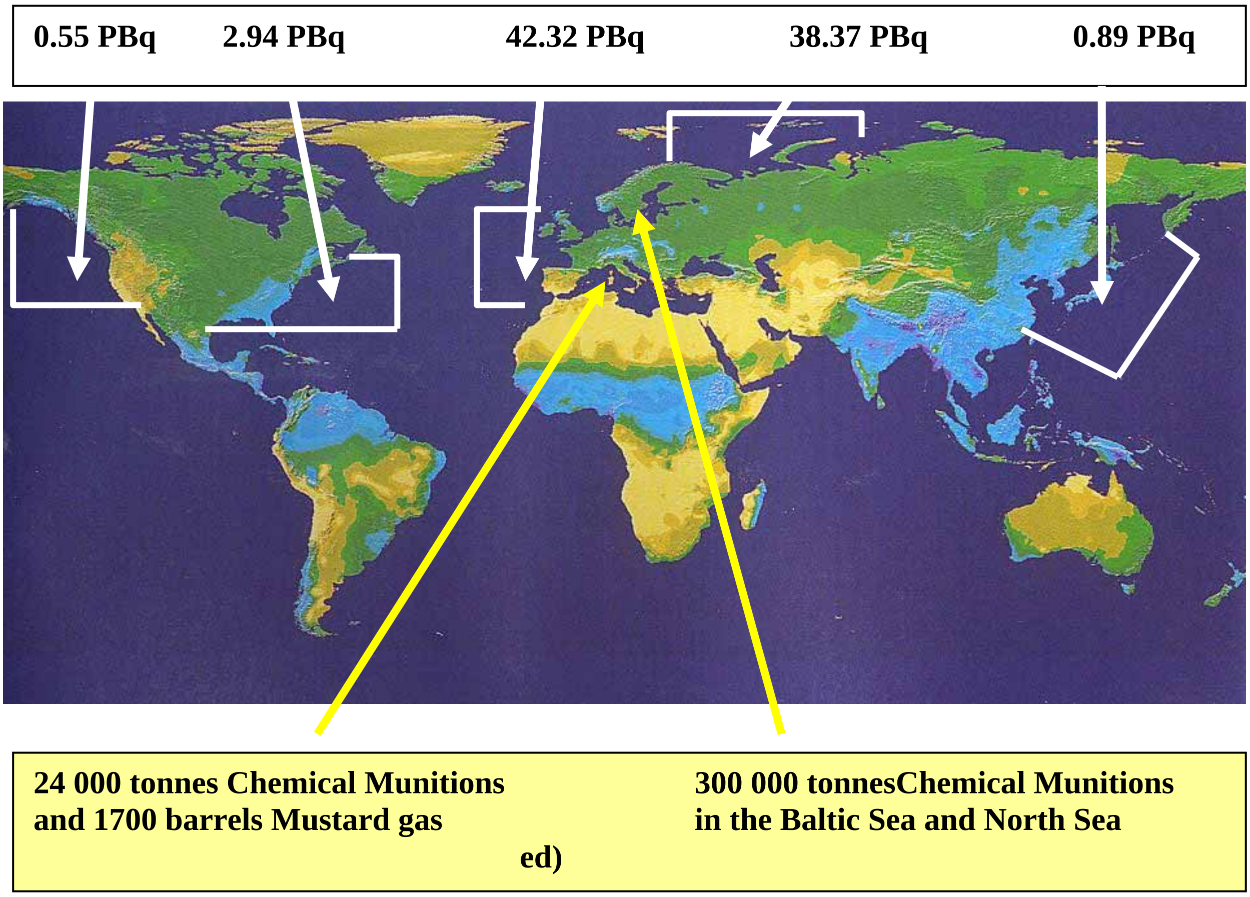

Fig. 17. Locations in the oceans of the zones of discharge of radioactive solid waste and chemical munitions of European origin.[34] (1 PBq = 10^{15} Bequerels; 5 gram of Mustard Gas is léthal for man).

❖ **Dumping of dangerous substances in the sea**

Conventions etc.: *IAEA, 1993. Resolution LC.51 (16): Report of the 16th Consultative Meeting of the contracting parties to the Convention on the Prevention of Marine pollution by Dumping of Wastes and Other Matter. LC 16/14, IMO, London.*

➢ **Low-level solid radioactive waste**

- Total prohibition of radioactive waste disposal at sea came into force on 20 February 1944. From 1946 - 1993 approximately 85 PBq (85 thousand TBq) had been dumped by 12 countries, either alone or together **(Fig. 17).**[35]

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[34] IAEA, 1999. Inventory of radioactive waste disposals at sea. IAEA-TEDOC-1105, 121 pp. Duursma, E.K. (Ed./co-author), 1999. Dumped Chemical Weapons in the Sea - Options. Dr.A.H.Heineken Foundation for the Environment. 60 pp. Etienne, J.-L 1999. La Mer en danger. Paris Match 15 avril 1999.

[35] 1 TBq = 10^{12} Bequerel; 1 PBq = 10^{15} Bequerel. IAEA, 1999. Inventory of radioactive waste disposals at sea. IAEA-TECDOD-1105, 121 pp.

➢ High-level radioactive waste

- Dumping of high-level radioactive waste in the oceans has not been taken place with the exception of 90 PBq of spent nuclear fuel and entire nuclear vessels, dumped by the former Soviet Union in the marginal Arctic Seas, of which for 95% in the Kara Sea[36].
- A study project, called SEABED, had been set up by a number of nations members of four international organizations: IAEA, NEA, the CE, and the CMEA (Council for Mutual Assistance), (1981-1984)[37] to study ultimate disposal of high-level nuclear waste in the sea bottom of the North Atlantic. Although it would be safe to leave containers (a kind of torpedo) under a layer of 30-60 m deep in fine clay sediment (Duursma et al, 1983), the techniques to dispose these containers were unsafe. Due to a growing political pressure to keep the Oceans free of disposal of any type of waste, the project was abandoned.

➢ Chemical Weapons

Convention: *Convention on the non proliferation of chemical weapons (Paris January 13, 1993), the OPCW Convention).*
Question: Are we convinced that of the chemical munitions dumped in the sea after World War II are safely stored?
Answer: Not really. After the War the dumping of German stocks of chemical weapons into the sea was the surest method to neutralize them. However, leakage of Mustard gas from corroded bombs and grenades have and may produce serious accidents **(Fig. 18)**.
Facts:
We inherited from World War II a great deal of the chemical munitions of which Germany deposed in 1947 amounting to the total 300.000 tons of bombs and grenades (clean weight of 65.000 tons).

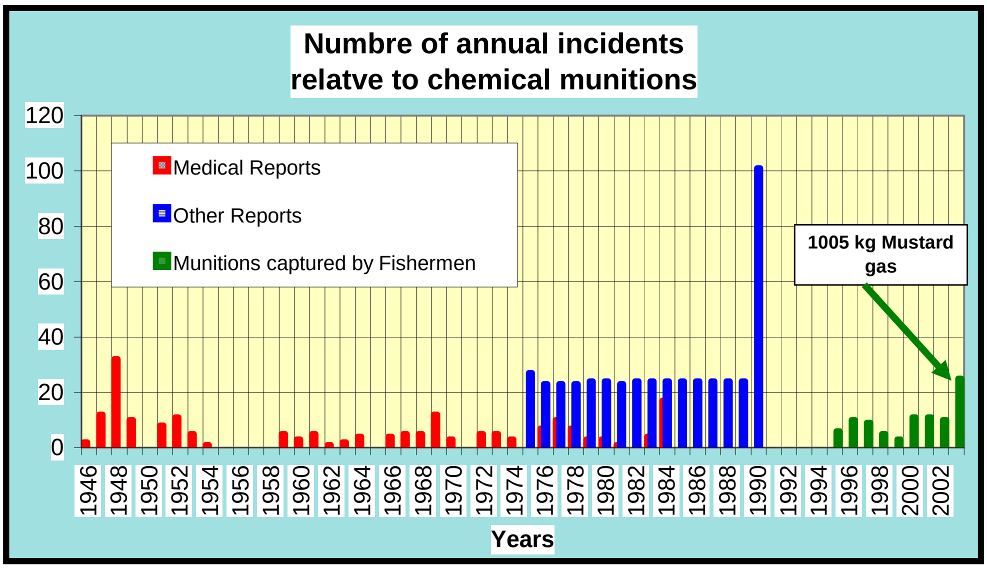

Fig. 18. Number of incidents due to chemical munitions dumped in the Baltic and North Sea, mentioned in the medical reports and by the Commission of Helsinki (2004).

[36] IAEA, 1999. Radioactivity in the Arctic Seas. IAEA-TECDOC-1075.
[37] Four international organisations: AIEA, NEA, the CE, and the CMEA (Council for Mutual Assistance).
E.K.Duursma, L.A. van Geldermalsen and J.W.Wegereef (1983). Migration processes in marine sediments caused by heat sources: simulation experiments related to deep-sea disposal of high level radioactive wastes. European Appl. Res. Rept.-Nucl. Sci. Technol. 5, No. 3, pp. 451-512.

- These have been dumped by the allied forces in the Baltic and North sea **(cf. Fig. 17)**.[38]
- The sites, non confirmed officially, exist in Mediterranean, off Saint-Rafael (24.000 tons) and off the Italian coasts (1700 barrels of mustard gas)[39] **(Fig. 18)**; 0,1% of these last ones contain a volume of gas potentially lethal for 50 thousand people.

Consequences:

- These munitions corrode and the principal danger is the liberation of large quantities of mustard gas lumps which are resistant to sea water that can be transported by the currents toward fishing regions and beaches. Some techniques are now available to prevent these leakages, but have not been applied yet, for example: the sacophaging of ship wrecks loaded with these munitions with gravel, or to cover loose bombs and grenades with a thick layer of marine sediment, allowing the mustard gas to escape in its molecular shape, which quickly hydrolysis in sea water.
- The coastal authorities of the dump sites of chemical munitions (North sea and Sea Baltic) or (Mediterranean; not officially confirmed), are **legally responsables**[40] of the setting up of emergency plans and of facilities for decontamination, identical to those used against fire. The national authorities are in principle obliged to monitor the dumping and to apply the best available techniques for avoiding a pollution by these substances.[41]

❖ **Pesticides and others: Global distribution of DDT and PCB's**

Convention: *Stockholm Convention on persistent organic pollutants (POPS: Into force 17 May 2004.*

Question: Does there exist a global contamination of DDT and PCB, and at what risk?

Answer: There exist indeed a global contamination at a very low level of DDT and PCB, but the remaining PCB stocks should be kept under control and destroyed.

Facts:

- Although the production and application of the pesticide DDT (Cl-Phenyl-$HCCCl_3$-Phenyl-Cl) has been banned since several decades, DDT and its derivatives (ΣDDT) have **not** disappeared.[42]
- Due to its environmental persistence, a global equilibrium (1996 data) is established between ΣDDT in the atmosphere (190 ton), ΣDDT in the Ocean surface waters (530 ton) and in **all** living organisms, including man.
- We all contain an almost stable content of about 1 mg ΣDDT per kg fat, as determined in body fat and mother's milk in the Netherlands, Kenya, Brazil and Germany. The same content is found in fat of the mussels around South America.
- This demonstrates that after an initial food-chain uptake, the final distribution and equilibrium are controlled by ΣDDT in the atmosphere in exchange with water of the oceans and fat in organisms.
- PCB (chlorinated bi-phenyl), a non-inflammable oil[43], has later been banned, with the burden to destroy the world- stocks of this very stable and toxic product.

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[38] The official opinion of the Baltic States concerning dumped chemical weapons is given by the Ad Hoc group on Chemical Munitions (HELCOM CHEMU) of the Environment Commission of the Baltic Sea (Helsinki Commission). See: Duursma, E.K. (Ed./co-author), 1999. Dumped Chemical Weapons in the Sea - Options. Dr.A.H.Heineken Foundation for the Environment. 60 pp.

[39] Paris Match, 15 April 1999.

[40] Duursma, J.C. (1999) Legal Responsibilities of States. Chapter 6, pp. 39-44 in: Dumped Chemical Weapons in the Sea - Options-. Dr. A.H.Heineken Foundation for the Environment, Amsterdam.

[41] OSPAR Commission, Ministerial Meeting, Sintra, 1998, pp. 110.

[42] Duursma E.K. and Carroll, J., 1996, Environmental Compartments; equilibria and assessment of processes between air, water, sediments and biota. Springer Verlag, Heidelberg, 277 pp.

- In 1996 the amount of PCB was 430 ton in the atmosphere and 2500 ton in the oceans, while its global content in mussels and mother's milk was around 2 mg per kg fat.

Consequences:

- **DDT:** There is no more environmental danger, except when it is still applied in some regions. The lethal dose is 200 mg/kg body weight. However, DDT has been replaced by modern pesticides with a much shorter persistence but also with much higher toxicity of up to 1 mg/ kg body weight.[44].
- **PCB:** There was still a global stock of 1.2 million ton in 1996. UNEP follows strongly the national obligations to destroy their stocks by agreed methods. This is necessary since destruction at too low temperatures produces the very high toxic product of Dioxin.

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[43] Used among others in transformers, spray tins, etc.
[44] Such as Organo-phosphorus insecticides

CONVENTIONS TO WHICH THE PRINCIPALITY OF MONACO IS A PARTY

With the date of inscription in the Journal de Monaco (Official Bulletin of the Principality). The English version of the conventions can be found in INTERNET.

Date	**Accords et Conventions**
12-06-1970	Convention internationale de 1959 pour la prévention de la pollution des eaux de la mer par les hydrocarbures, modifiée en 1962.
07-09- 1970	Convention sur l'Organisation Hydrographique internationale.
20-05-1975	Convention internationale sur l'intervention en haute mer en cas d'accidents entraînant ou pouvant entraîner une pollution par les hydrocarbures (Bruxelles).
18-07-1975	Amendements 24 et 25 de la constitution de l'OMS signée à New York le 22 juillet 1946.
19-12-1975	Convention internationale sur la responsabilité civile pour les dommages dus à la pollution par les hydrocarbures (Bruxelles 29 novembre 1969) et ses amendements.
13-06-1977	Convention sur la prévention de la pollution des mers, résultants de l'immersion de déchets et autres matières (Londres 29 décembre 1972).
23-06-1978	Convention sur le commerce international des espèces de faune et flore sauvage menacés d'extinction (Washington 3 mars 1973) et ses amendements.
31-01-1979	Convention pour la protection du Patrimoine Mondial culturel et naturel (Paris 23 novembre 1972).
15-11-1979	Convention portant création d'un fonds international d'indemnisation pour les dommages dus à la pollution par les hydrocarbures (Bruxelles 18 décembre 1971) dénoncée à compter du 16 mai 1998 par le protocole de Londres du 27 novembre 1992 rendu exécutoire à Monaco le 3 avril 1977..
30-09-1980	Convention pour la protection de la mer Méditerranée contre !a pollution ainsi que deux protocoles (Barcelone 16 février 1976).
10-12-1980	Accord relatif à la protection des eaux du littoral Méditerranéen (Monaco 10 mai 1976) entre les Gouvernements de !a République française, de !a République italienne et de S. A S. le Prince de Monaco (RAMOGE)..
18-05-1982	Convention internationale pour la réglementation de la chasse à la baleine (Washington 19 novembre 1956).
07-11-1992	Convention internationale pour la prévention de la pollution par les navires (MARPOL Londres 2 novembre 1973 modifiée par le protocole du 17 février 1978, rendu exécutoire à Monaco le 20 août 1992).
12-05-1993	Convention internationale du 23 juin 1979 sur la conservation des espèces migratrices appartenant à la faune sauvage.
23-05-1993	Convention de Vienne pour la protection de la couche d'ozone et le protocole de Montréal relatif à des substances qui appauvrissent la couche d'ozone tel qu'amendé par le protocole de Londres rendu exécutoire à Monaco le 10 juin 1993.
09-05-1994	Convention sur la diversité biologique (Rio de Janeiro 10 juin 1992).
25-04-1995	Traité de non prolifération des armes nucléaires fait à Londres, Moscou et Washington 1er juillet 1968.
30-05-1996	Convention de l'Organisation Météorologique Mondiale (Washington 11 octobre 1947).
20-05-1997	Convention sur la non prolifération des armes chimiques (Paris 13 janvier 1993).
23-01-1998	Convention relative aux zones humides d'importance internationale particulièrement comme habitat des oiseaux; d'eau (RAMSAR le 2 février 1971).
17-06-1999	Convention des Nations Unies sur la lutte contre la désertification dans les pays gravement touchés par la sécheresse et/ou la désertification en particulier en Afrique.
21-07-1999	21 juillet 1999 Convention sur la protection des Alpes.
14-08-1999	Convention sur l'interdiction de la mise au point et du stockage des armes bactériologiques (biologiques) ou à toxines et sur leur destruction.
13-10-1999	Accord sur la conservation des chauves-souris en Europe et son amendement signé à Bristol les 24 et 26 juillet 2000 rendu exécutoire à Monaco le 23 avril 2001.

16-03-2000	Convention sur la pollution atmosphérique transfrontalière à longue distance et son protocole relatif au financement à long terme du programme concerté de surveillance continue et d'évaluation du transport à longue distance des polluants atmosphériques en Europe.
01-08-2000	Convention internationale de 1990 sur la. préparation, la lutte, la coopération en matière de pollution par les hydrocarbures.
23-04-2001	Convention sur les aires spécialement protégées et la diversité biologique en Méditerranée (ASPIM) et ses annexes relatives à la Convention de Barcelone.
26-09-2001	Accord de 1986 sur l'huile d'olive et les olives de table tel qu'amendé et reconduit en 1993 et prorogé en dernier lieu en 2000.
12-10-2001	Convention des Nations Unies sur les effets transfrontaliers des accidents industriels (Helsinki 17 mars 1992).
17-01-2002	Convention des Nations Unies sur le droit de la mer 10 décembre 1982 relatif à la conservation et à la gestion des stocks de poissons dont les déplacements s'effectuent tant à l'intérieur qu'au delà des zones économiques exclusives (stocks de chevauchement) et stocks de poisons migrateurs (New York 4 août 1995).
18-02-2002	Accord relatif à la création en Méditerranée d'un sanctuaire pour les mammifères marins (Rome 25 novembre 1999).
04-03-2002	Convention pour la conservation des cétacés dé la Mer Noire, de la Méditerranée et de la zone atlantique adjacente (ACCOBAMS) Monaco 24 novembre 1996.
17-06-2002	Convention sur la réduction du soufre.
17-06-2002	Accord sur la conservation des oiseaux d'eau migrateurs d'Afrique et d'Eurasie (La Haye 15 août 1996).
03-04-2003	Accord sur l'interdiction de !a mise au point, de la fabrication, du stockage et de l'emploi des armes chimiques et sur leur destruction (Genève 3 septembre 1992).
05-06-2003	Convention sur la protection des Alpes de 1991 relatif à l'aménagement de territoire et développement durable (Chambéry 20 décembre 1994).

EVALUATION OF THE ENVIRONMENTAL BUDGET OF MONACO

Organisations related to Environment	**Budget of 2005 in €**	**Type**
IHB (International Hydrographical Bureau)	56 200	Subvention
IAEA (International Atomic Energy Agency)	1 067500	Subvention
Institut de Droit Economique de la Mer	90 000	Subvention
International Organisations	1 350 200	Cortication
UNESCO	65 000	Representation
International Cooperation	2 070 000	Deepness
Oceanographic Museum	60 300	Subvention
Palaeontology Institute	18 300	Subvention
Medical Congress	68 000	Subvention
Reforesting around Monaco	230 000	Subvention
Garden Services	4 250 600	Deepness
Anthropologic Museum	406 500	Deepness
DEUC Environment	788 300	Deepness
Scientific Centre of Monaco (CSM)	1 275 400	Subvention
New Therapies	700 000	Subvention
Total	€ 12 496 300	

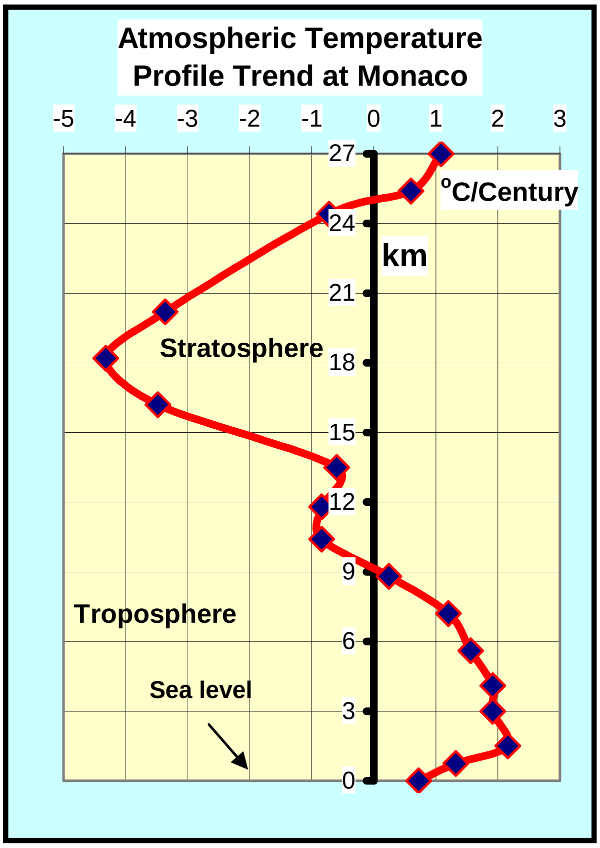

Fig. left
Profile of temperature trends in the atmosphere at Monaco. Between 1948 et 2001 the greenhouse effect is composed of a maximum warming at 1500 metres altitude et a cooling in the stratosphere.

Fig. below
The rainfall in the Principality of Monaco decreases 12% per Century. The irregularities are a natural phenomenon, as observed for practically all stations of the world.