Klimat, środowisko, energia, czyli o efekcie cieplarnianym

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Zakład Dydaktyki Fizyki

Uniwersytet Mikołaja Kopernika w Toruniu

Milano, 17.10.2002

Toruń, 17.10.2024

Sped. in A.P.45% art.2
comma 20/BL. 662/96Verona
2012

CLIMA PAZZO
È colpa dell'Atlantico

OGGI

Alluvioni nel nord Europa e siccità al sud: l'oceano blocca i campi di pressione

B
BASSA PRESSIONE

PIOGGE

FRA 10 ANNI

Il calo della salinità rallenterà la corrente del Golfo, portando il gelo in Europa

SICCITÀ

Rok 2002

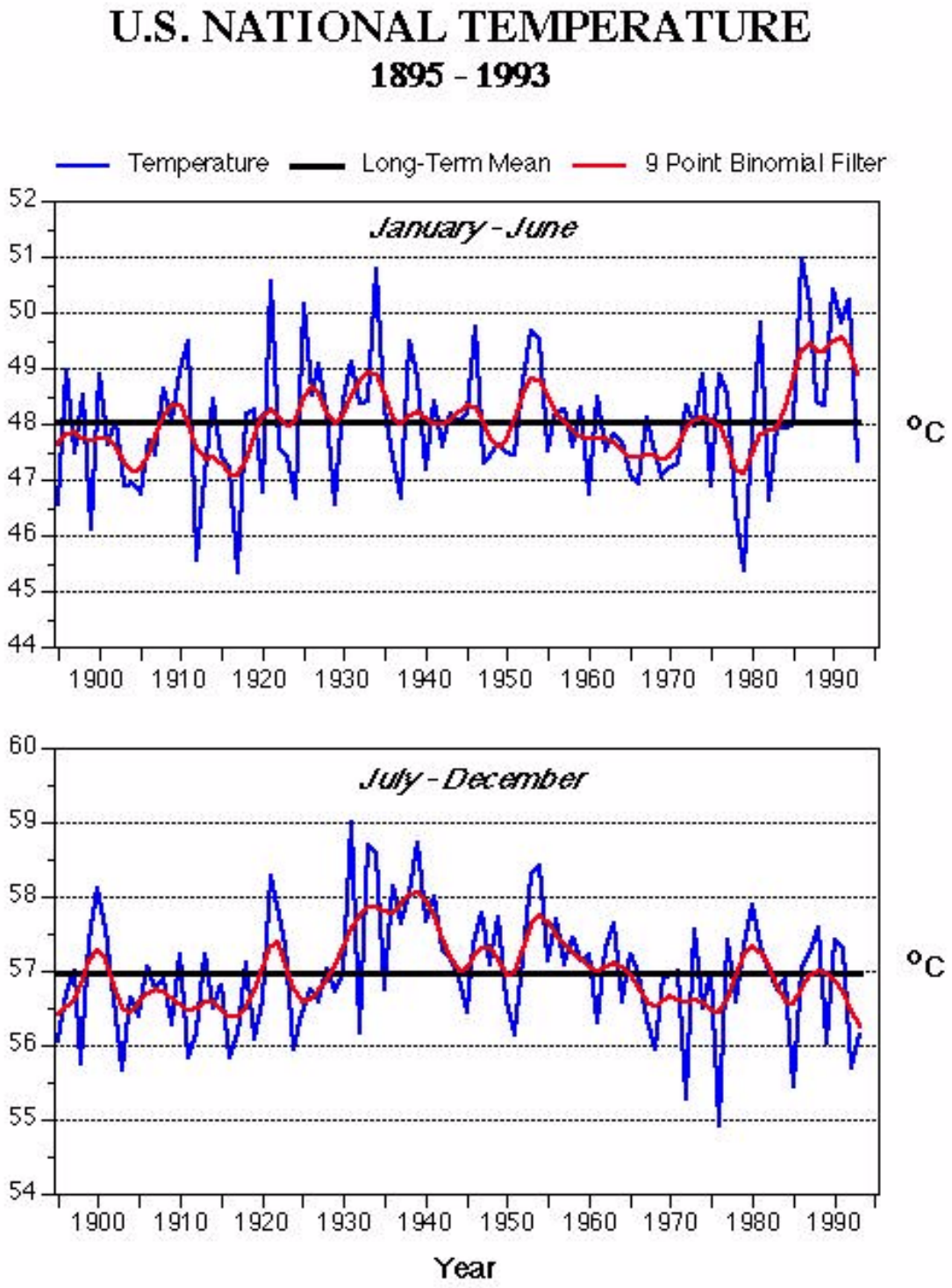
ALTA PRESSIONE

A

Il ruolo dell'effetto serra, e la scoperta di un "El Niño" atlantico

RIMINI
LABORATORIO DEL COMPORTAMENTO
I PRIMI RISULTATI

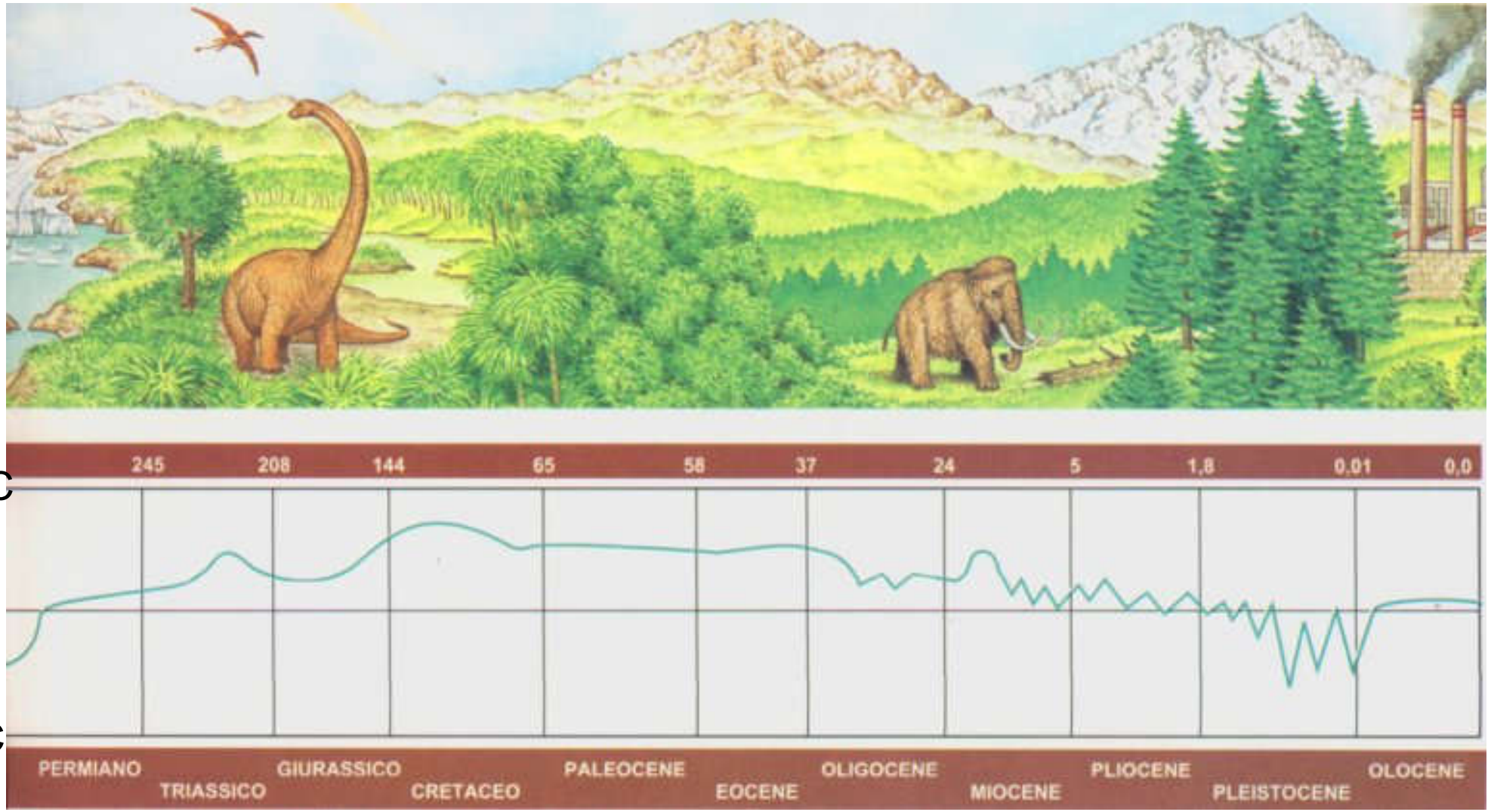
Effetto serra?



Rok 1996
Wykład na
Politechnice w Mediolanie

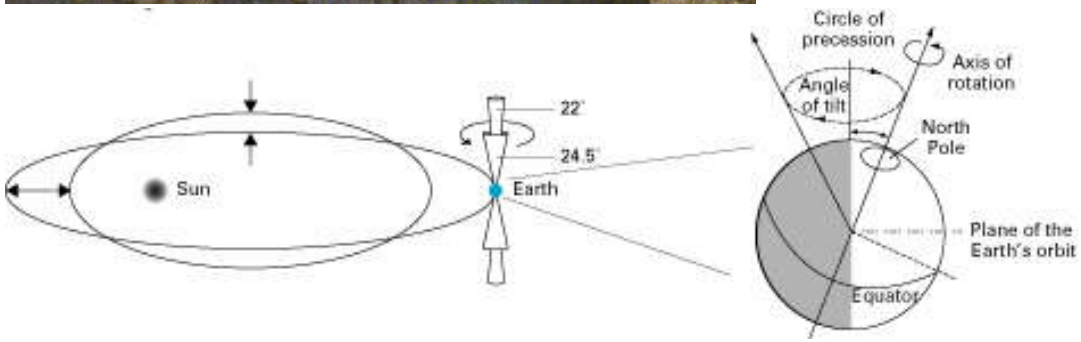
Source: NOAA, 1996

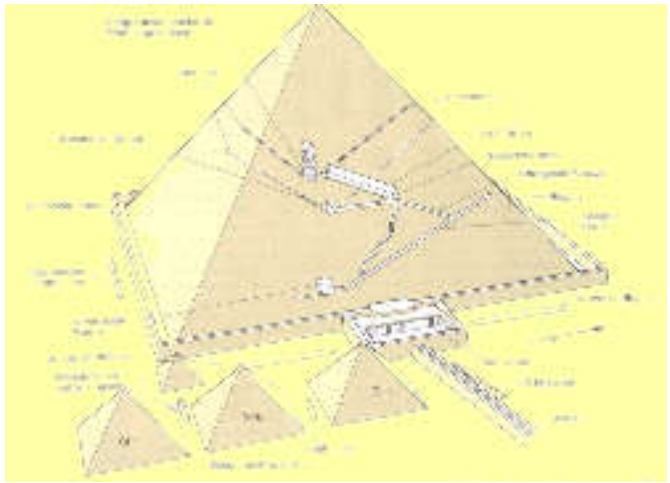
“efekt cieplarniany” czy zmiany naturalne?

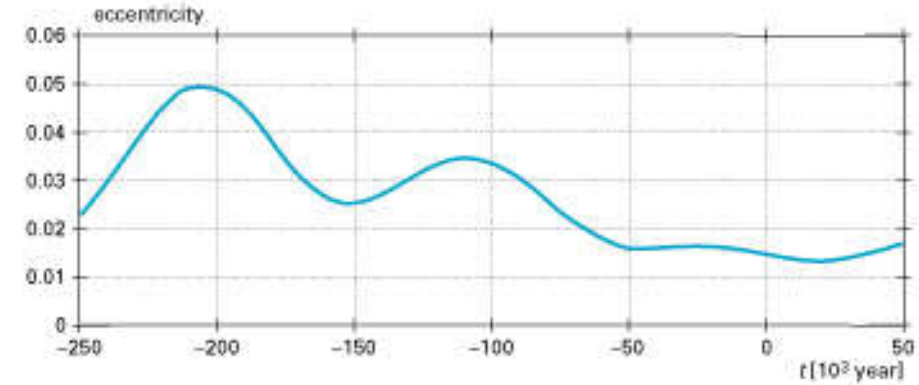


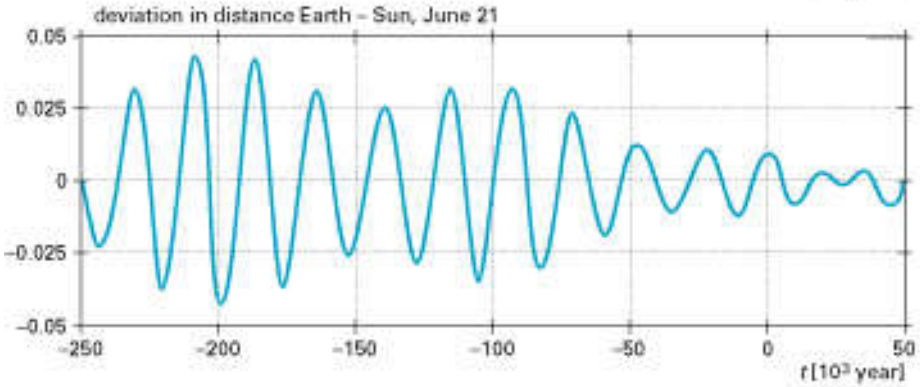
Source: Le Scienze

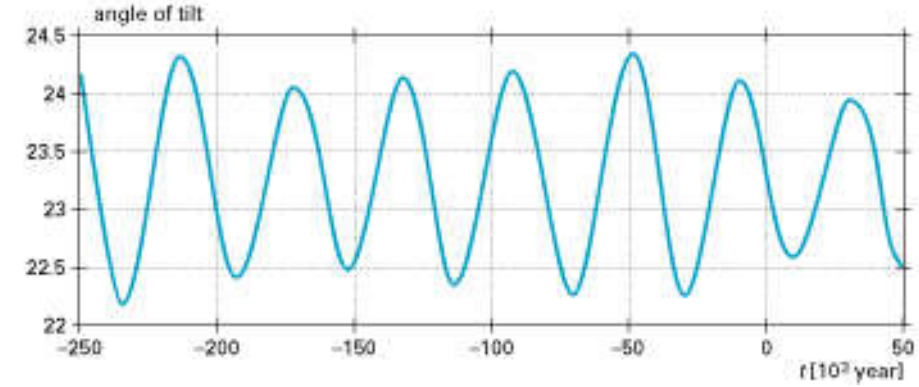
Zmiany naturalne (astronomiczne)







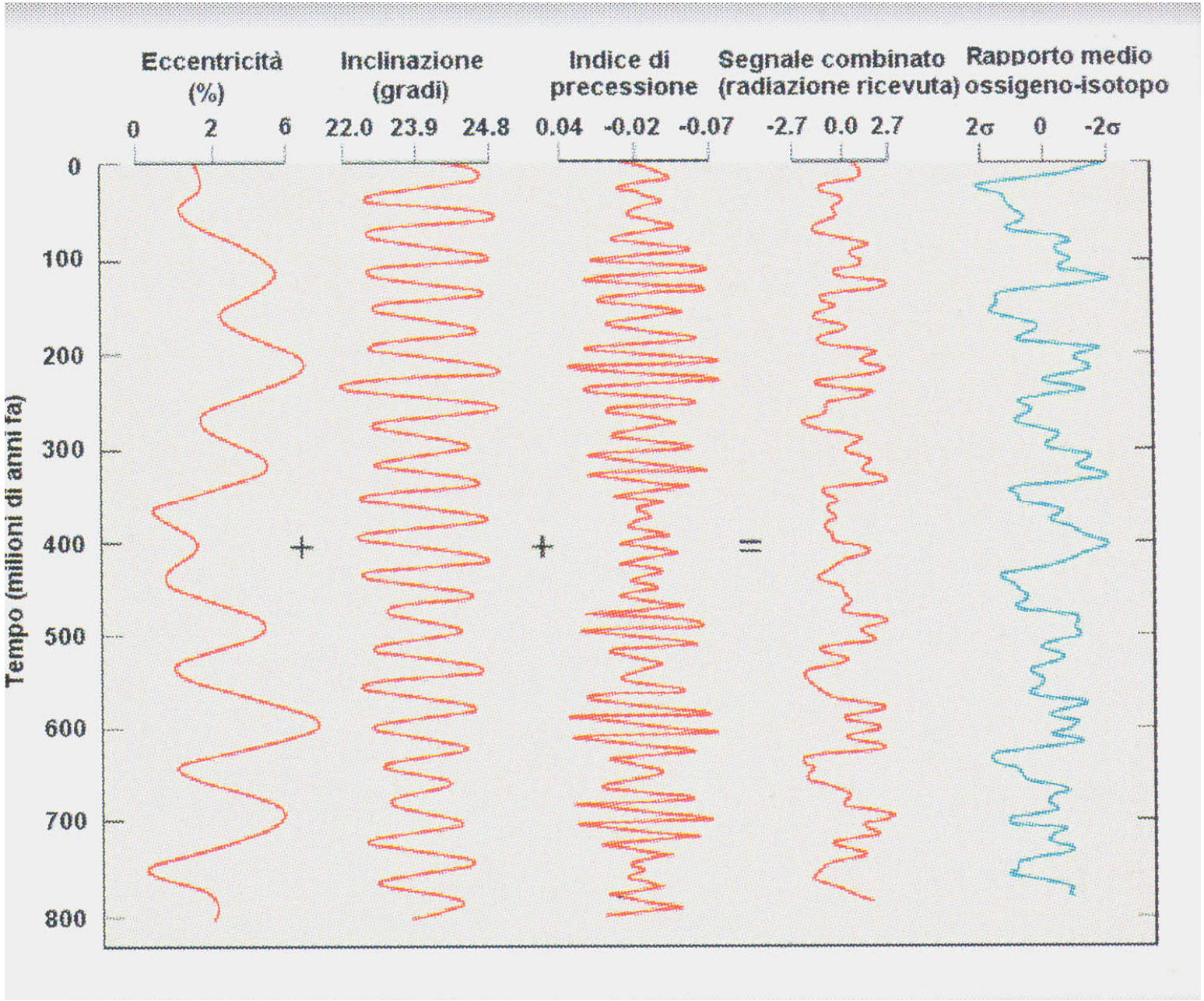




Cykle Milankovica

Source: wiki

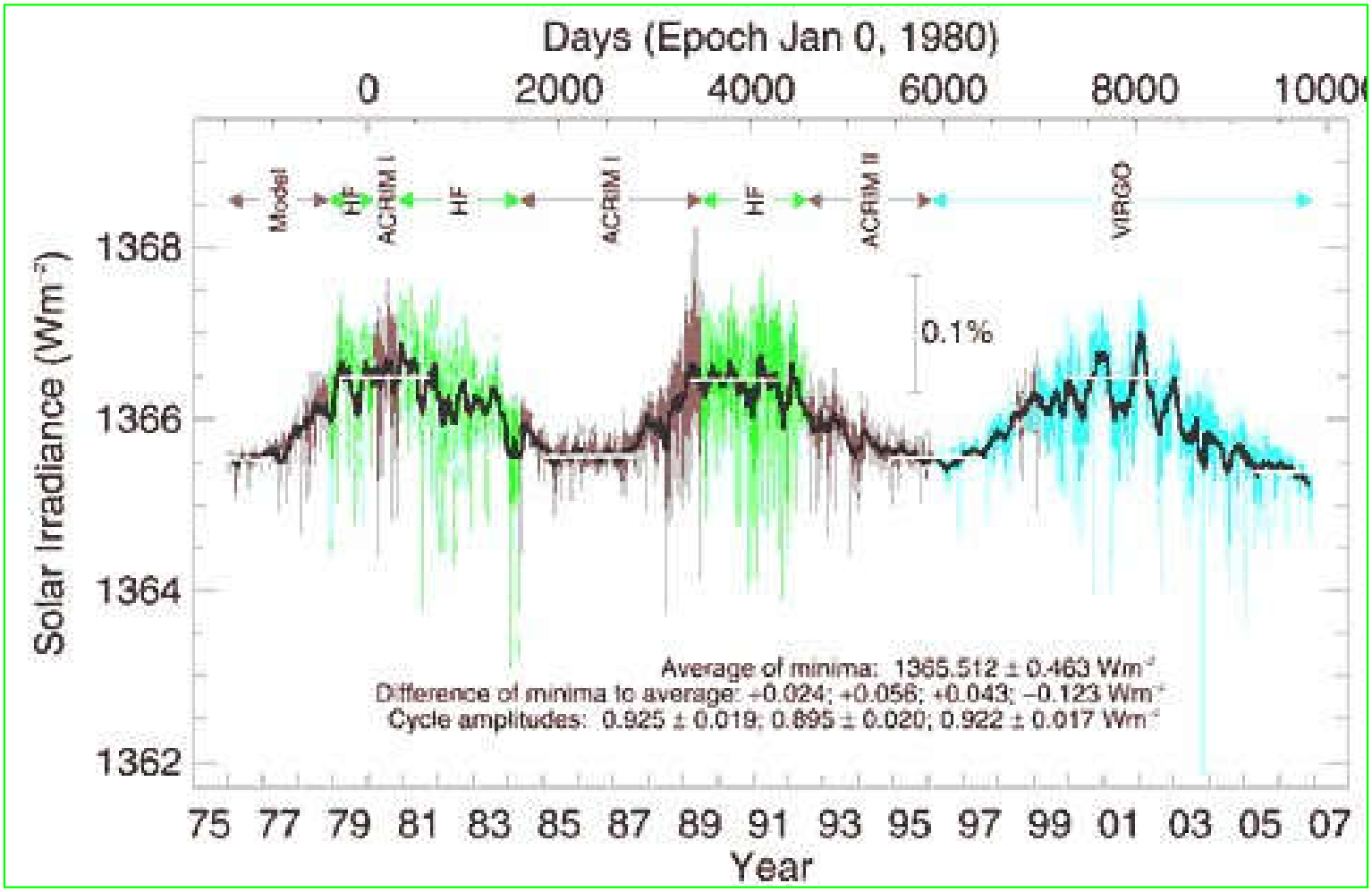
Zmiany naturalne (astronomiczne)

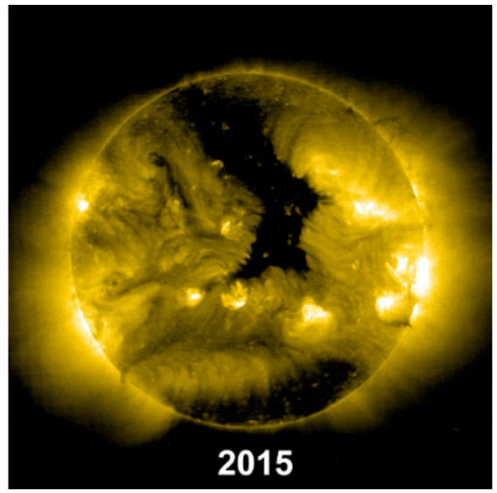


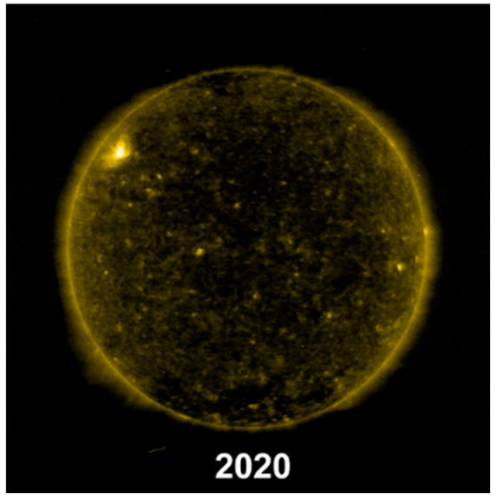
O^{18} = temp.

Source: Le Scienze

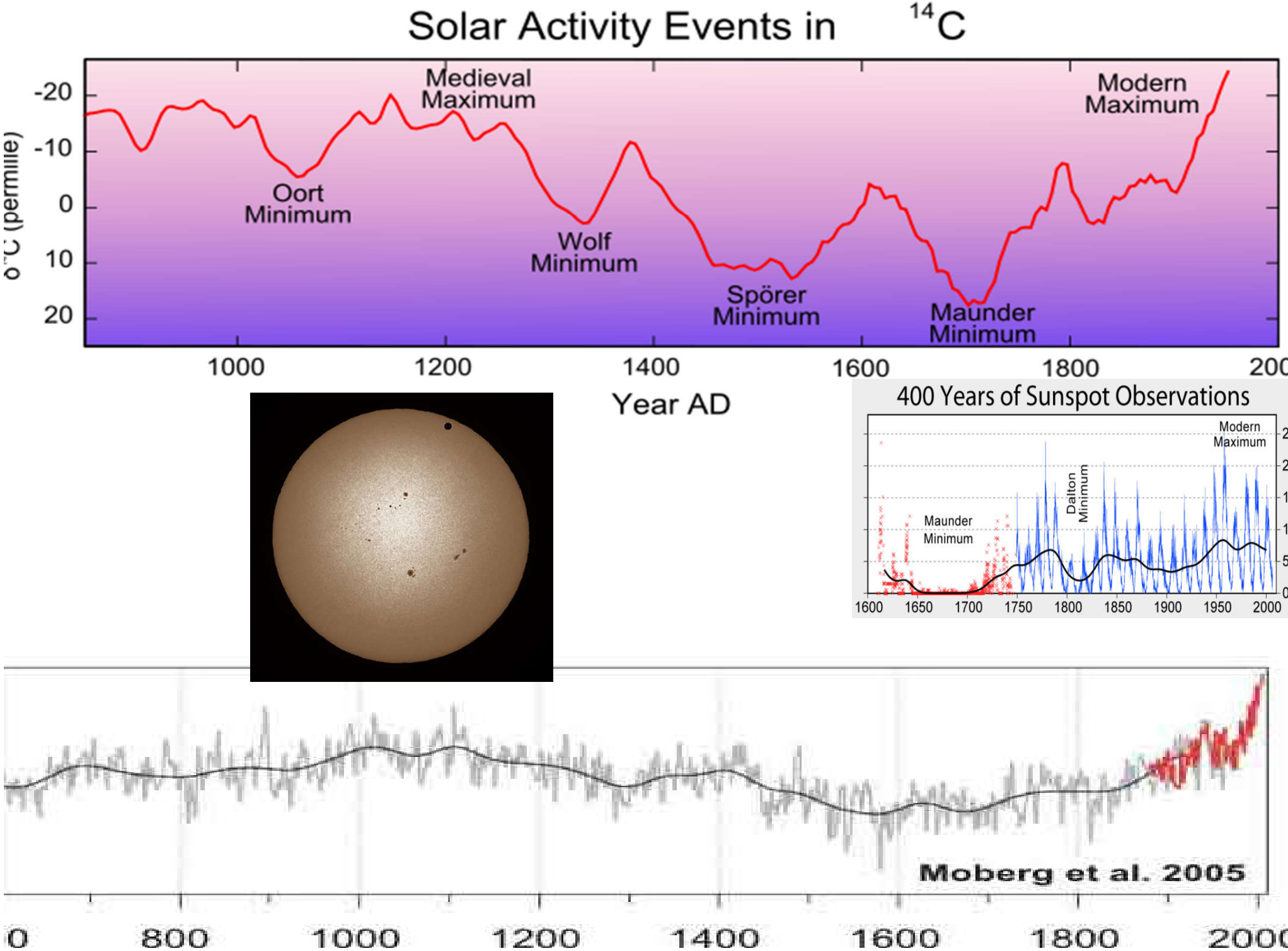
Bilans energetyczny: Słońce







A i w krótszych okresach, co jakieś 11 lat, zmienia się ilość plam na Słońcu, a przez to ilość energii docierająca do Ziemi


Solar Activity Events in ^{14}C
δ¹⁴C (permille)
-20
-10
0
10
20
Medieval Maximum
Oort Minimum
Wolf Minimum
Spörer Minimum
Maunder Minimum
Modern Maximum
1000
1200
1400
1600
1800
2000
Year AD
400 Years of Sunspot Observations
Modern Maximum
Dalton Minimum
Maunder Minimum
Sunspot Number
250
200
150
100
50
0
1600
1650
1700
1750
1800
1850
1900
1950
2000
Moberg et al. 2005
Temperature Anomalies, degrees C
800
1000
1200
1400
1600
1800
2000

Bilans energetyczny – aerozole

Fig. A1. Example of a non-volcanic sunse
Turner entitled "The Lake, Petworth, Sunset",

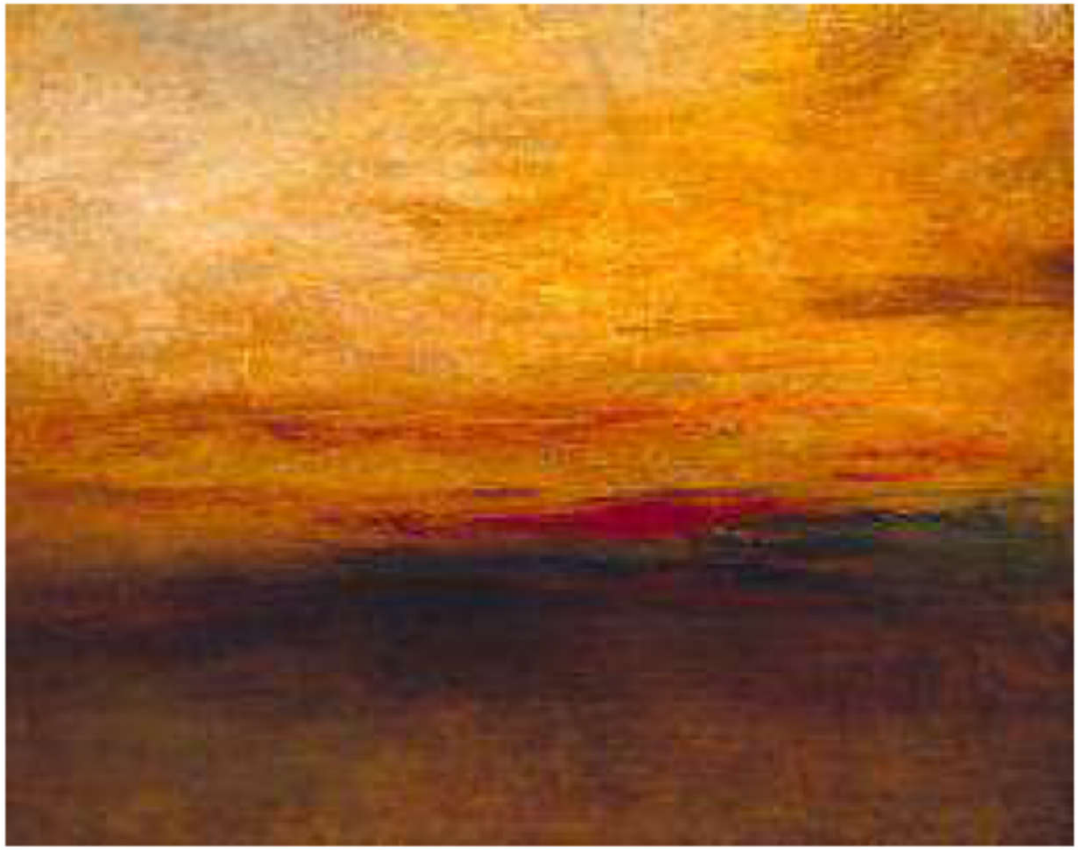
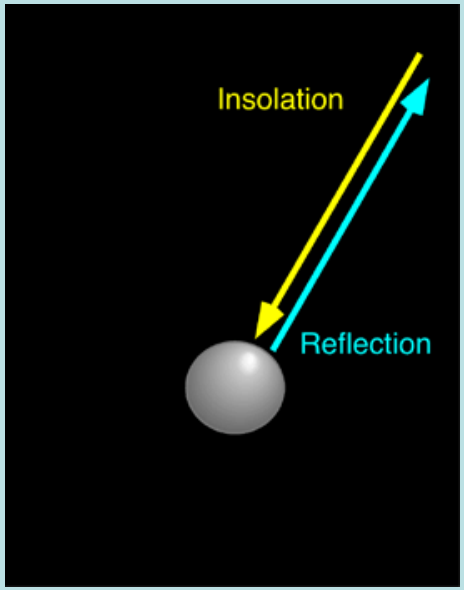


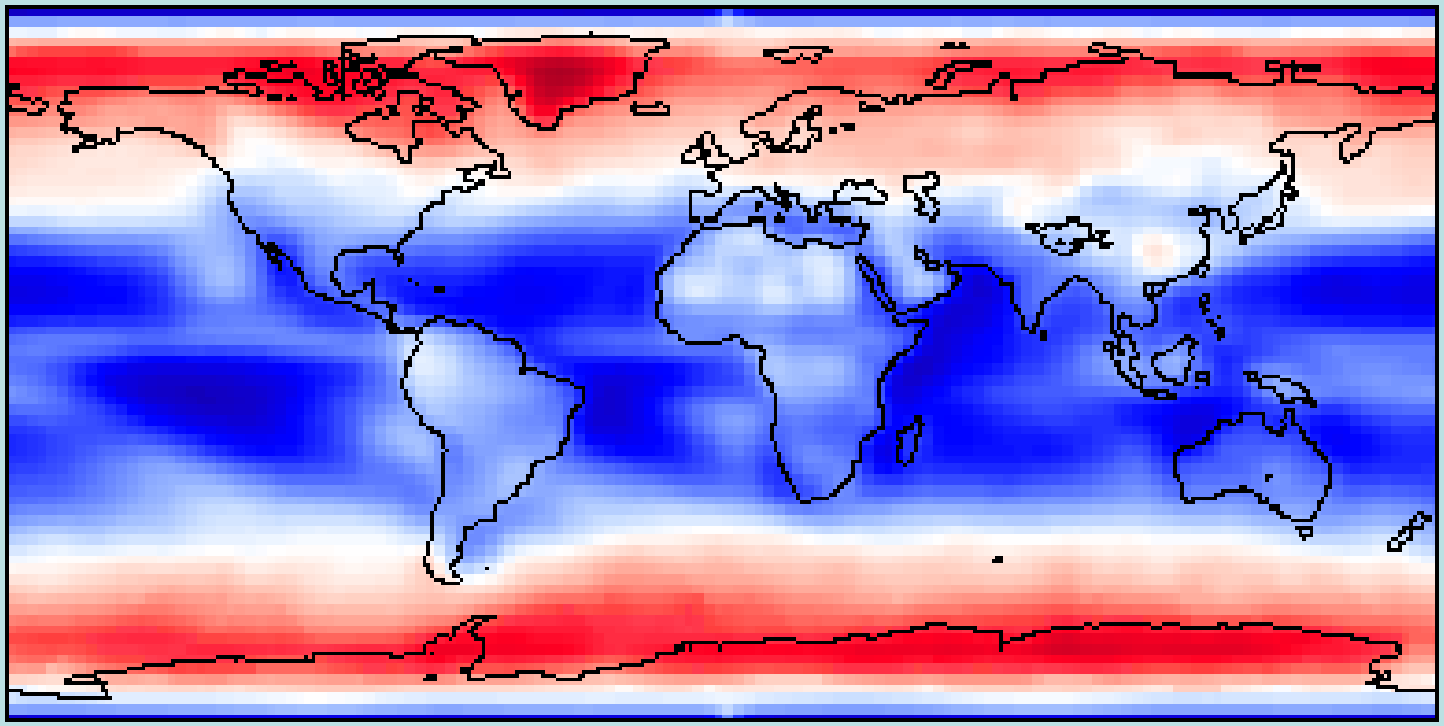
Fig. A2. Example of volcanic sunset by J. M. W. Turner en-
itled "Sunset" (c.1833) with R/G ratio of 1.76±0.03. that illus-

Source: GK, KS, Foton 2015

Termodynamika: bilans energii

1. odbicie

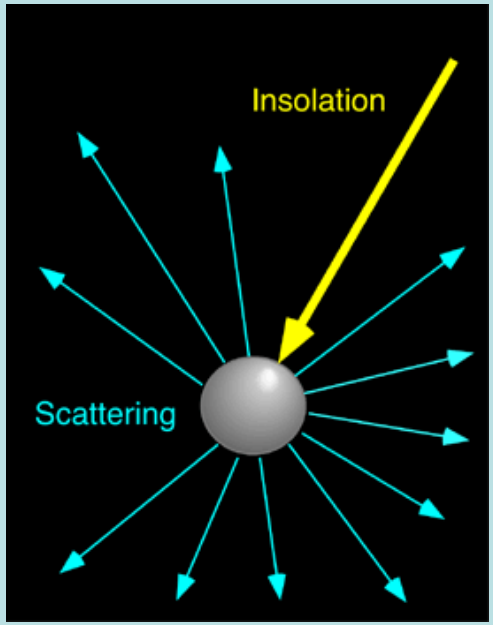


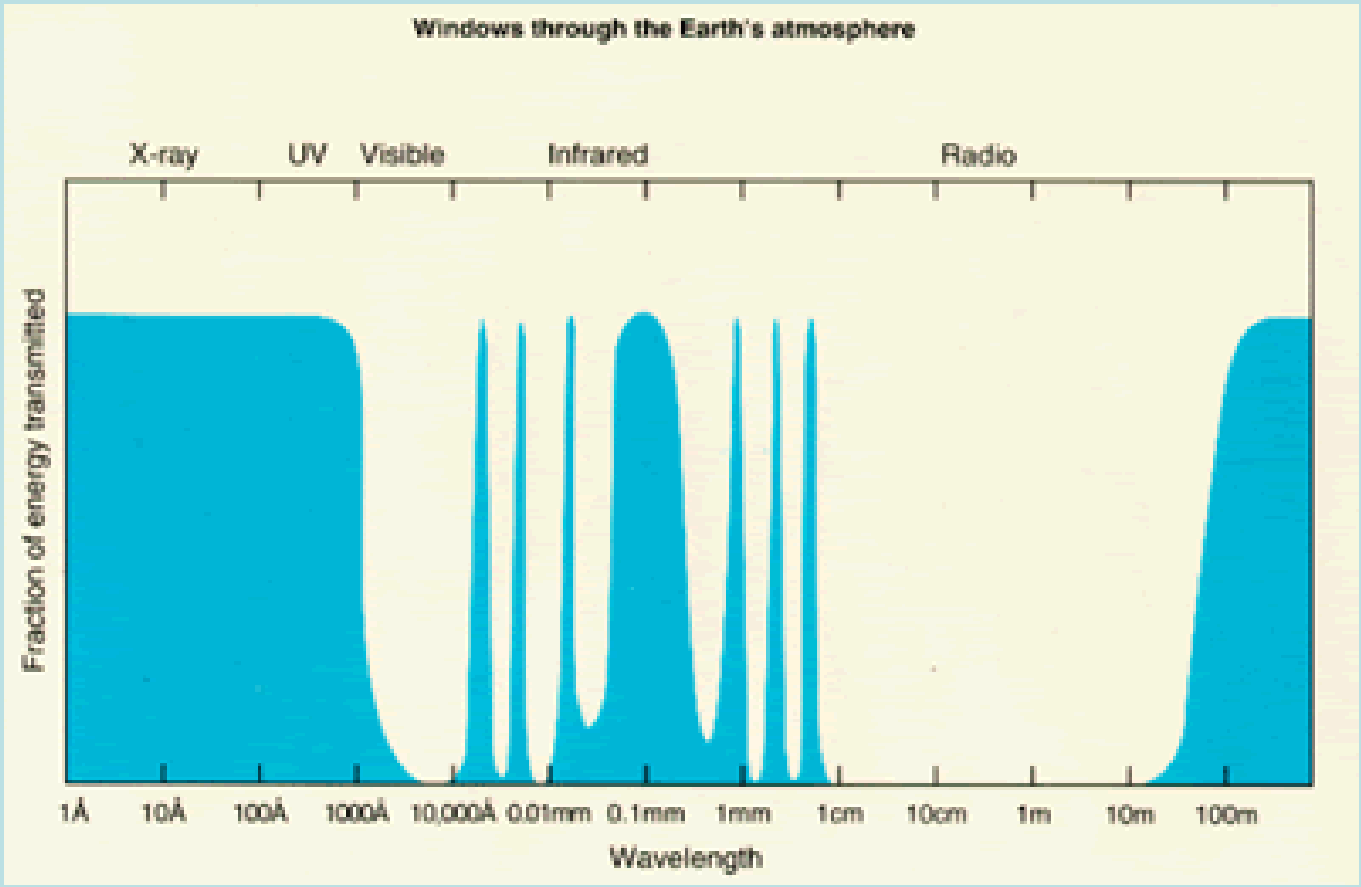


= albedo

Bilans energii

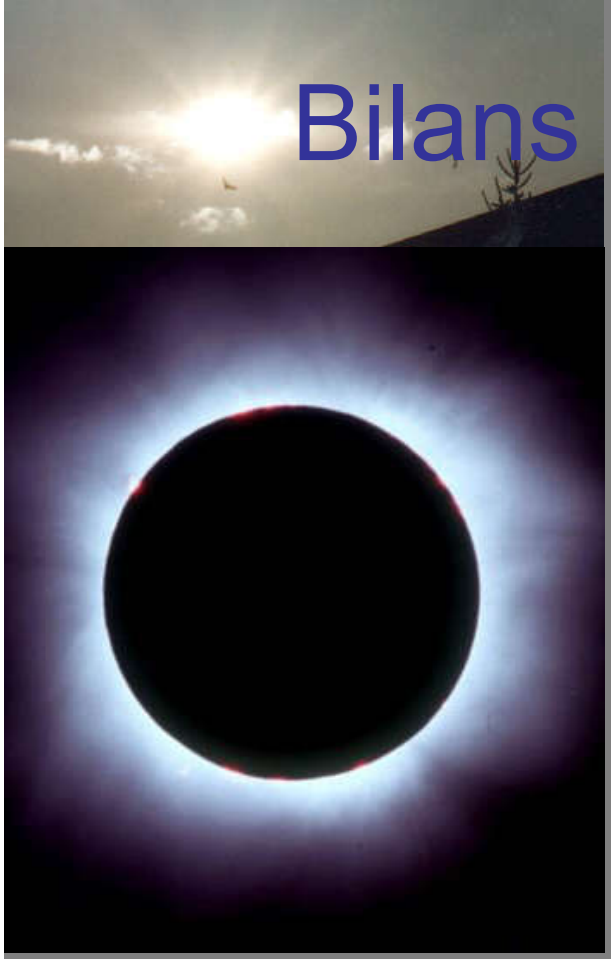
2. absorbcja

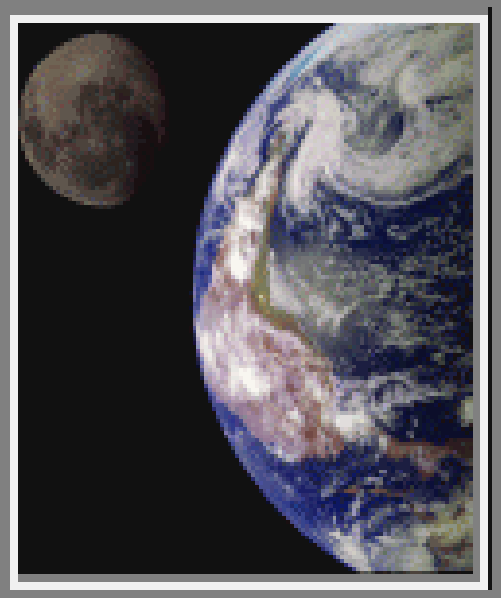




~0% w zakresie widzialnym

Bilans energii: ciało doskonale czarne

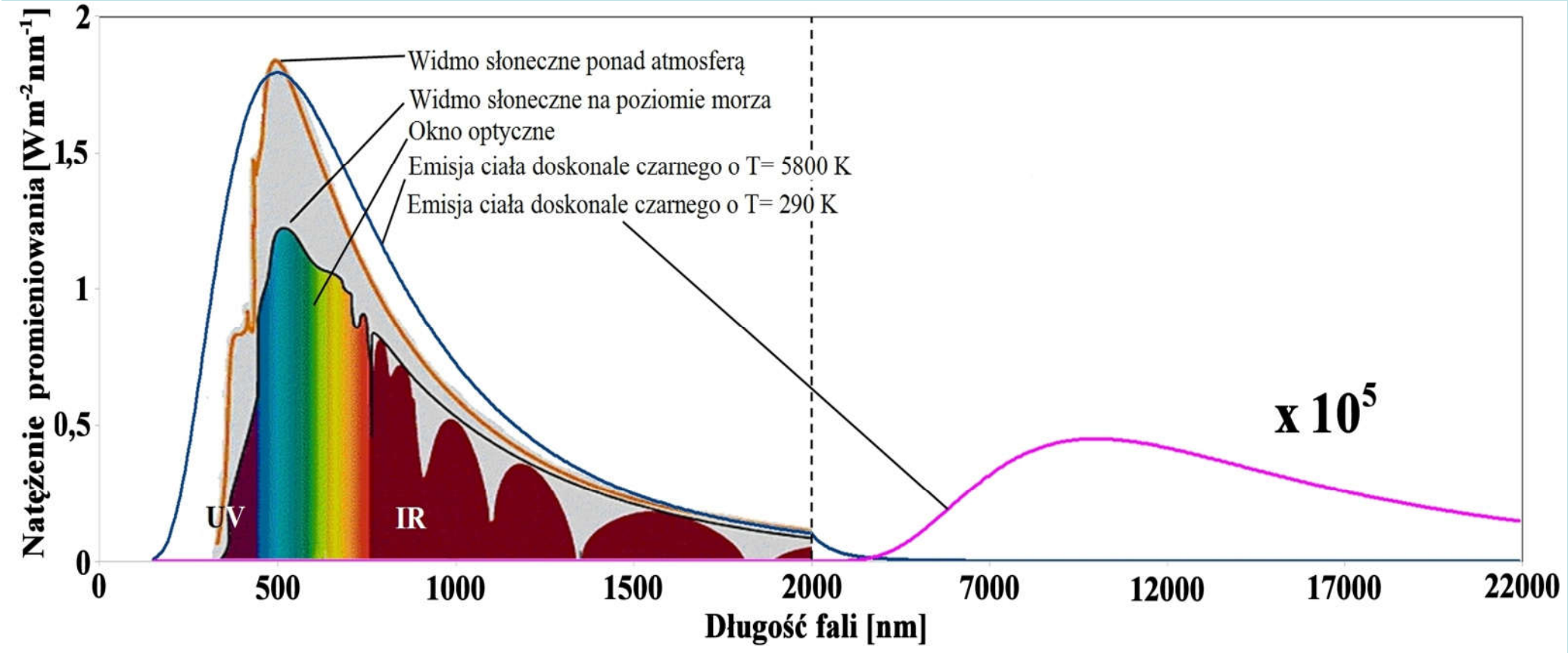




T = 5500 K

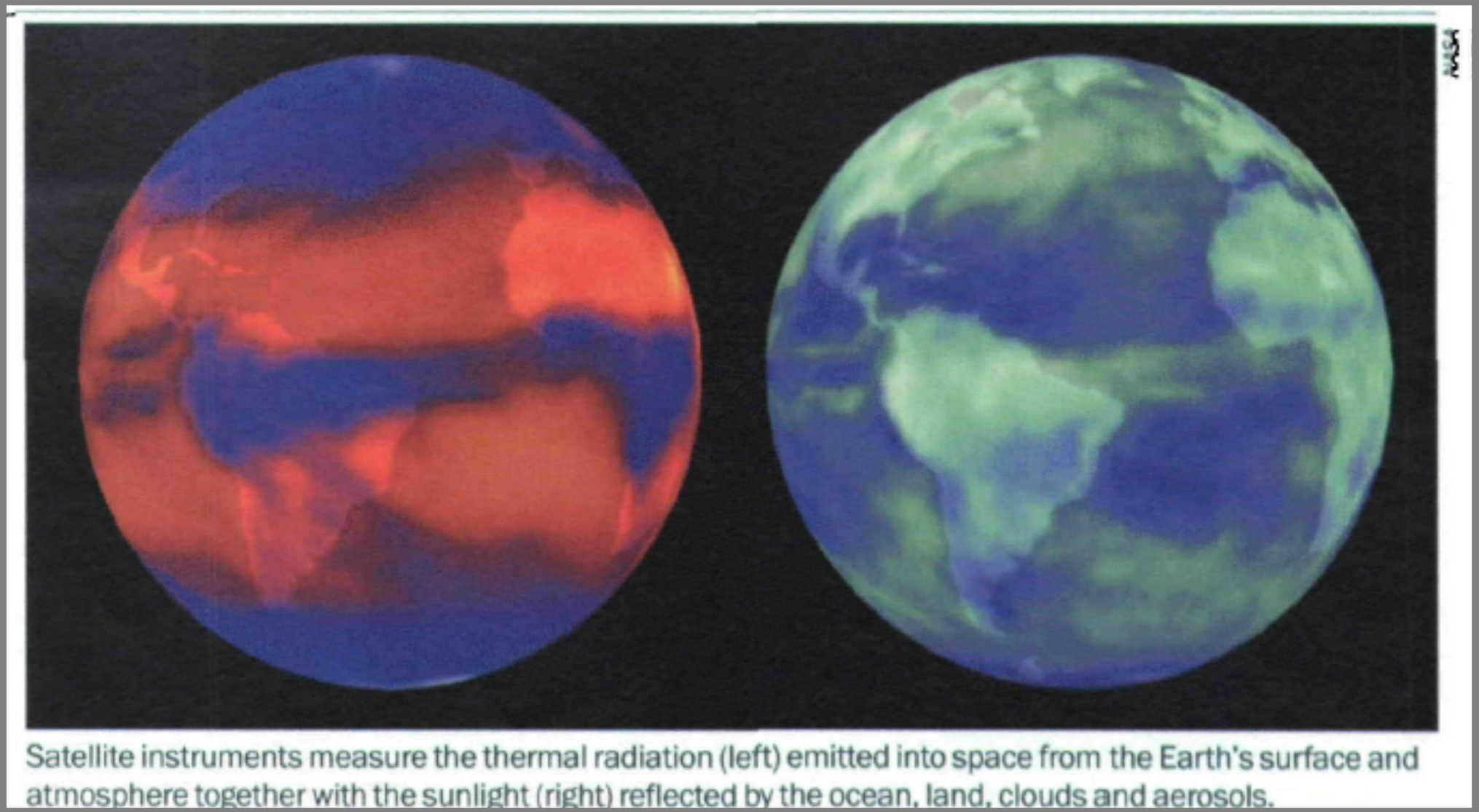
T= 300 K

Bilans energii: ciało doskonale czarne



Source: GK, KS, 2015

Emisja w IR, absorpcja w VIS



Satellite instruments measure the thermal radiation (left) emitted into space from the Earth's surface and atmosphere together with the sunlight (right) reflected by the ocean, land, clouds and aerosols.

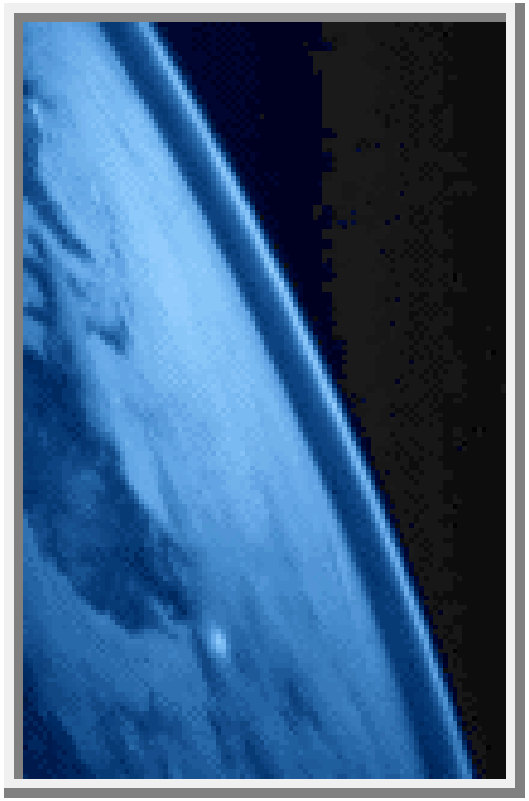
T= 300 K

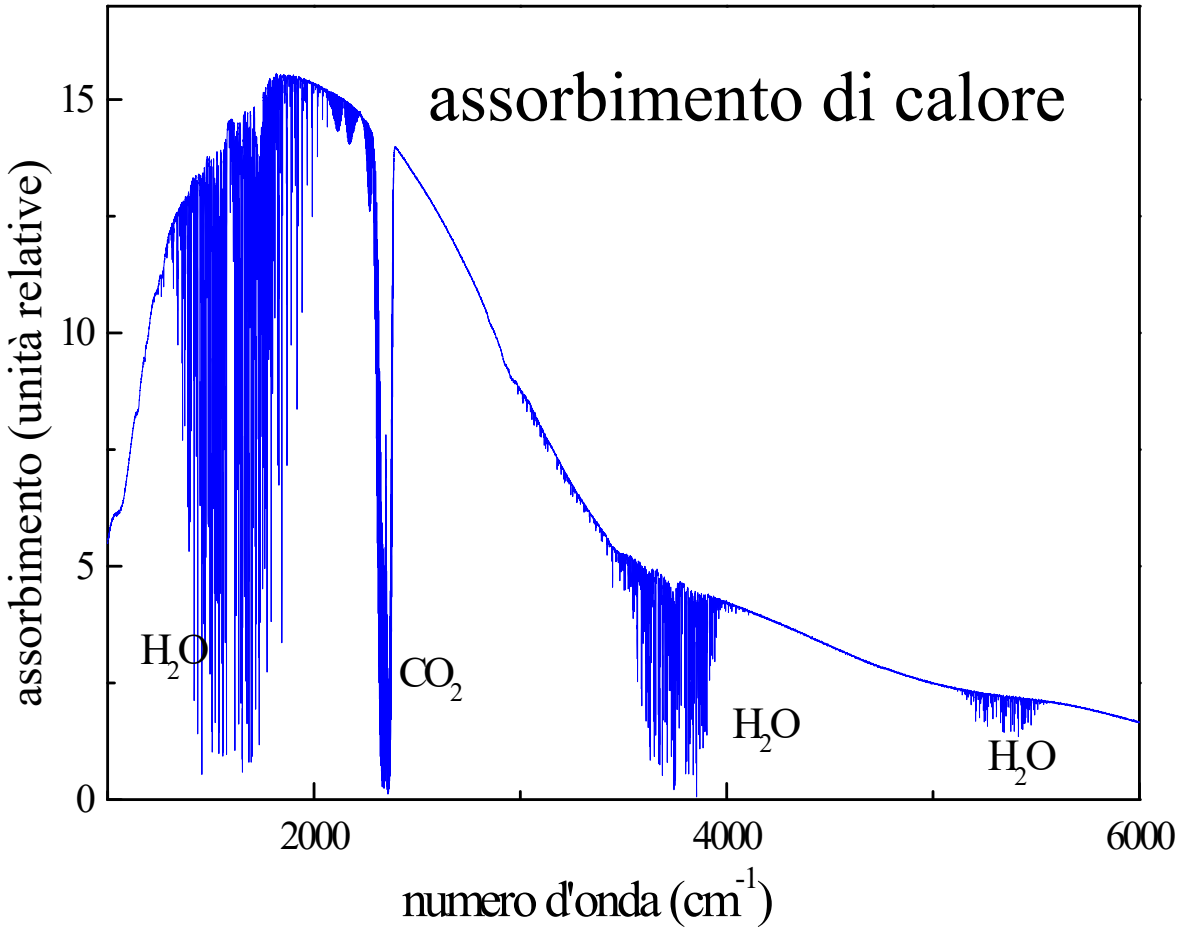
T = 5500 K

Source: Physics Today

„feather blanket” = water vapour + carbon dioxide

Podwójna pierzynka



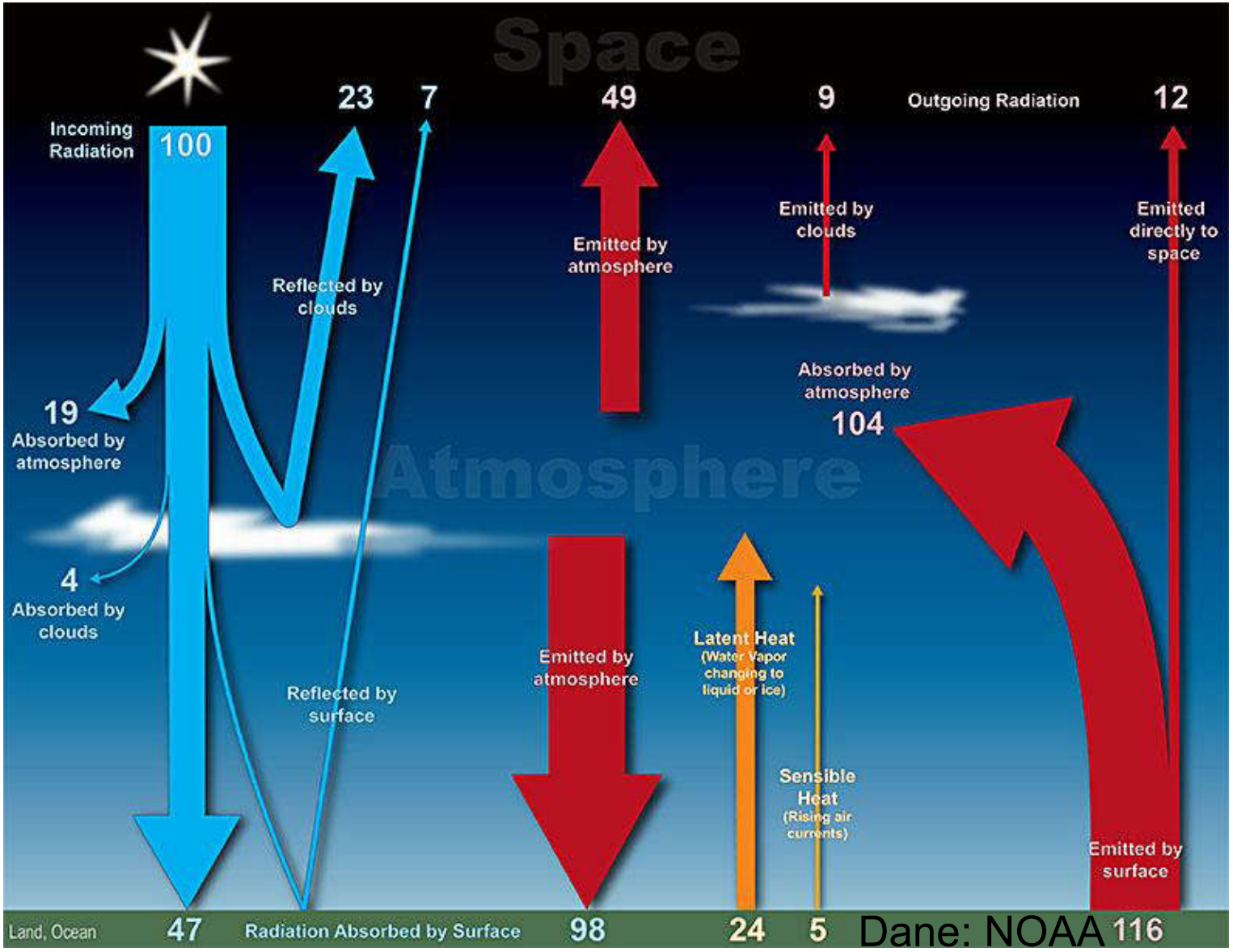


H_2O: -18°C →+15°C

CO_2: +15°C →+???

Source: GK, G. Mariotto

Bilans energetyczny Ziemi



Naturalny efekt cieplarniany:

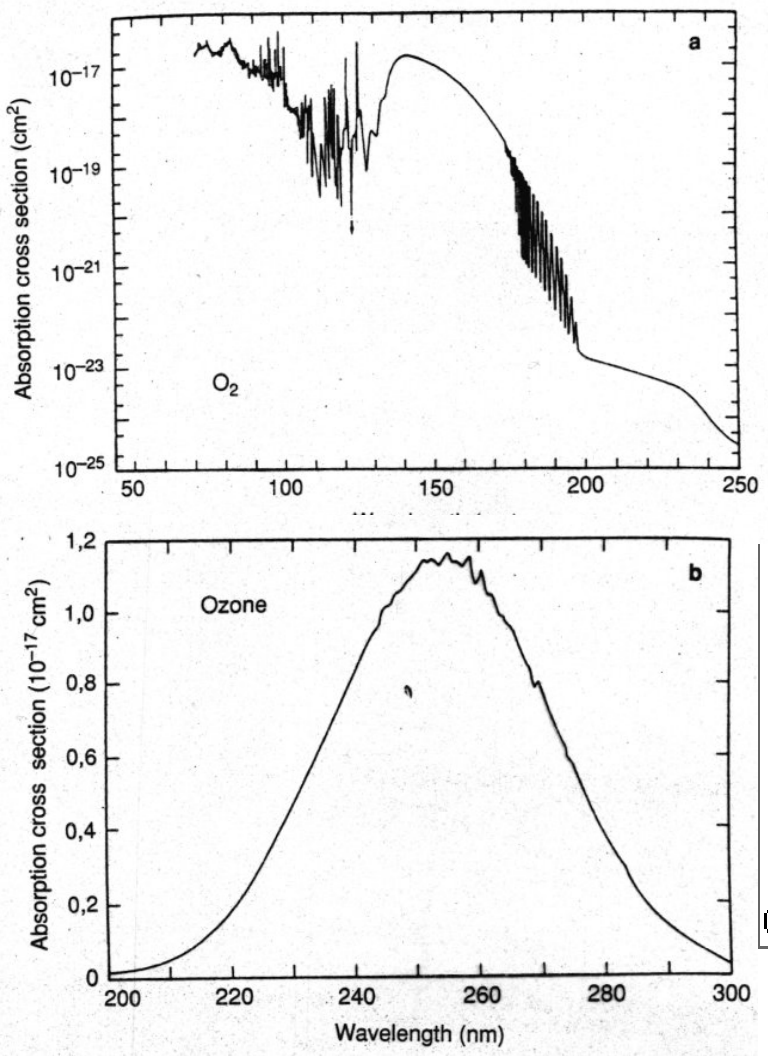
+ 33 K

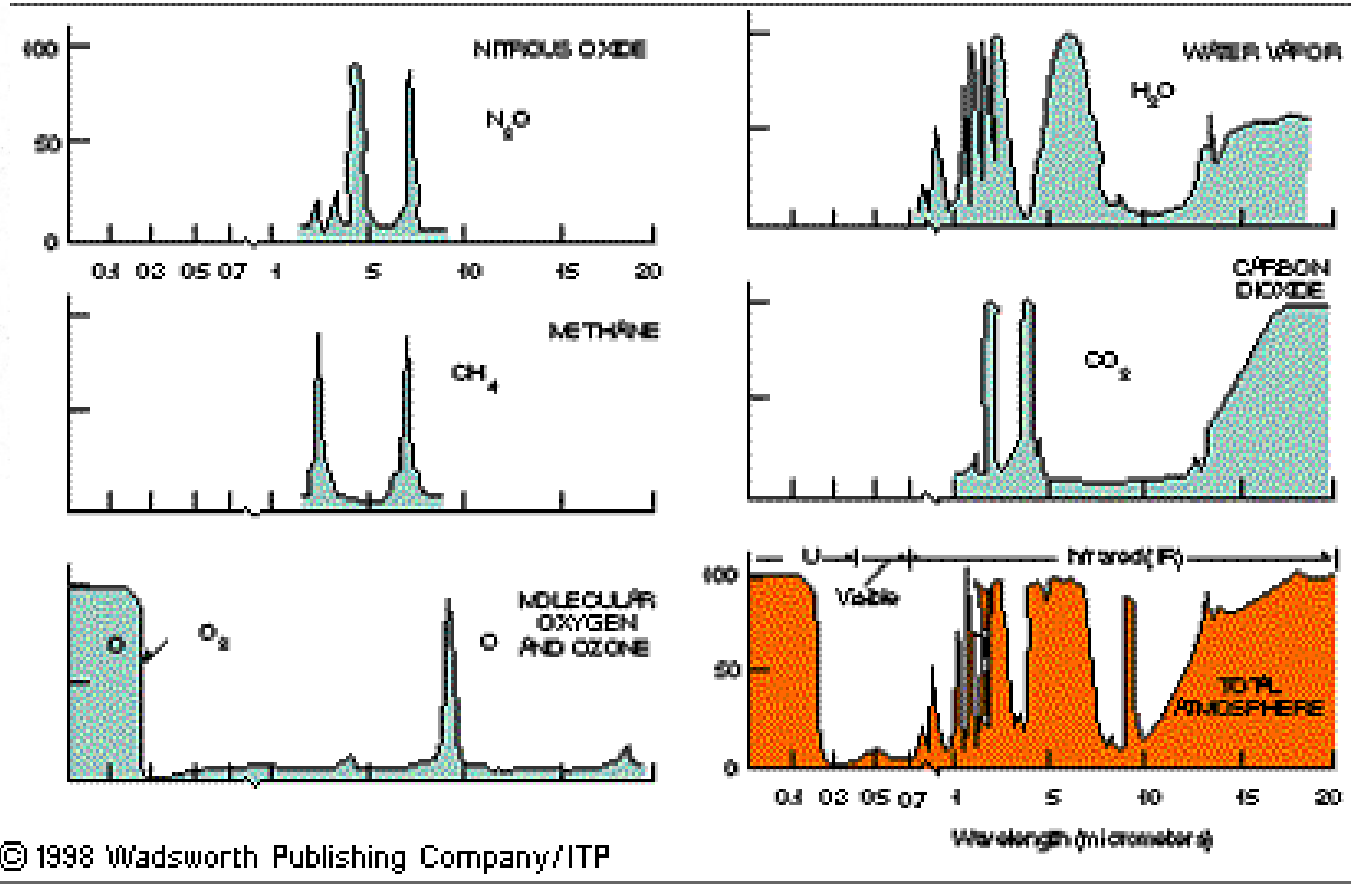
Zamiast śnieżnej kuli (-18ºC) ciepły majowy wieczór (+15º C)

Mars: + 3K (- 60º C)

Z uwagi na obecność gazów „cieplarnianych” (H_2O i CO_2) Ziemia dysponuje aż **116%** energii docierającej ze Słońca

Nie tylko CO_2 jest gazem „cieplarnianym”

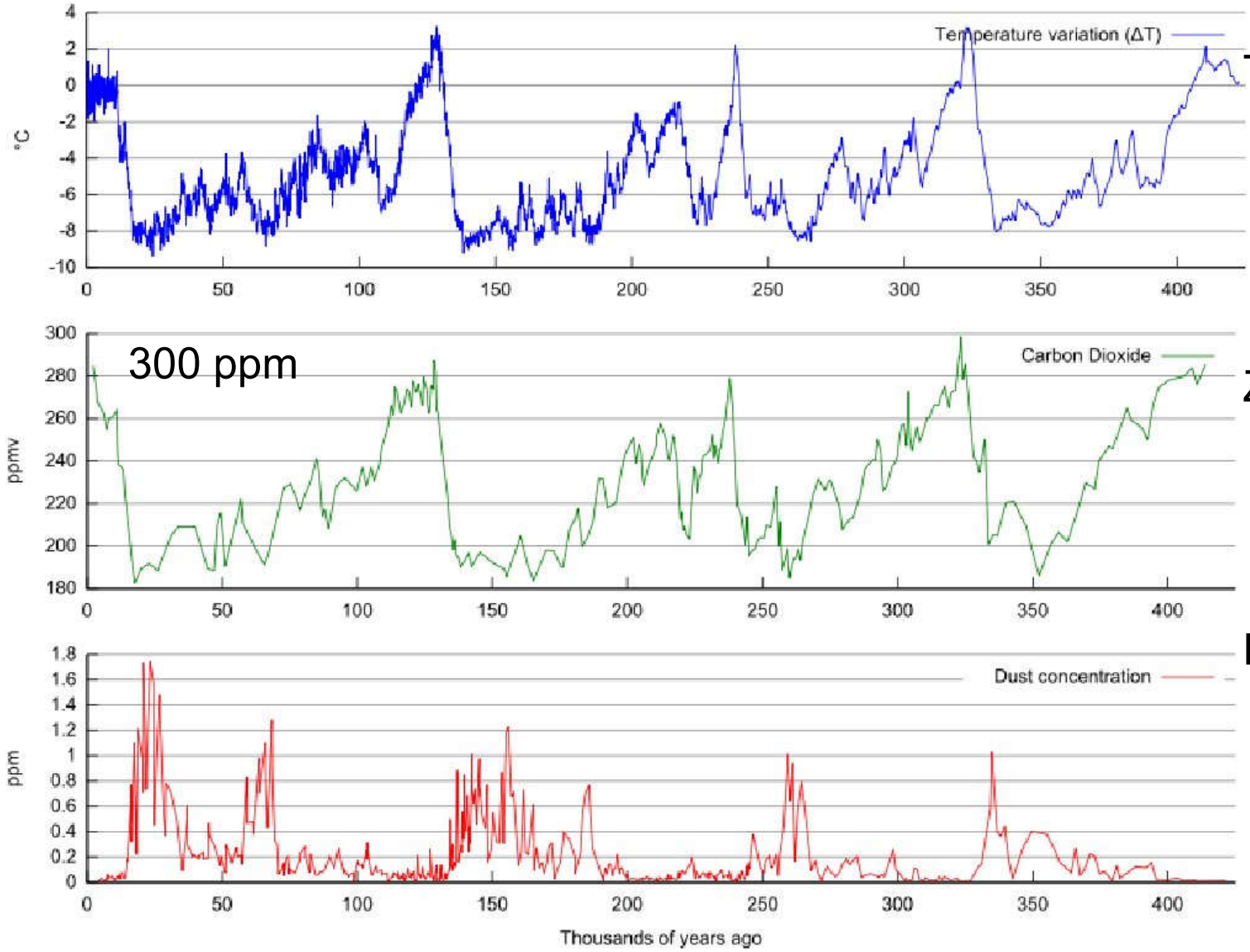




O_2 e O_3: **UV**

CO_2, N_2O, H_2O: **IR**

Korelacja $CO_2 \leftrightarrow$ temperatura ?



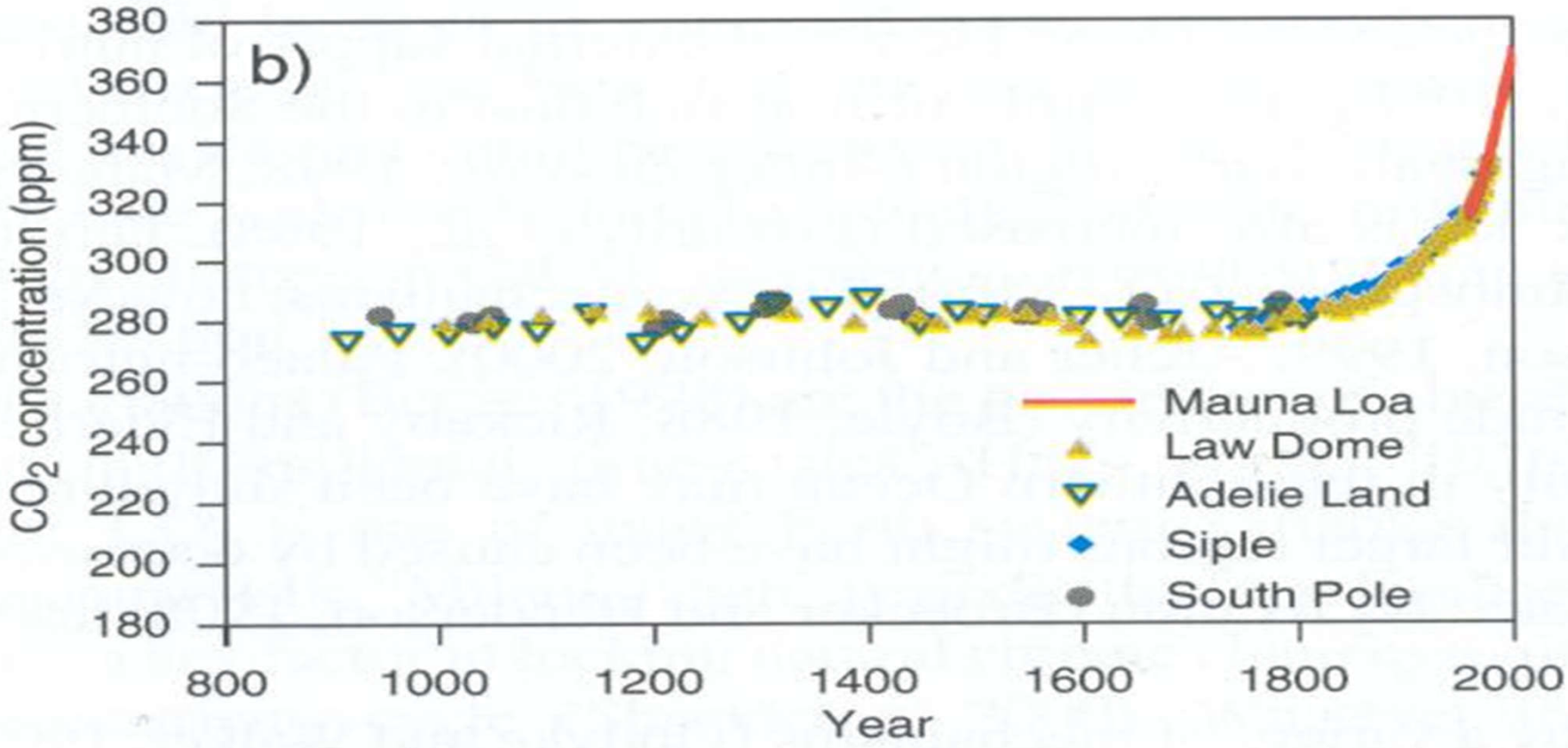
Temperatura

Zawartość CO_2

Pyły

Tak!

Ostatnie 400 tys. lat, dane z Antarktydy



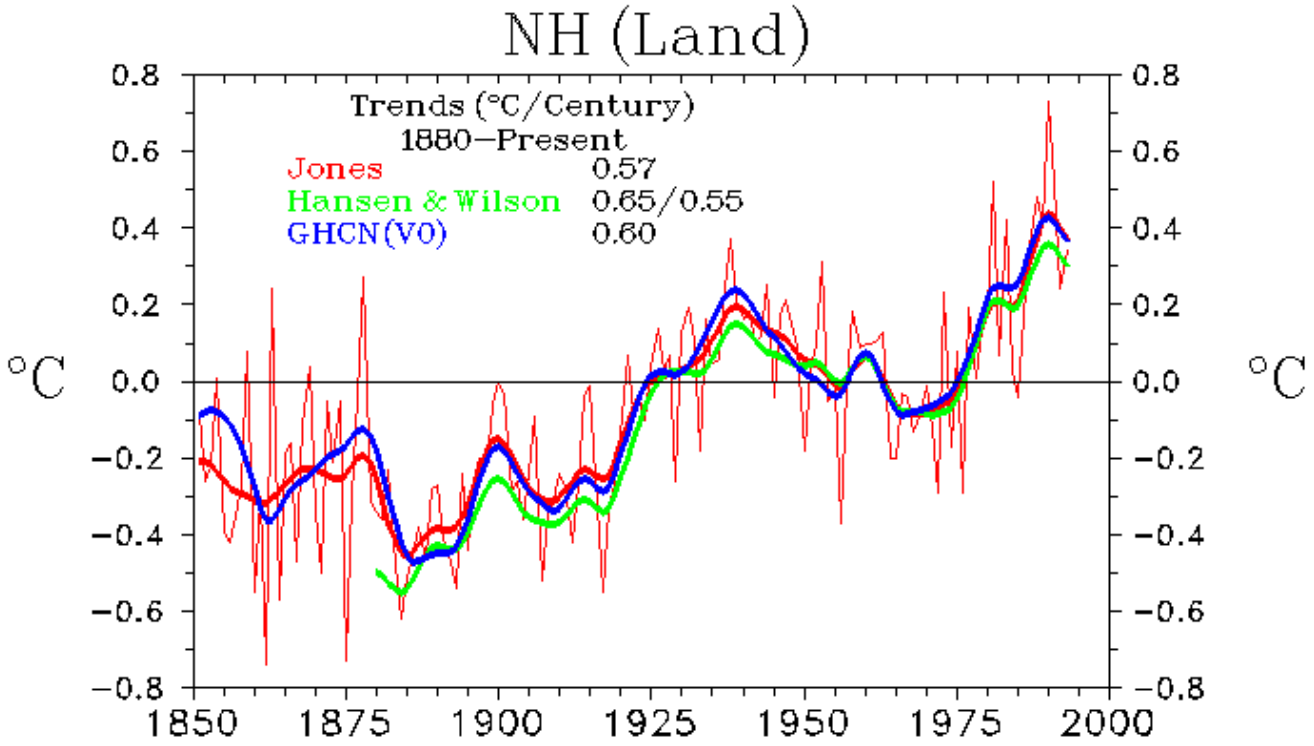
Antropogenic greenhouse effect = CO_2 !

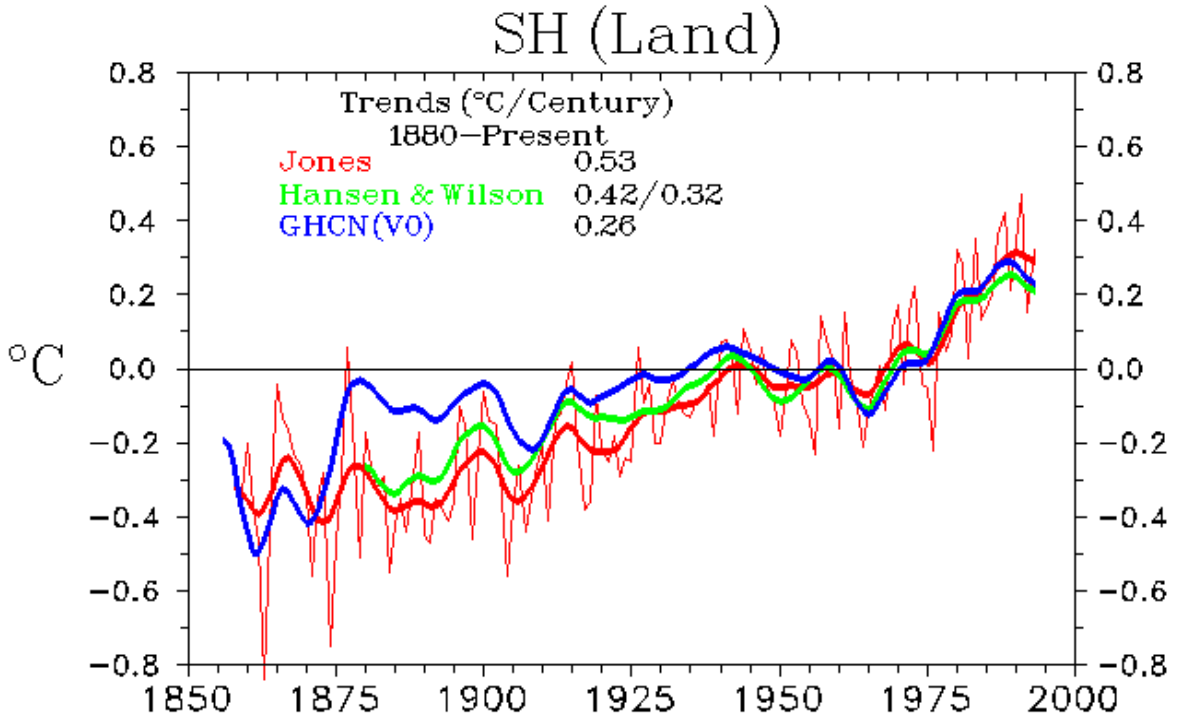
280 ppm → 400 ppm (>1/3)

Efekt cieplarniany ?

Tak!

Ale zróżnicowany

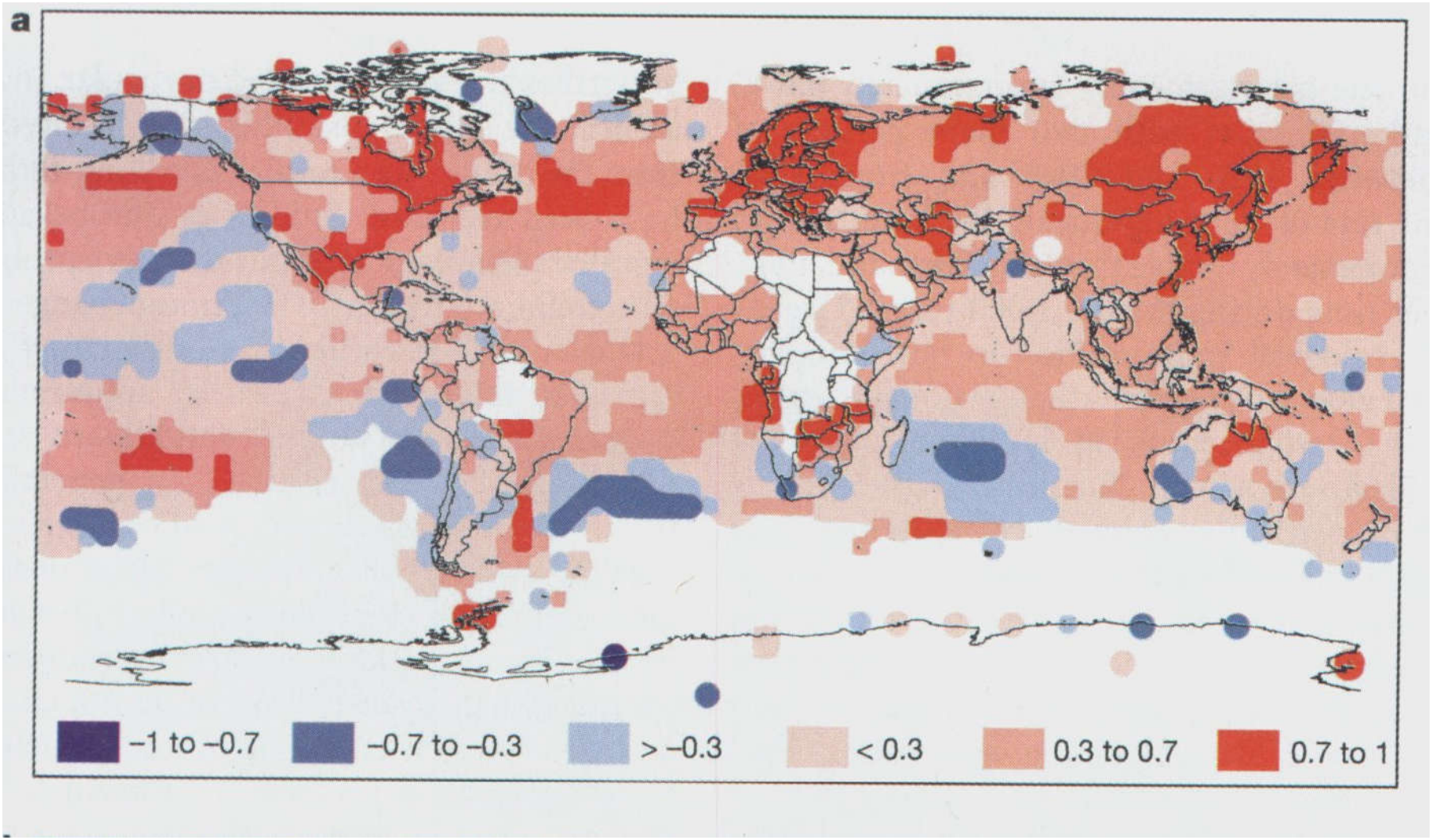




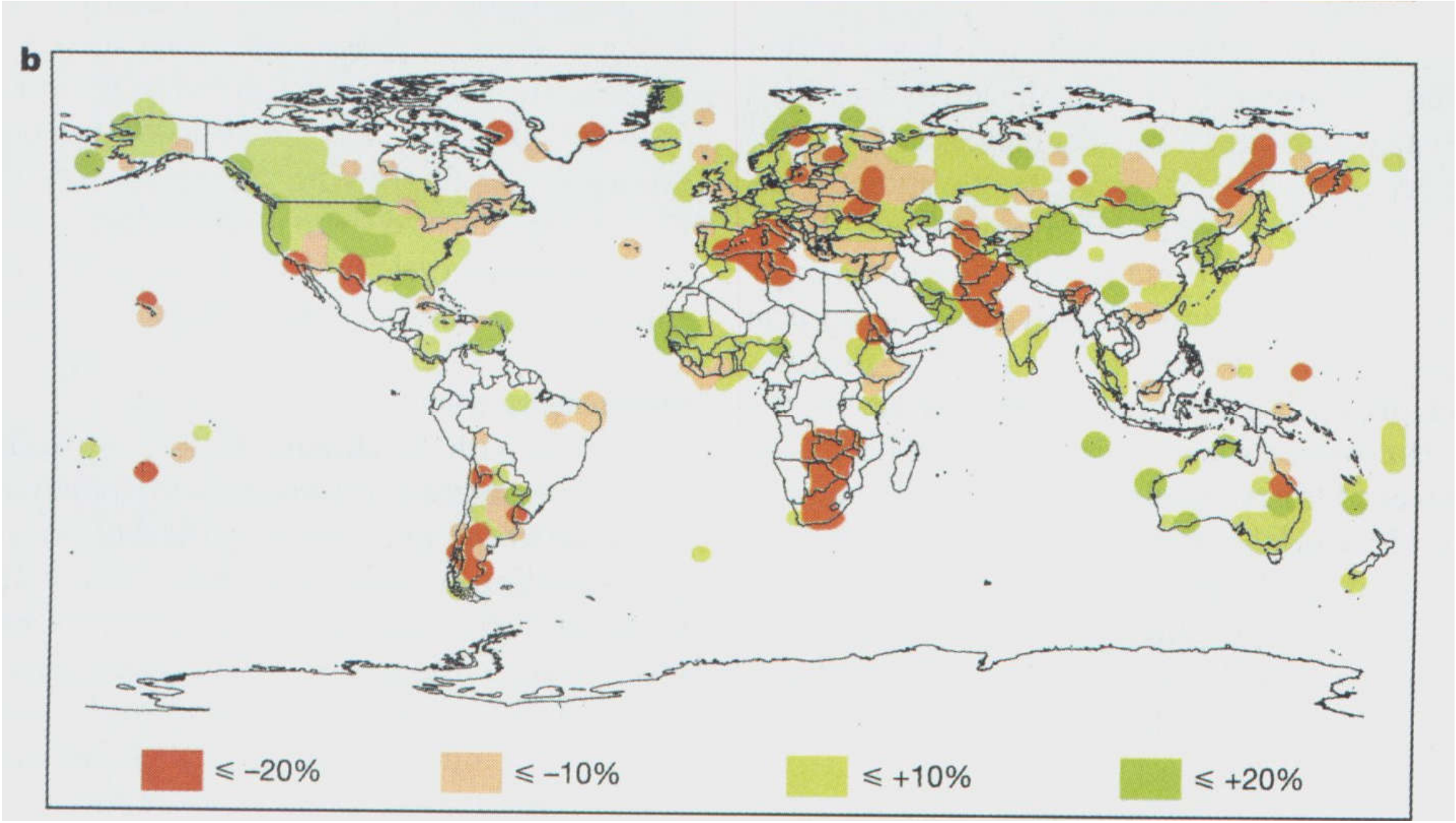
Półkula południowa: głównie oceany

Source: NOAA, 1996

Efekt cieplarniany = grzanie, ale nie jednorodne (Syberia)



Efekt cieplarniany = susza (ale na pustyni, np. Kalahari)



Variazione di precipitazioni (da 1976)

Nature, 28.03.2002, p. 390

Effetto serra = clima **violento !**

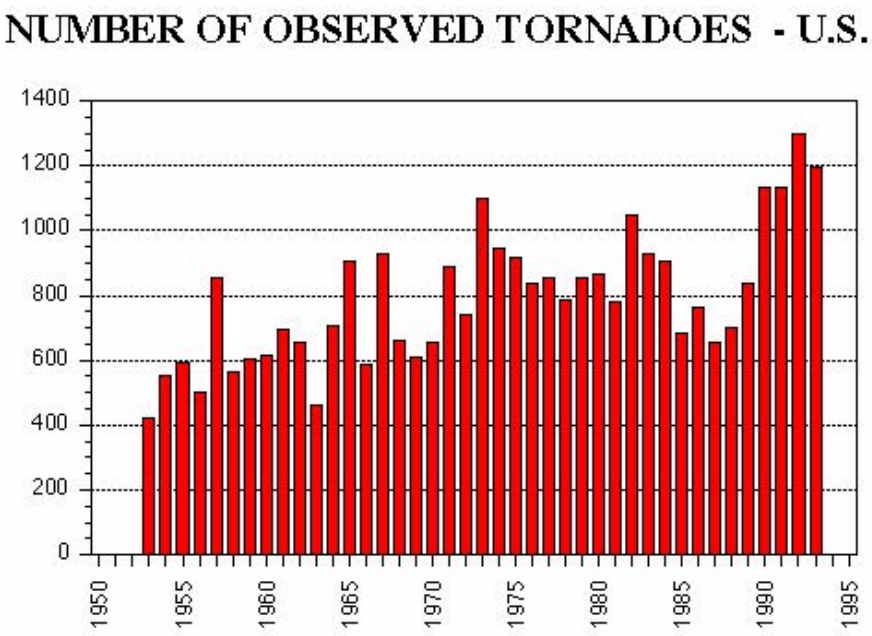
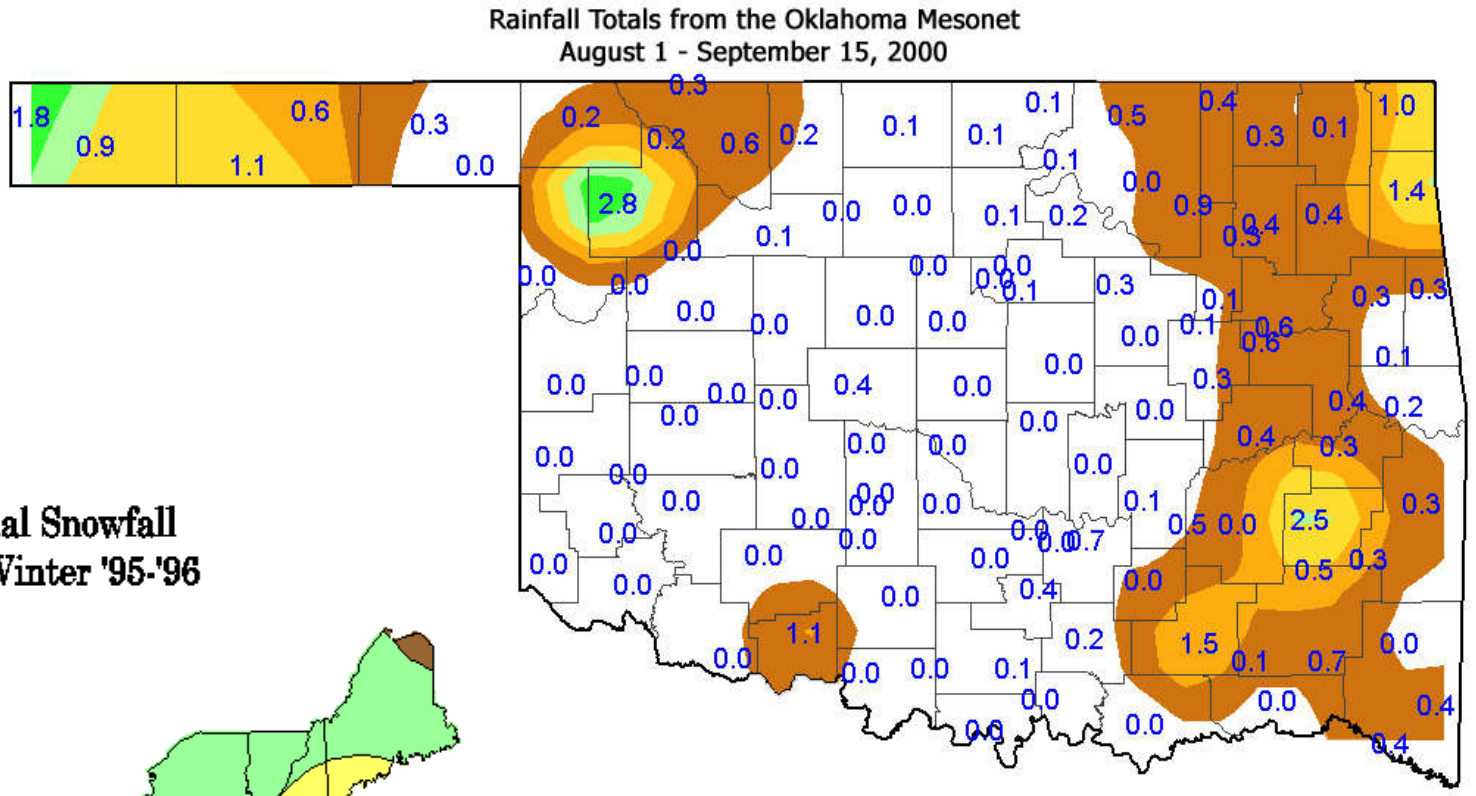


Foto: M. Karwasz, RAI

Efekt cieplarniany = klimat niestabilny

Oklahoma 08/2000



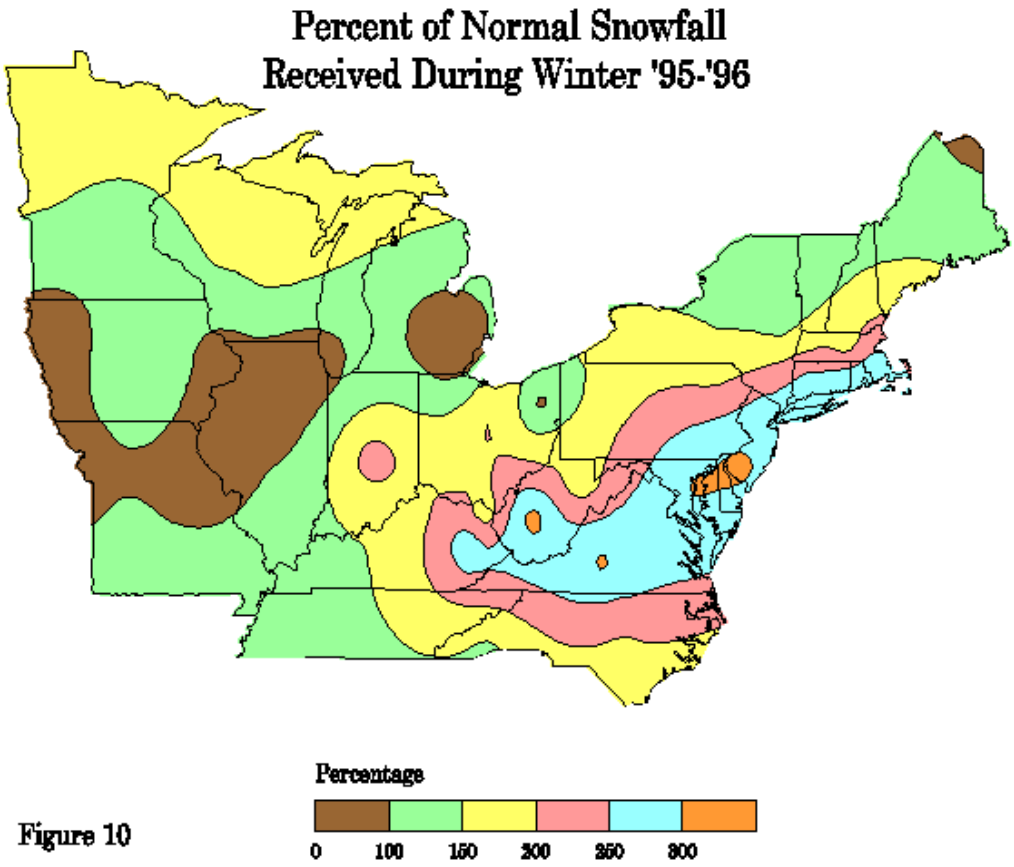


Figure 10

USA ‘95-96

Source: NOAA

Lodowce górskie

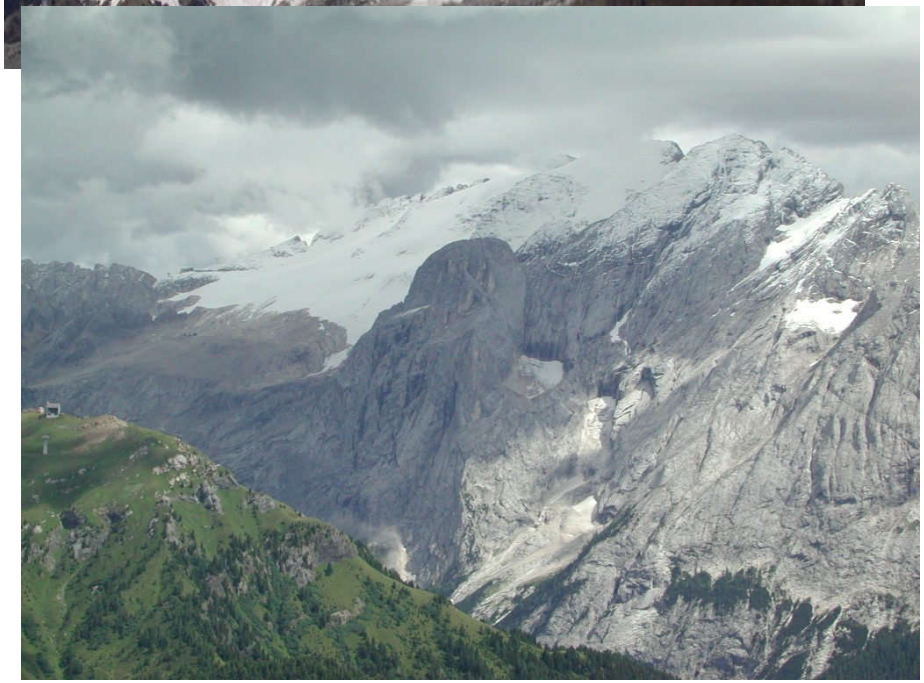
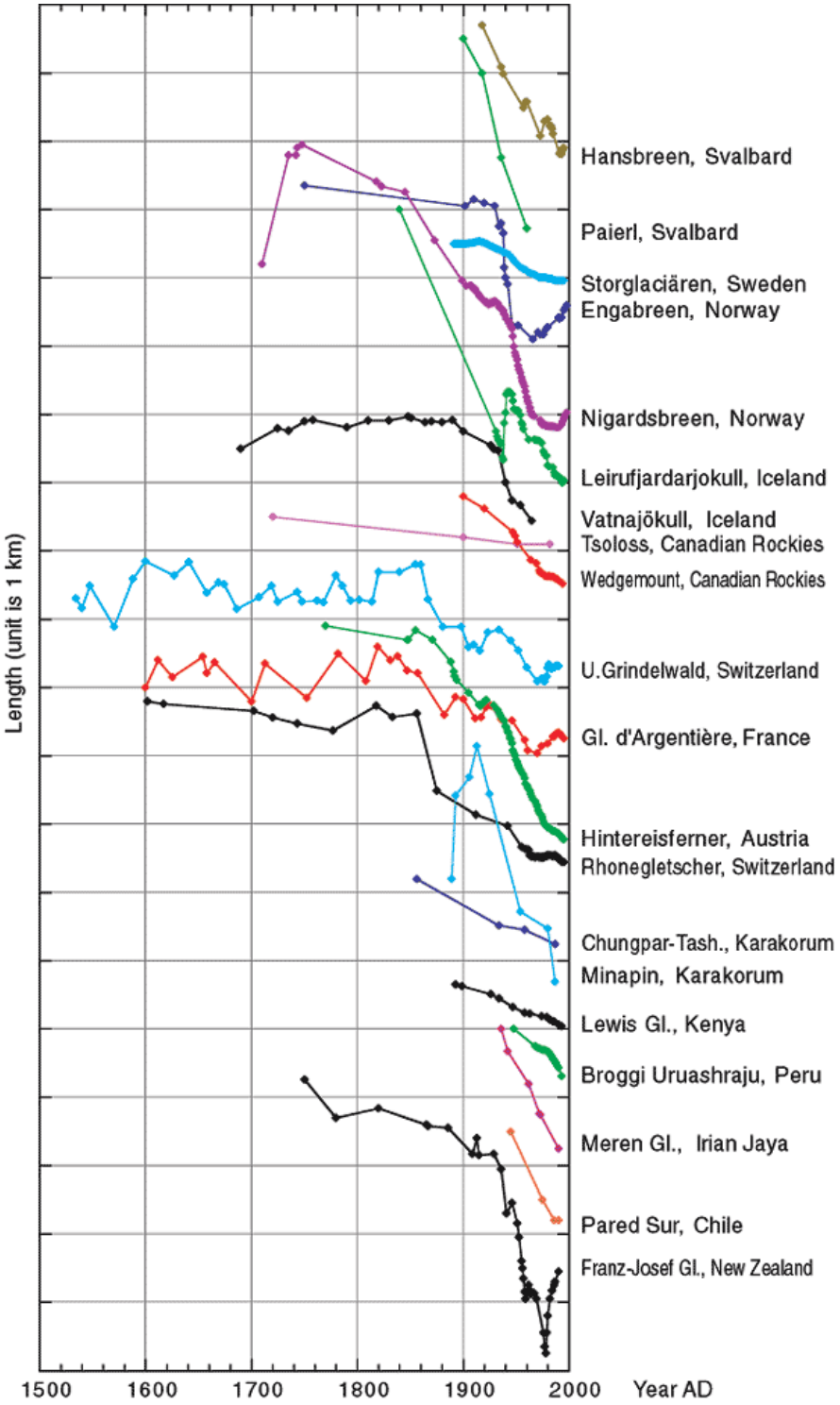
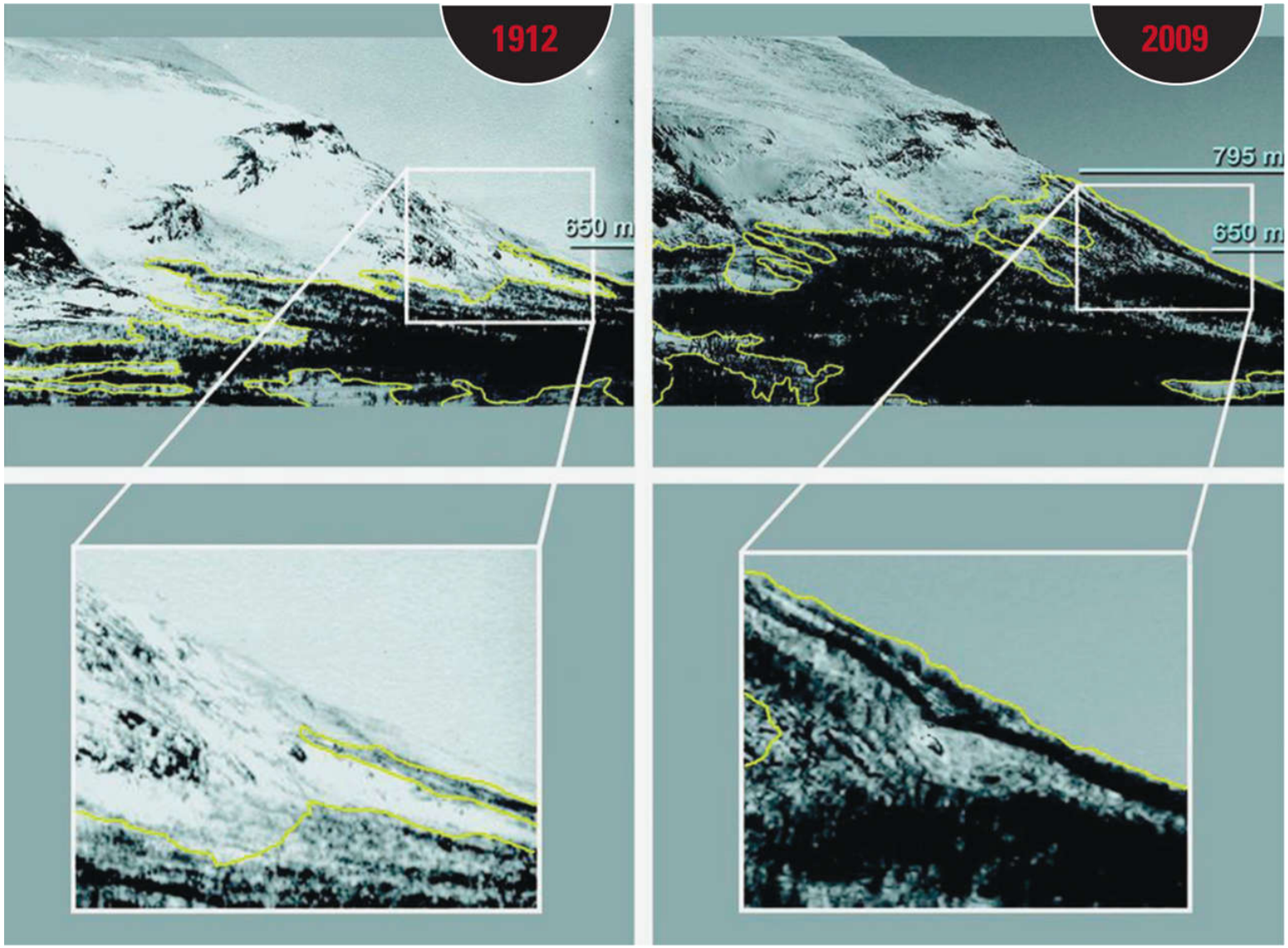


Photo: Maria Karwasz



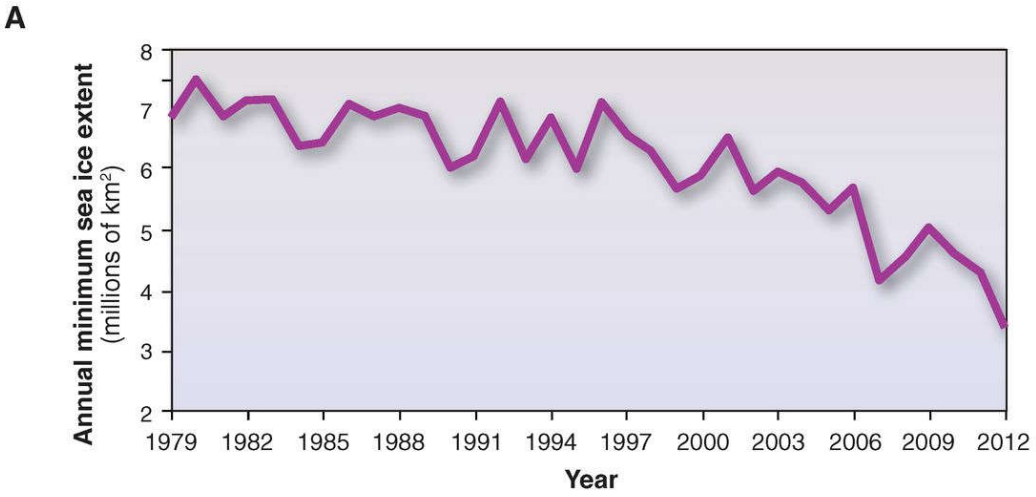
Forest in motion.In Sweden, trees moved up a mountain slope, but climate change was not the reason, removal of human impact was.



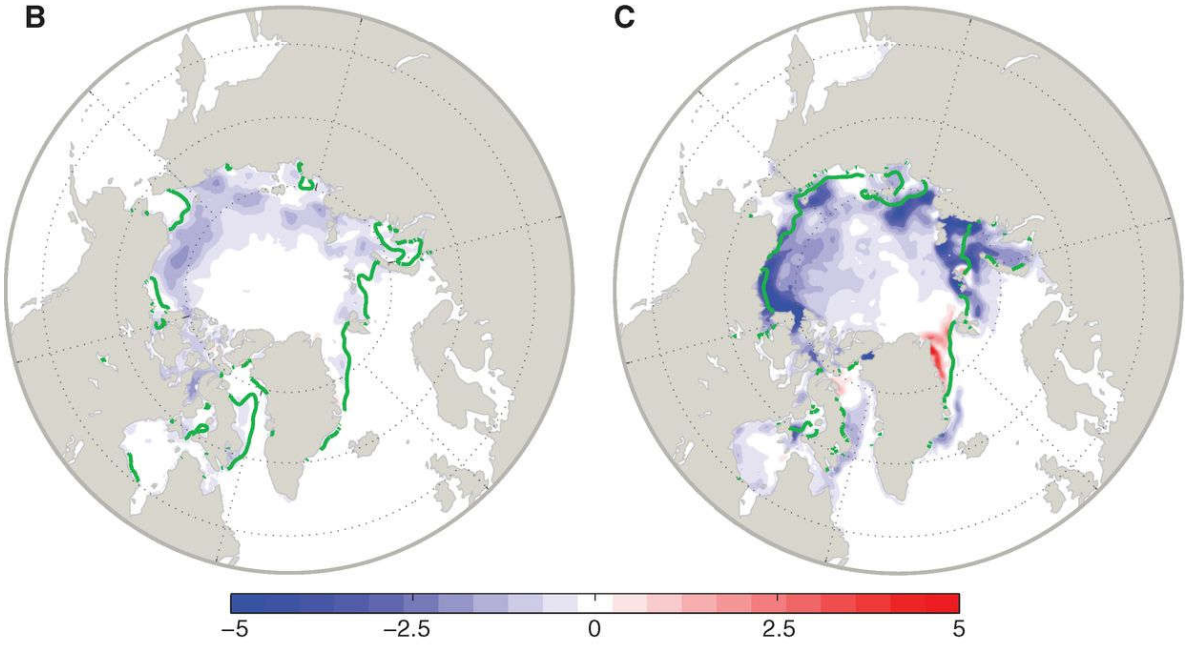
E Pennisi Science 2013;341:484-484

Szwecja

Lód na Oceanie Arktycznym



Marit-Solveig Seidenkrantz Centre for Past Climate Studies & Arctic Research Centre Department of Geoscience, Aarhus University (Denmark)



Minimalny zasięg pokrywy lodowej zmniejszył się o 50%

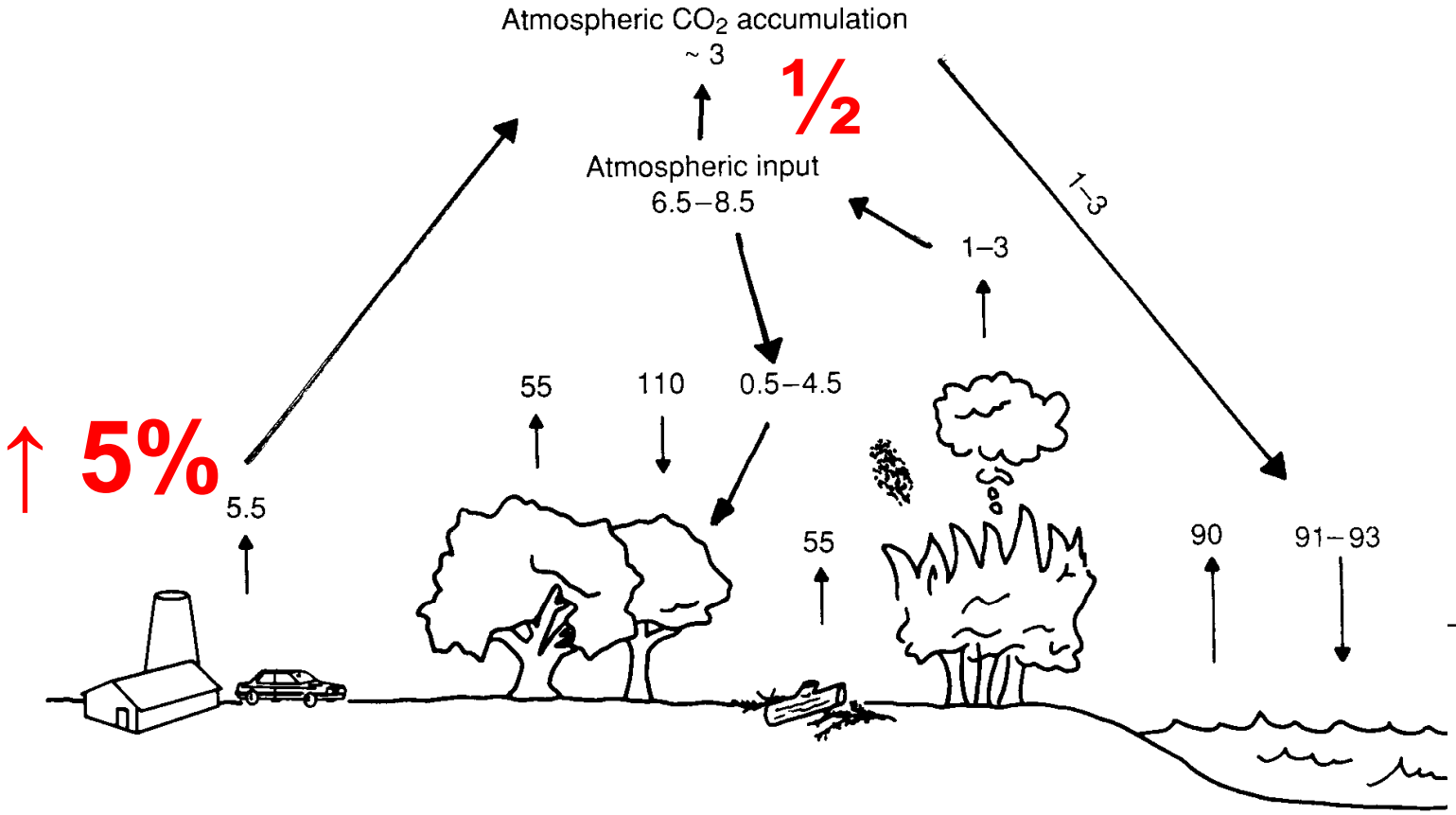
Science
AAAS

Fig. 2 Trends in arctic sea ice through time and space. Annual minimum sea-ice extent (A) has declined dramatically from 1979 to 2012.

E Post et al. Science 2013;341:519-524

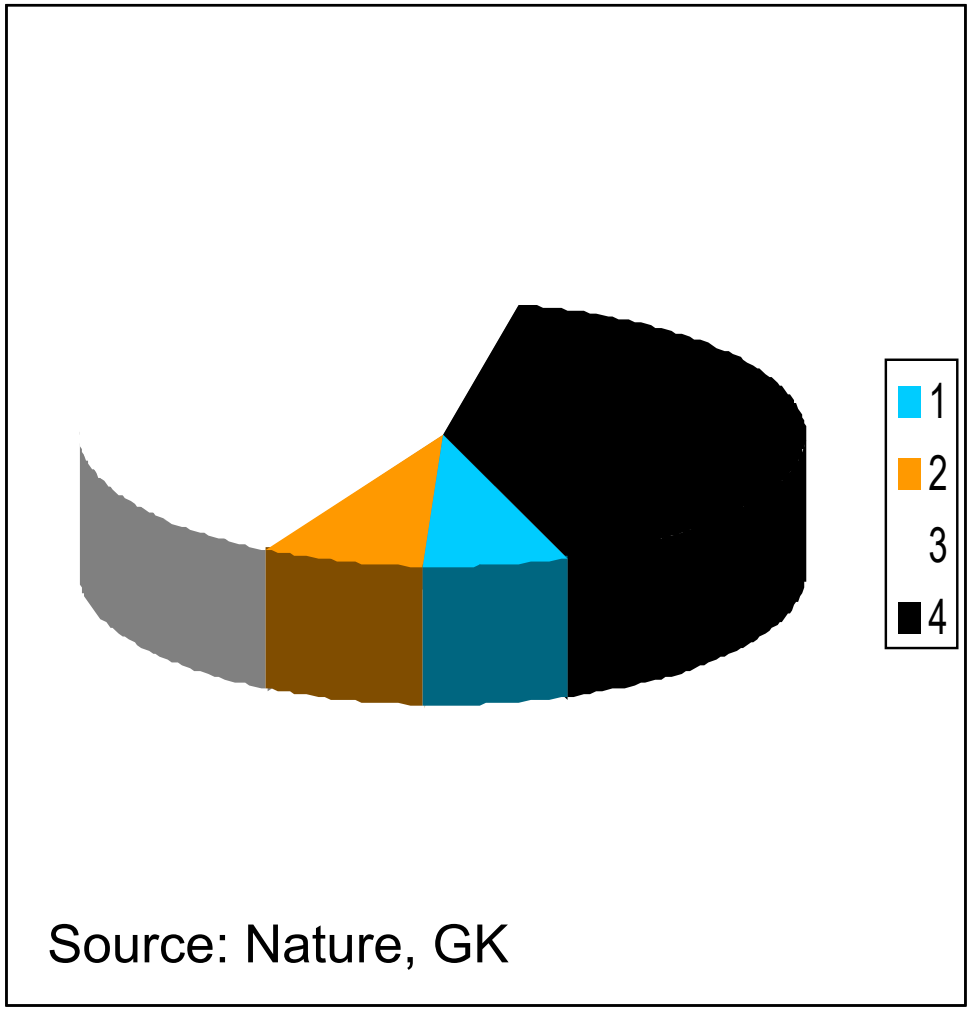
Source: Peixoto

Bilans węgle [Gt]:



Zasoby całkowite:

Reszta? Zjedzona (a raczej spalona)



Source: Nature, GK

Węgiel: 202 lat

Gaz: 55 lat

Ropa naftowa:

Daily consumption: 2,3 mln barels

resourced: 27 bln barels ??

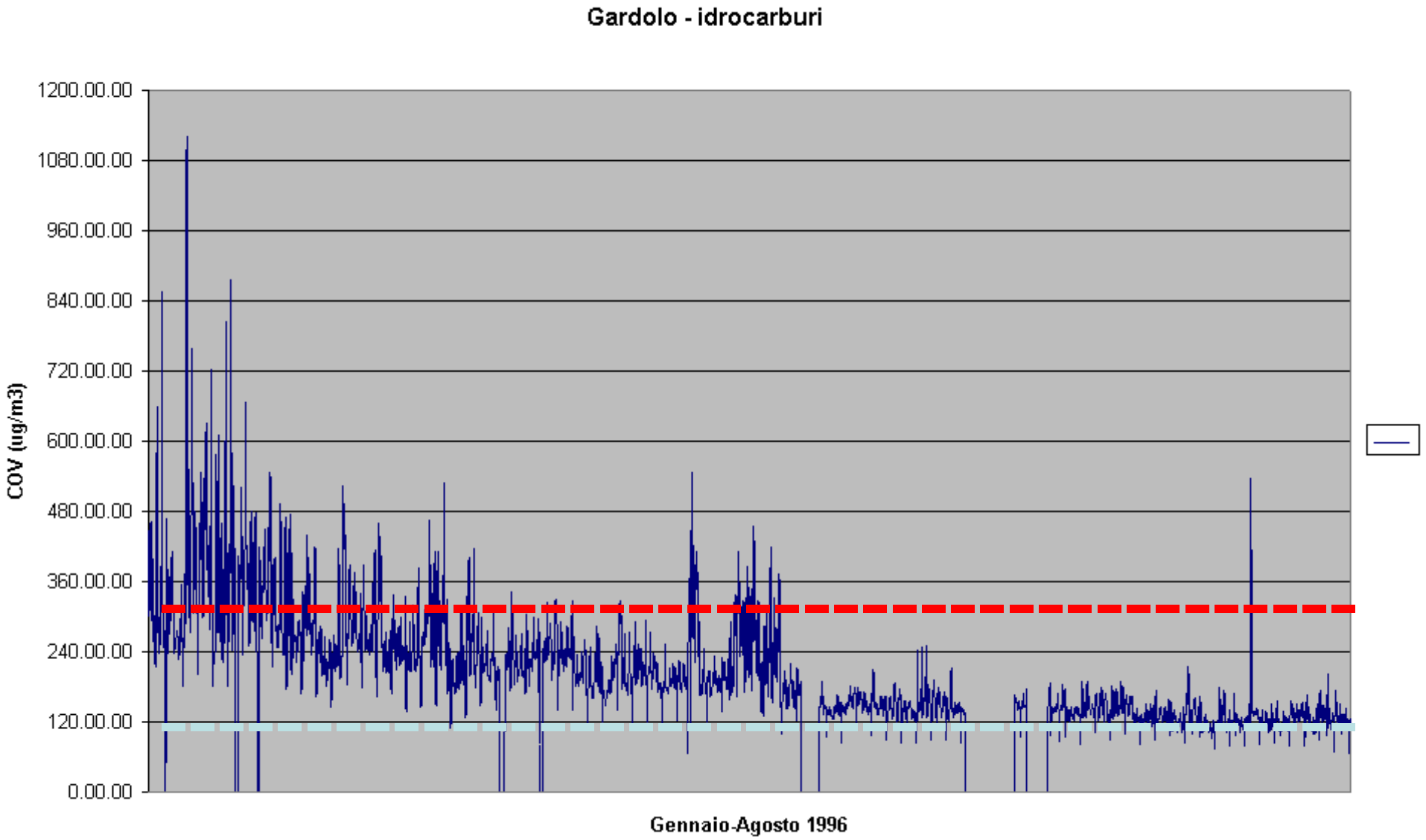
= 37 lat !!

“Nature”, 20.11.2002

Zanieczyszczenie atmosferyczne (lokalne):

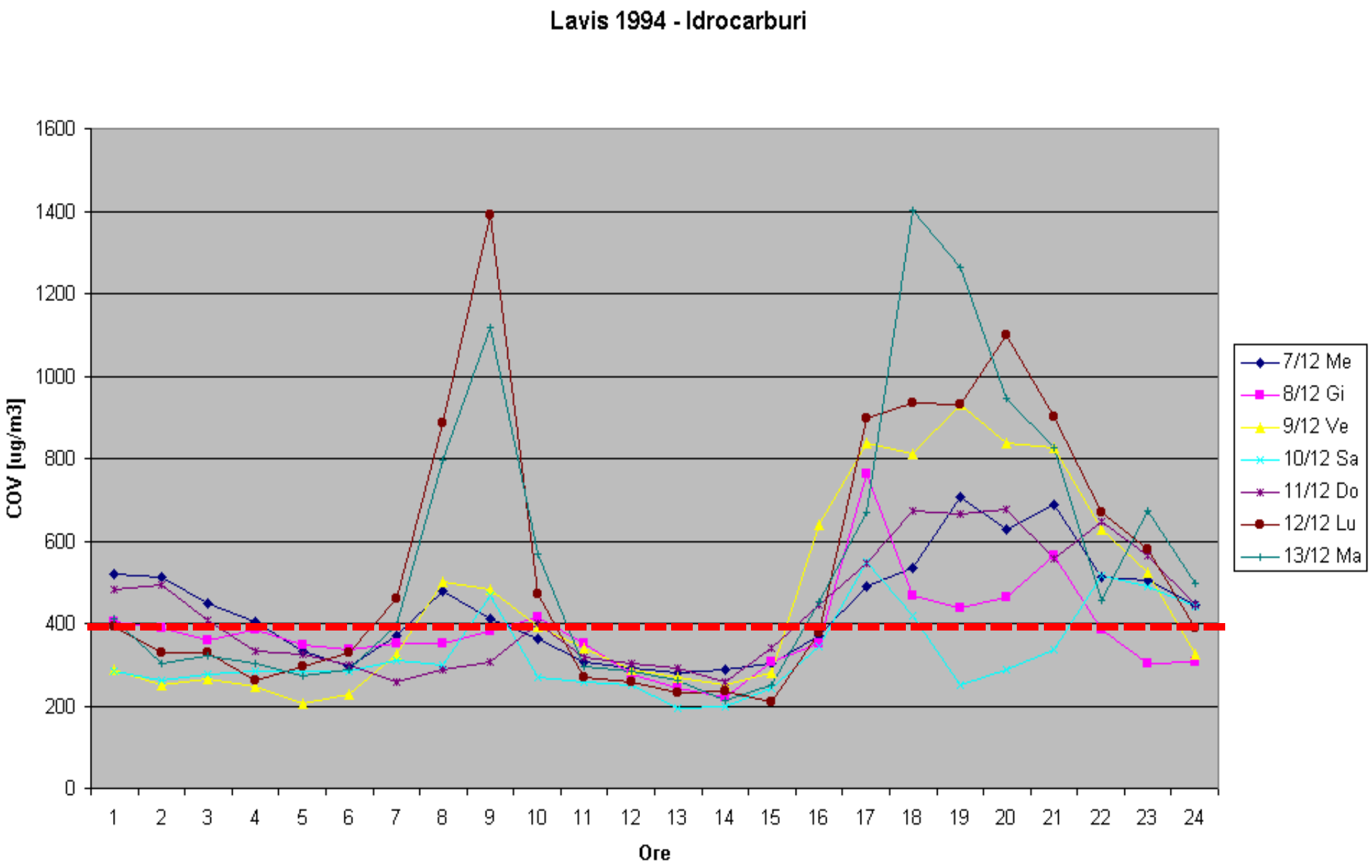
- Tlenek węgla CO 30 mg/m^3
- Mikropyły (PM10) 150 $\mu g/m^3$
- Tlenki azotu (NO, NO_2) 200 $\mu g/m^3$
- Dwutlenek siarki (SO_2) 15 mg/m^3
- ozon O_3 180 $\mu g/m^3$ (dla roślin 150 $\mu g/m^3$)
- Węglowodory (benzen) 15 $\mu g/m^3$

Zanieczyszczenie lokalne (węglowodory)



Data: APPT, analisis GK

Zanieczyszczenie lokalne (węglowodory – ruch drogowy)



Polska ma najbardziej zanieczyszczone powietrze w UE

30 gru 14.07:44

Skomentuj 0 Podziel się 0

fot. wburris, flickr,cc

Polska od lat ma najbardziej zanieczyszczone powietrze w Unii Europejskiej - alarmuje NIK. Izba wskazuje, że

- https://www.forbes.pl/csr/polska-ma-najbardziej-zanieczyszczone-powietrze-w-ue/sfb3hlm

Polska: jakość powietrza (I)

Polska od lat ma najbardziej zanieczyszczone powietrze w Unii Europejskiej - alarmuje NIK. Izba wskazuje, że mimo iż samorządy wydawały pieniądze na walkę z zanieczyszczeniami, jakość powietrza, którym oddychamy, poprawiła się tylko nieznacznie

Najwyższa Izba Kontroli w opublikowanym w poniedziałek raporcie podkreśliła, że niespełnienie standardów jakości powietrza, które są określone w prawie unijnym (tzw. dyrektywa CAFE), może kosztować Polskę nawet 4 mld zł kary.

3. Kraków
…
10. Katowice

Izba powołała się na dane OECD, które wskazują, ze ponad 3,5 mln osób na świecie przedwcześnie umiera z powodu chorób wywoływanych **zanieczyszczonym powietrzem**. W Polsce szacuje się, że rocznie z tego powodu może tracić życie nawet 45 tys. osób.

"Niestety dane te, choć są szokujące, nie powinny dziwić, skoro Polska od lat ma najbardziej zanieczyszczone powietrze w całej Unii. Według informacji Europejskiej Agencji Środowiska aż 6 polskich miast znalazło się w pierwszej dziesiątce miast europejskich z największą liczbą dni w roku, w których przekroczono dobowe dopuszczalne stężenie pyłu PM10 (pozostałe cztery miasta są w Bułgarii)" - dodano w raporcie.

Benzo-piren a rak

exposure (Maynard et al., 1997).

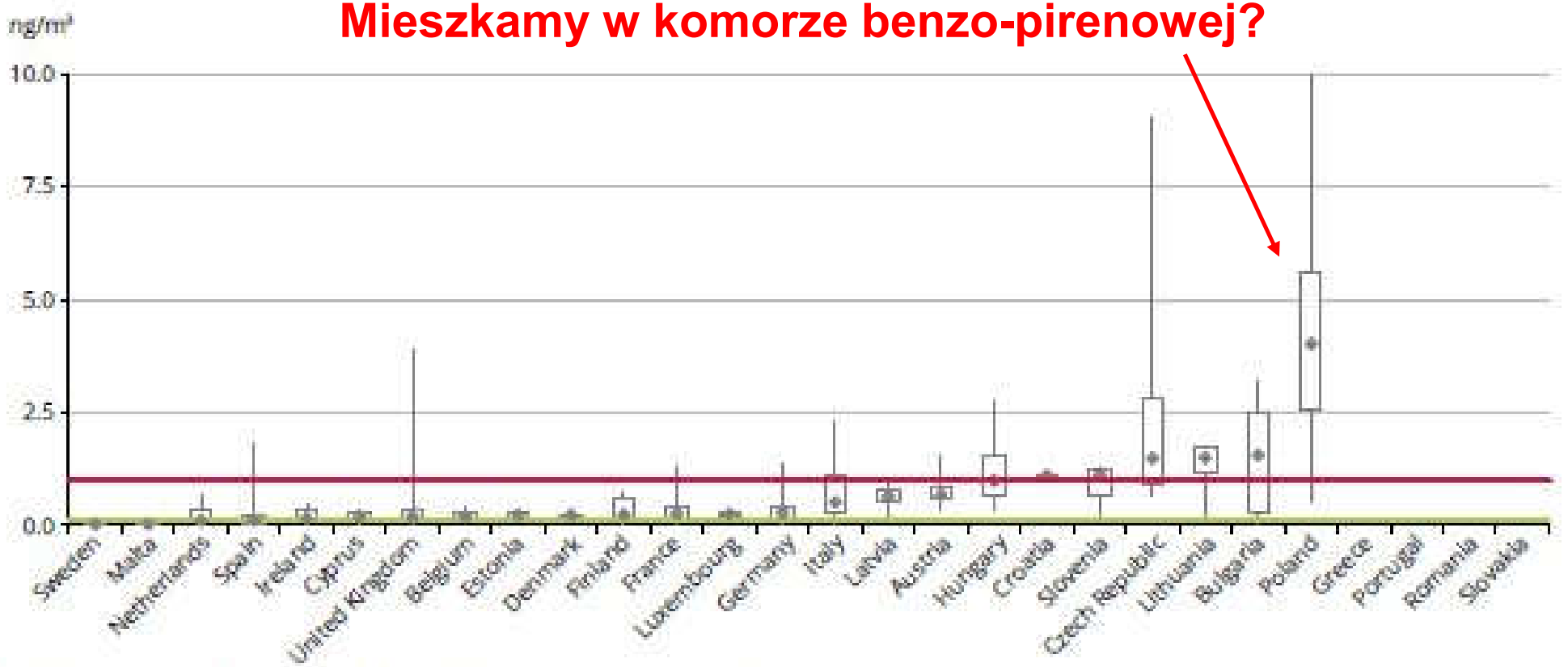
PAH=poli-aromatic-hydrocarbons

The UK Expert Panel on Air Quality Standards (EPAQS) used the scientific expert judgment approach to set the UK PAH standard for ambient air. EPAQS considered the PAH mixture described in an epidemiological study in an aluminum smelter in Canada, where high exposures were linked to lung cancers (Armstrong et al., 1994), as the best starting point for the derivation of the standard. Armstrong et al. (1994) identified that an exposure to of a mixture of PAH compounds represented by 0.25–2.5 μg/m^3 BaP during a working life (40 years) was associated with a 50% increase in the risk of lung cancer. The lower bound of this range, 0.25 μg/m^3 of BaP, was taken as representing the lowest observed adverse effect level (LOAEL). Three safety factors of 10 were used to account for (a) moving from a LOAEL to a no observed adverse effect level (NOAEL), (b) extrapolating from a working life exposure to an entire lifetime exposure, and (c) accounting for the range of sensitivity to carcinogens likely to exist in the general population. Hence, EPAQS selected the value of 0.25 ng/m^3 of BaP as the UK air quality standard (EPAQS, 1999).

Benzopiren w Polsce: 4 ng/m^3

Map 10.1 **Population-weighted concentration field of annual mean BaP in 2012**

Figure 6.1 **Attainment situation for BaP in 2013 in the EU-28**



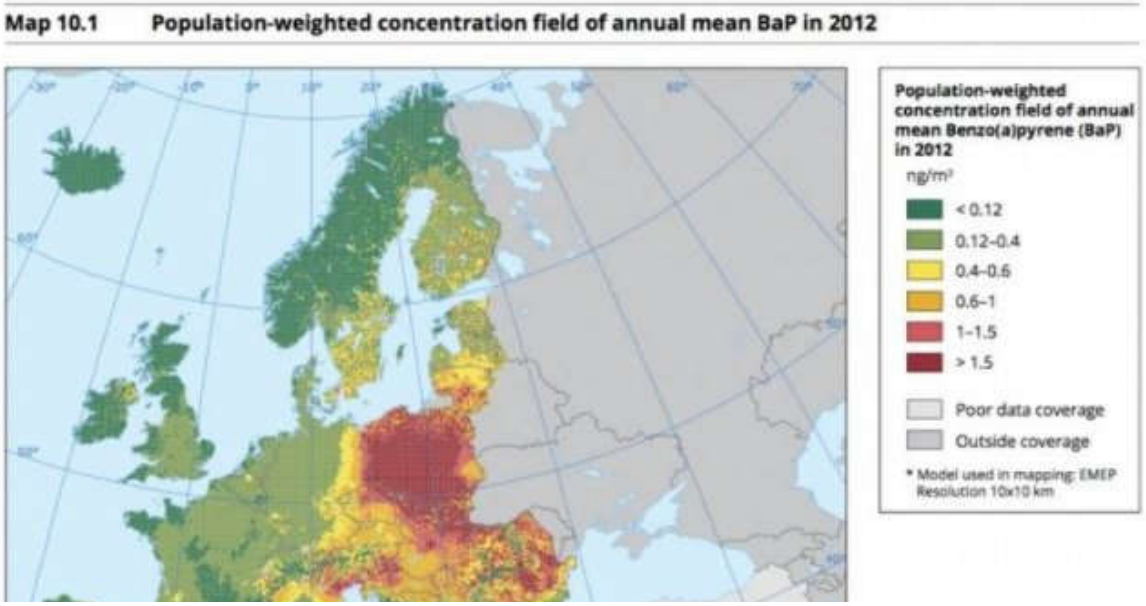
Notes: The graph is based on the annual mean concentration values for each Member State. For each country, the lowest, highest and median values (in ng/m³) at the stations are given. The rectangles give the 25 and 75 percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The target value set by EU legislation is marked by the red line. The estimated air quality reference level is marked by the green line.

Source: Based on Air Quality e-reporting database (EEA, 2015a).

Polska: jakość powietrza (II)

FOCUS.pl

1/2



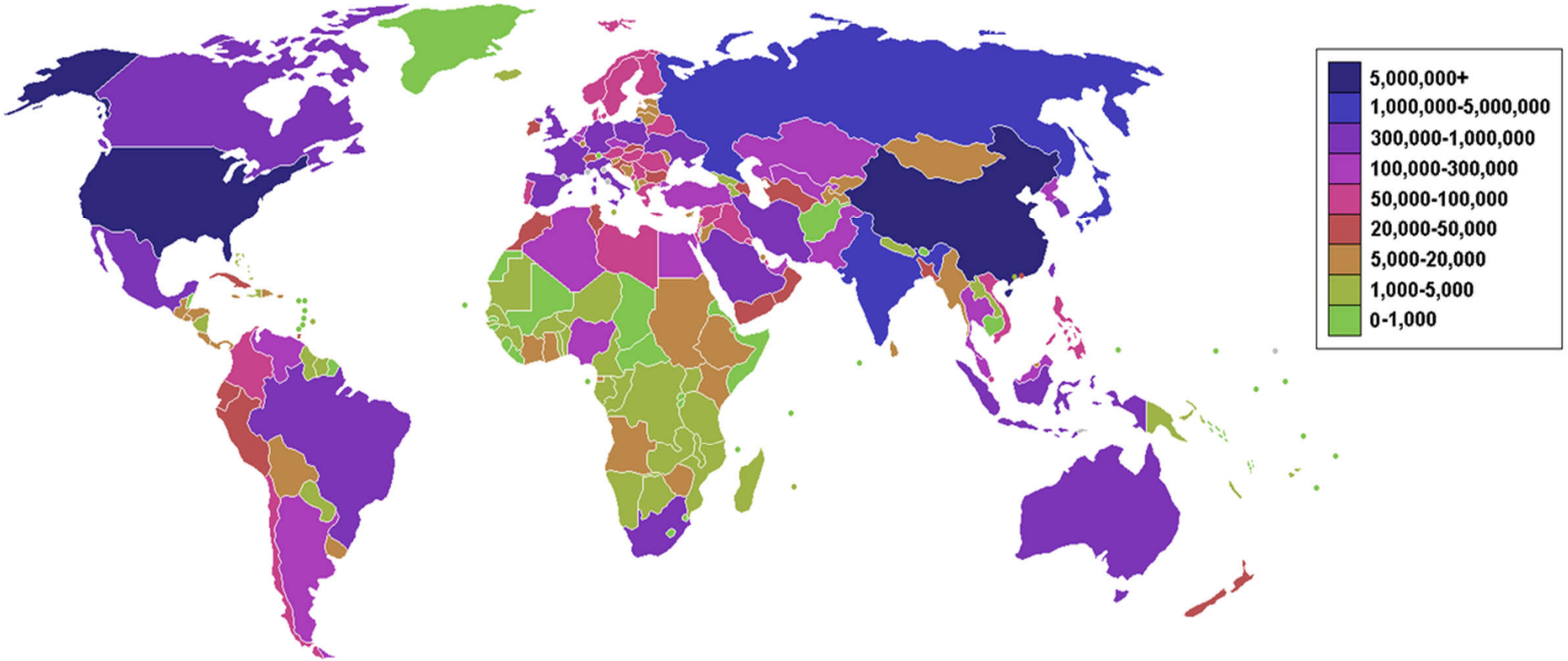
Polska na czele krajów zatruwających powietrze w Unii Europejskiej

1/2. Polska na czele krajów zatruwających powietrze w Unii Europejskiej

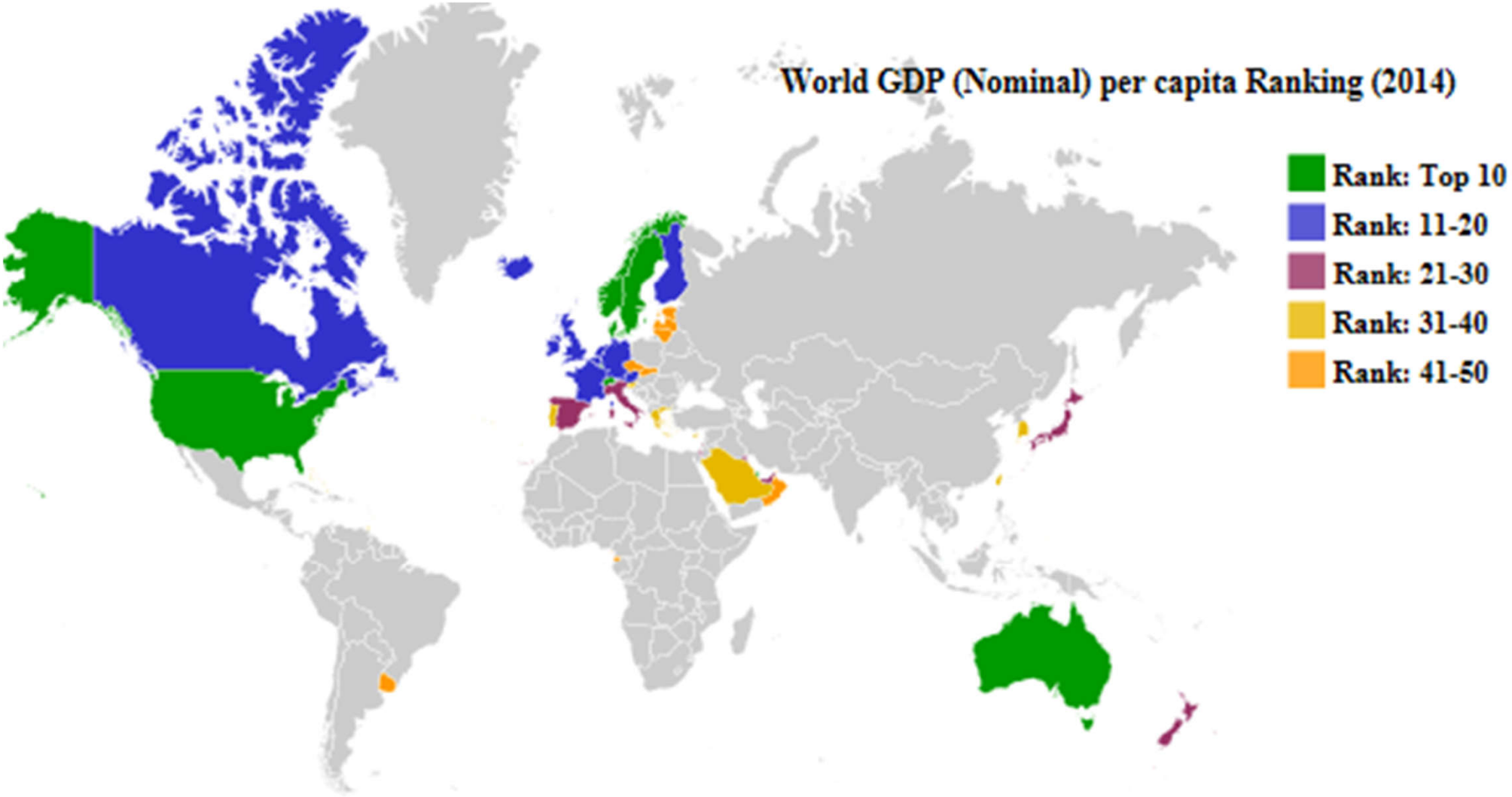
Stężenie benzopirenu w powietrzu

NIK wskazała, że największym problemem dla jakości powietrza w Polsce jest ponadnormatywne stężenie pyłu zawieszonego (PM10 i PM2,5) oraz benzo(a)pirenu (B(a)P). "Wysokie stężenie pyłu zawieszonego powoduje i pogłębia choroby płuc i układu krążenia. Z kolei benzo(a)piren jest związkiem silnie rakotwórczym. Tymczasem we wszystkich kontrolowanych miastach w 2013 r. dopuszczalne stężenie benzo(a)pirenu przekroczone zostało średnio o 500 proc. Najwyższe stężenie B(a)P odnotowano w Nowym Sączu - limity przekroczone jedenastokrotnie, a w Głubczycach (w woj. opolskim) dziesięciokrotnie. Z kolei w czterech miastach (Kraków, Nowy Sącz, Katowice i Dąbrowa Górnicza) przekroczone zostało średnioroczne stężenie PM10. W skali kraju w latach 2010-2013 przekroczono dopuszczalne poziomy pyłu PM10 w ponad 75 proc. wszystkich stref, w których dokonuje się oceny jakości powietrza, a w przypadku benzo(a)pirenu w ok. 90 proc. stref" - czytamy w raporcie.

Emisja CO_2 (całkowita)

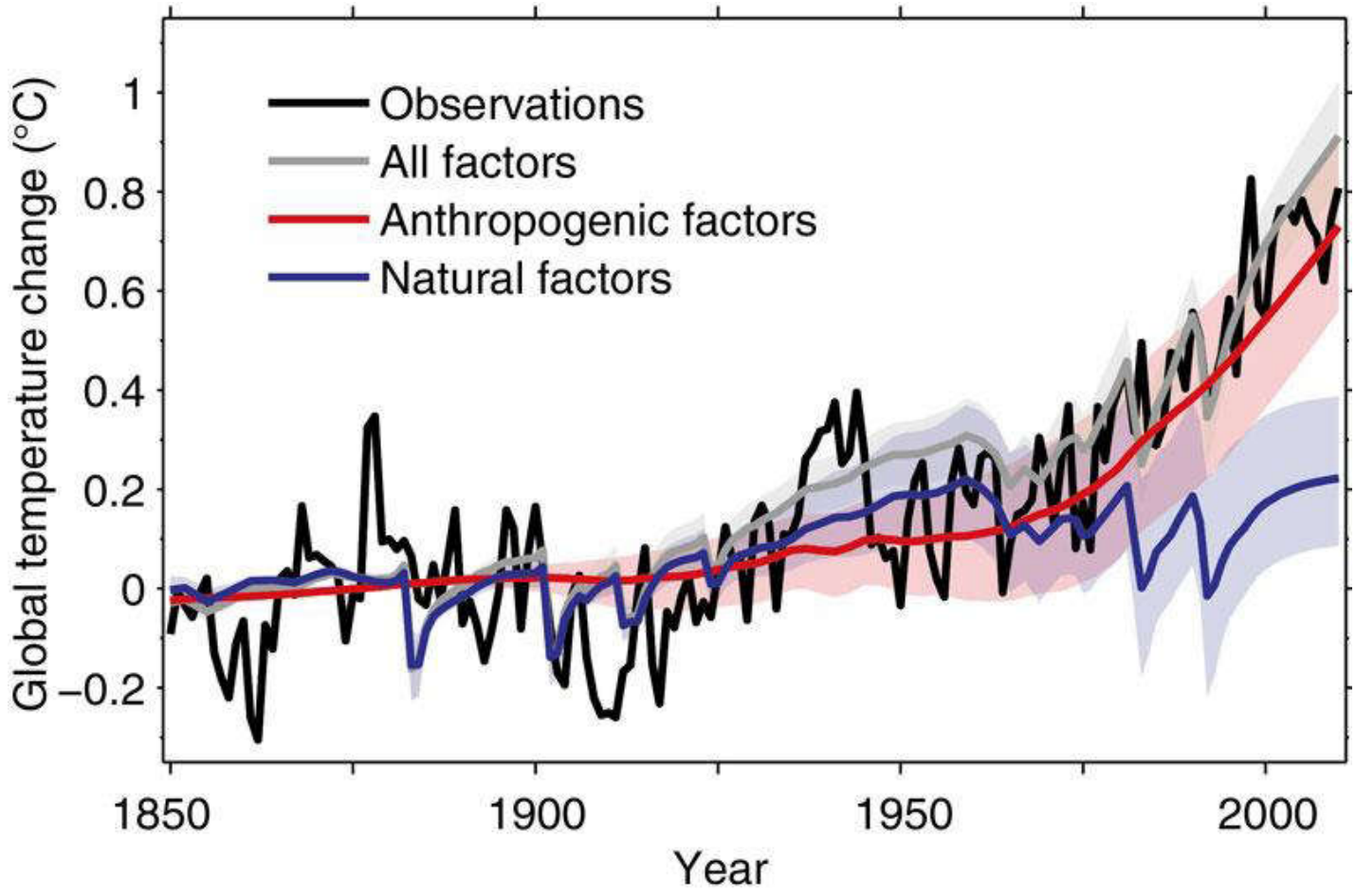


GDP per capita (2014)



http://statisticstimes.com/economy/world-gdp-capita-ranking.php

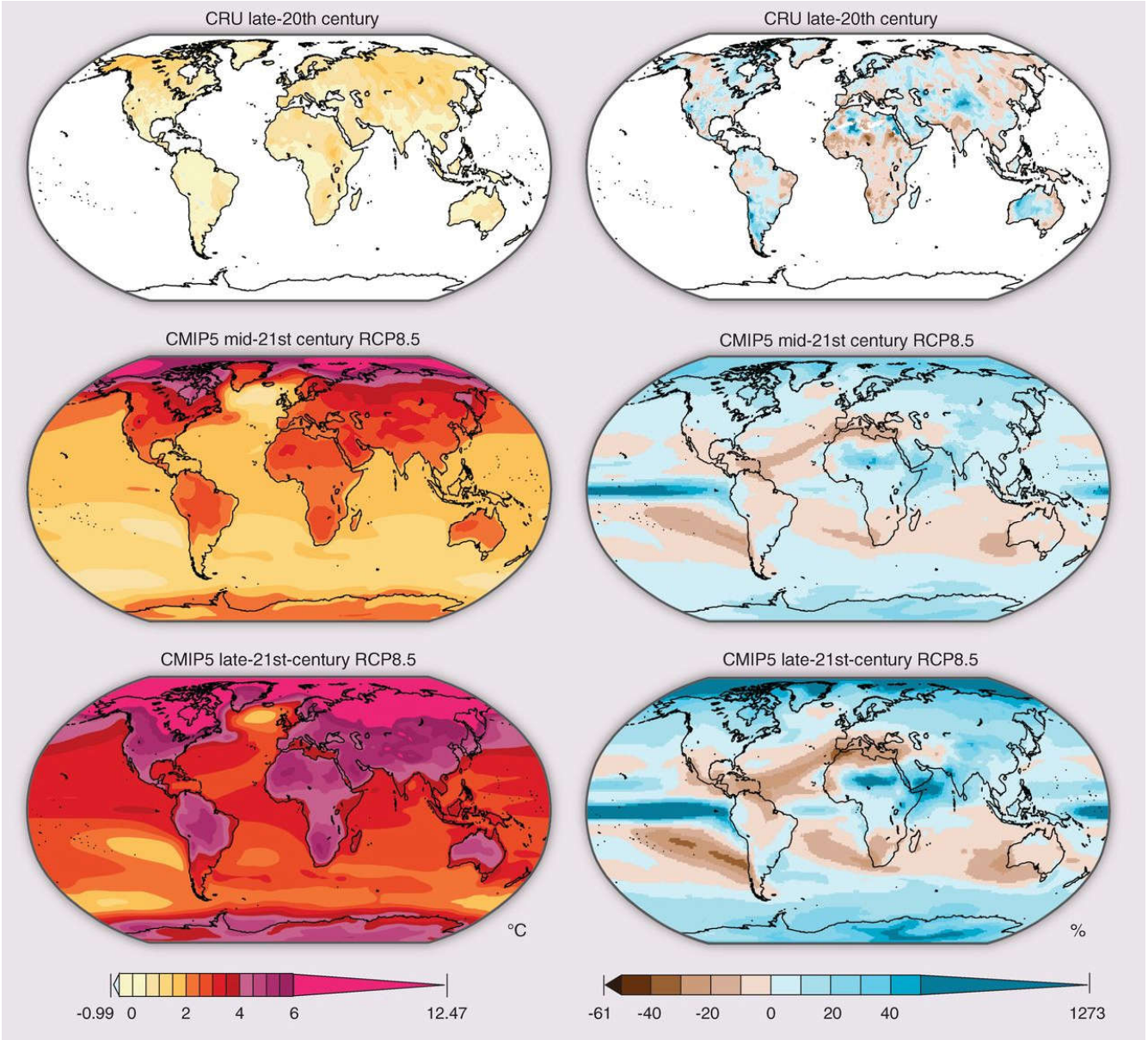
Prognoza (Physics World, 2012)



Globalne ocieplenie przyspiesza:
nie uwzględniliśmy sprzężeń zwrotnych!

Fig. 1 Observed and projected changes in annual temperature and precipitation.(Top) Climatic Research Unit (CRU) observations (which are available only over land), calculated as 1986–2005 minus 1956–1975.

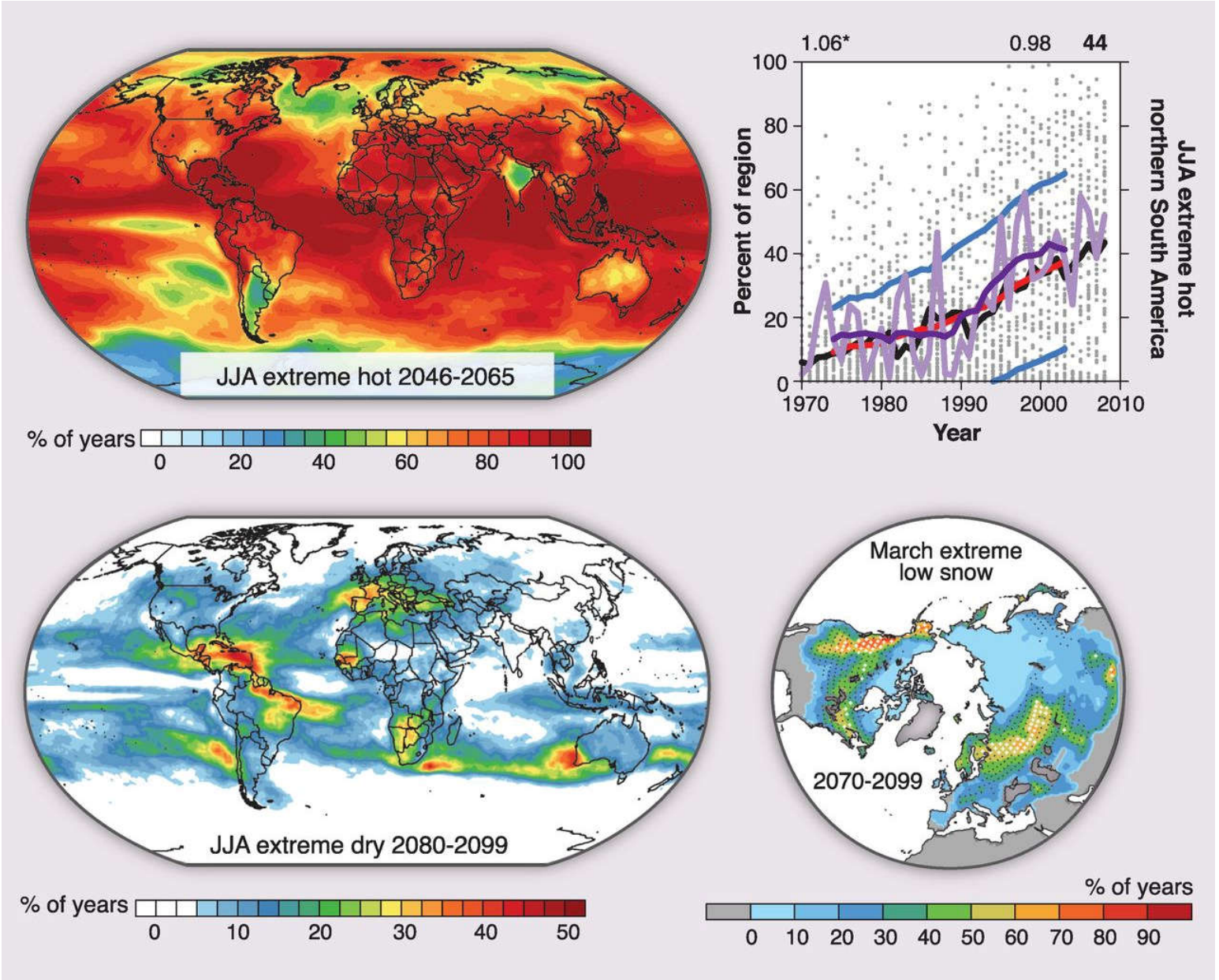
Future?



N S Diffenbaugh, and C B Field Science 2013;341:486-492

Published by AAAS

Fig. 2 Changes in seasonal extremes.(Left) The frequency of the 1986–2005 maximum June-July-August (JJA) temperature (top left) and minimum JJA precipitation (bottom left) in the 2046–2065 and 2080–2099 periods of RCP8.5 [from (65)].



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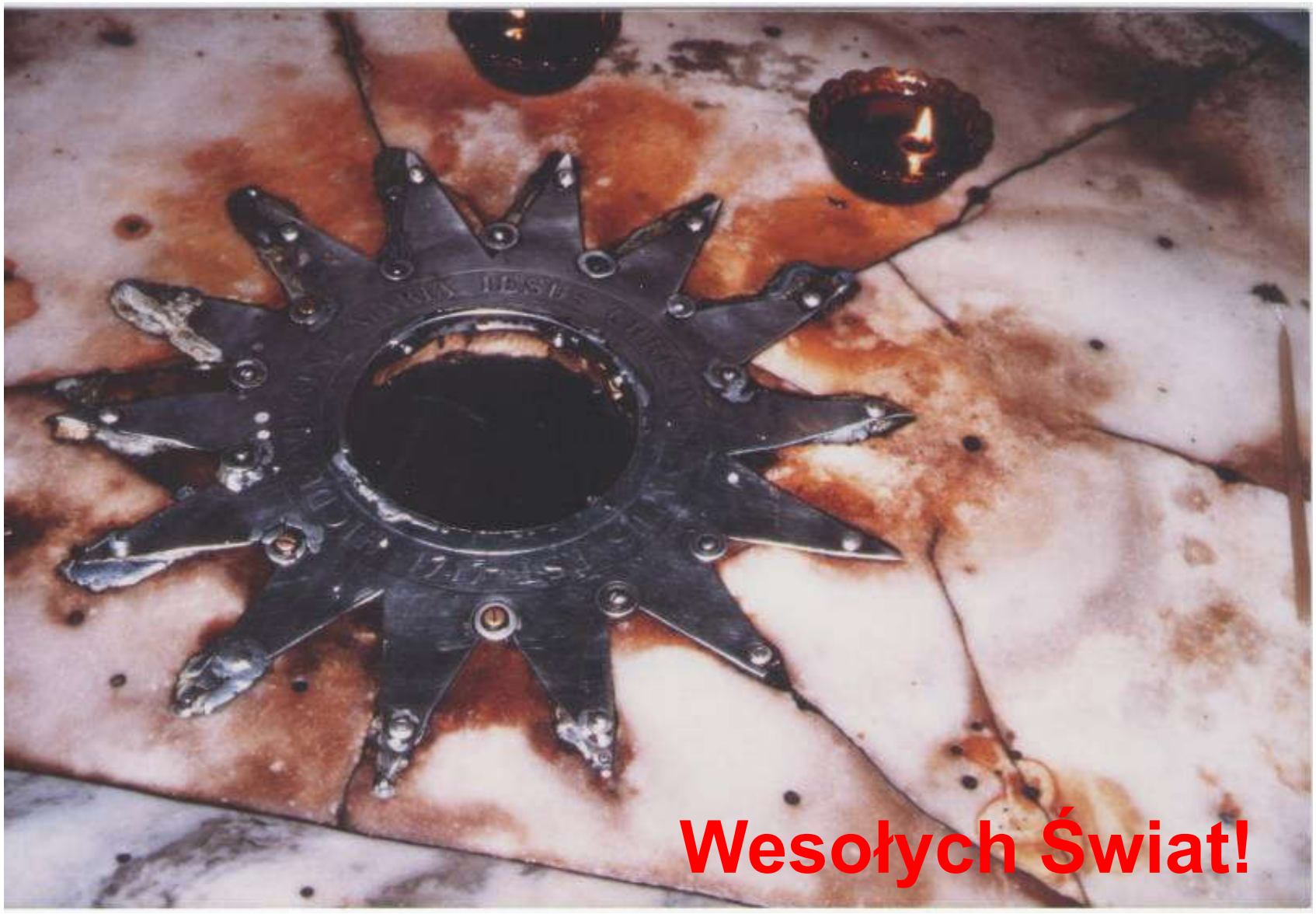
N S Diffenbaugh, and C B Field Science 2013;341:486-492


Dziękuję za uwagę !

Termojądrowy reaktor przemysłowy
stanie w Korei w 2050 roku
We work for you...!

Energia z gwiazd



Basilica di Nativita', Betlejem, foto GK, 1999

~~**C a r b o n i o**~~

↓

Effetto serra, inquinamento etc. ↓

1. Eliminare carbonio !

Carbone = 100%

Benzina (C_6H_{14}) ≈ 50%

Metano (CH_4) ≈ 20%

Idrogeno (H_2) ≈ 0%

2. Energie rinnovabili

Energy in last century

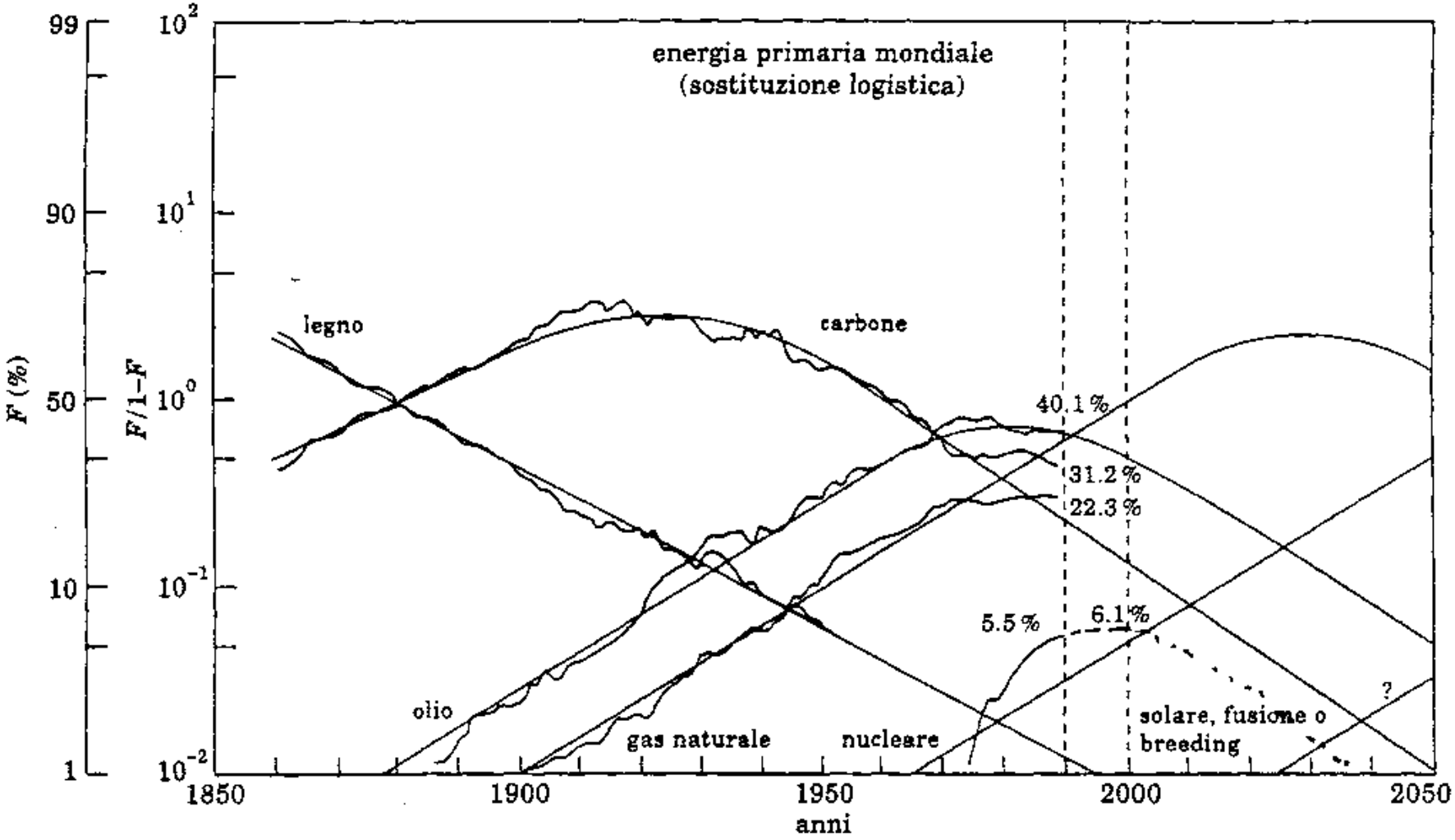


Fig. 3. – Analisi storica (IIASA, C. Marchetti) della evoluzione delle energie primarie a livello mondiale. Le curve di modello seguono i criteri logistici delle sostituzioni di mercato e si proiettano sugli anni futuri dando le previsioni fino al 2050.

Analysis 1995

Nuclear energy

Nuclear energy – hidden costs

Reactor Radioactive Waste Production

3 GW Thermal PWR Yearly Discharge ≈ 50 t

Nuclide	Half-Life (yrs)	kg
238Pu	88	4.5
239Pu	24000	166
240Pu	6600	77
241Pu	14	25
242Pu	380,000	16
237Np	2,000,000	15
241Am	432	17
243Am	7400	3
99Tc	200,000	25
129I	16,000,000	6
135Cs	3,000,000	10
93Zr	1,500,000	23
107Pd	6,500,000	7
90Sr	30	13
137Cs	30	31

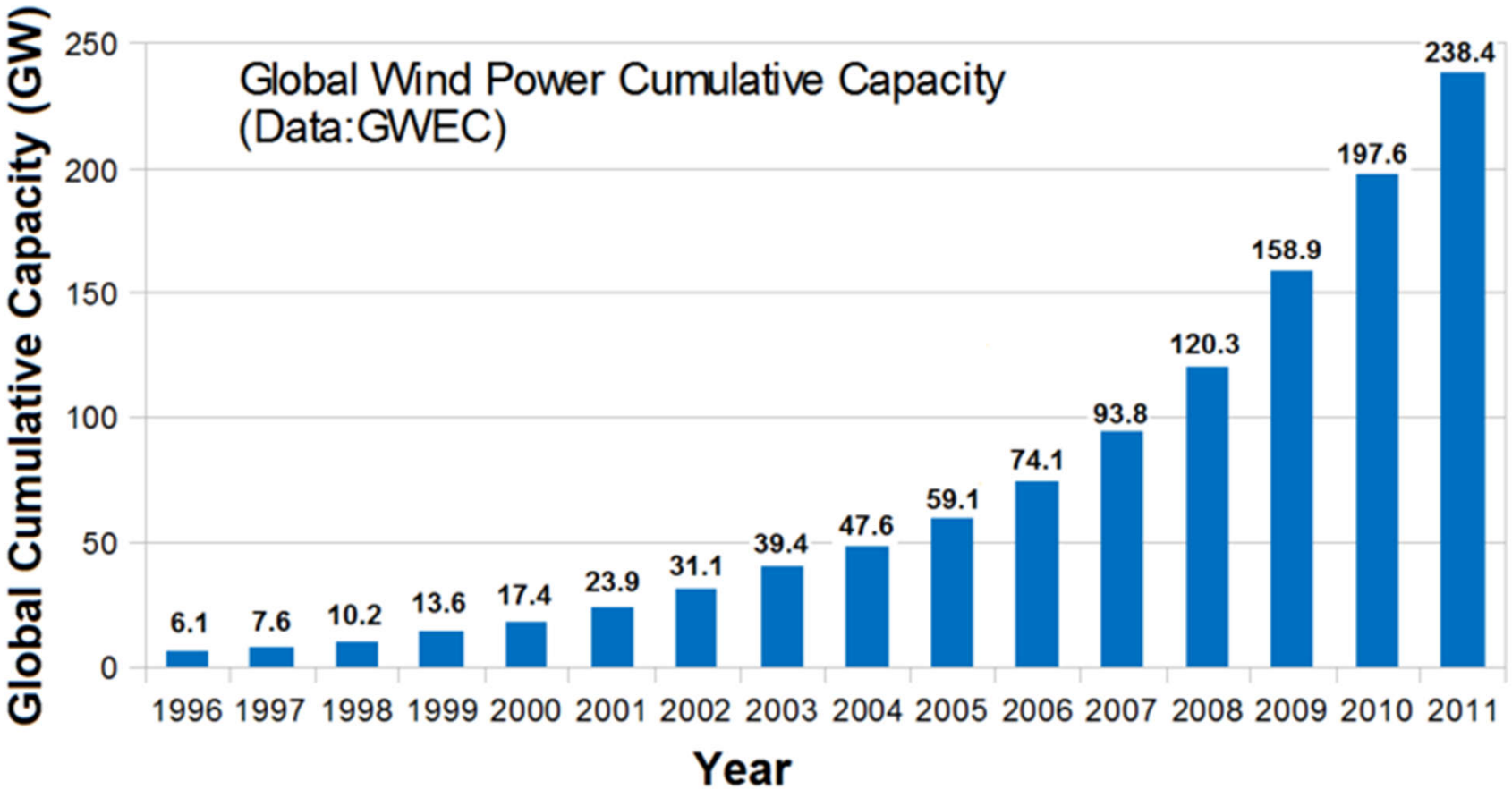
Fig. 2. Long-lived Radionuclides in High-level Nuclear Waste.

Nuclear: 60 $/barile 100-120 $/barile

Wind power

Ø 10m → 20-30 kW
Ø 90m → 3 MW (Vestas) = 1000 housholds

Eolic - total


Global Wind Power Cumulative Capacity
(Data:GWEC)
Global Cumulative Capacity (GW)
250
200
150
100
50
0
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59.1
74.1
93.8
120.3
158.9
197.6
238.4
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year

Wind power (2.5%)

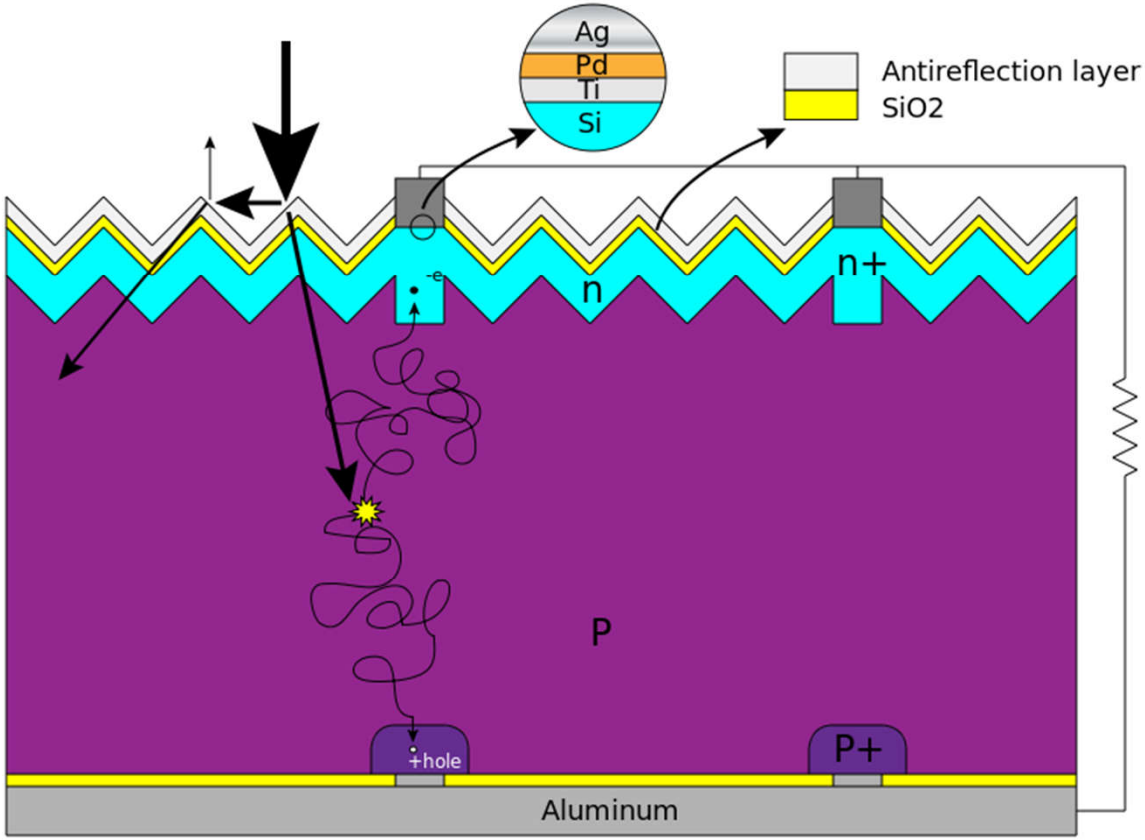
Top 10 countries by nameplate windpower capacity (2011 year-end)[40]

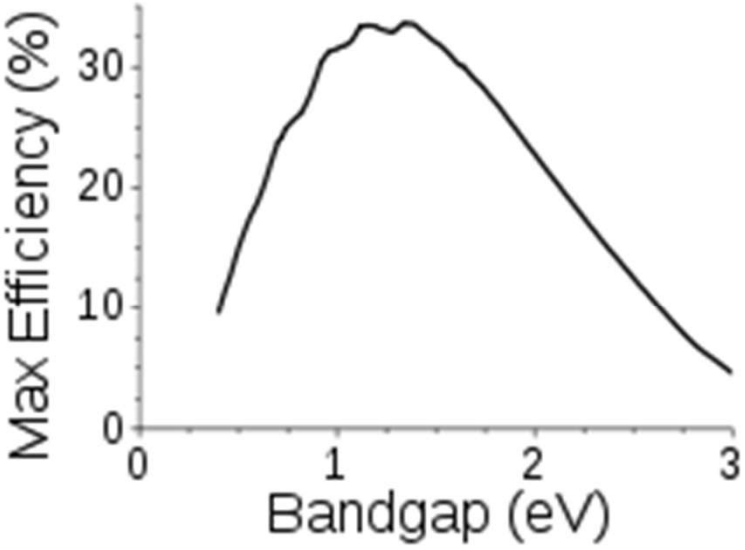
Country	Windpower capacity (MW) ‡provisional	% world total
China	62,733‡	26.3
United States	46,919	19.7
Germany	29,060	12.2
Spain	21,674	9.1
India	16,084	6.7
France	6,800‡	2.8
Italy	6,747	2.8
United Kingdom	6,540	2.7
Canada	5,265	2.2
Portugal	4,083	1.7
(rest of world)	32,446	13.8
World total	**238,351 MW**	**100%**

Top 10 countries by windpower electricity production (2010 totals)[56]

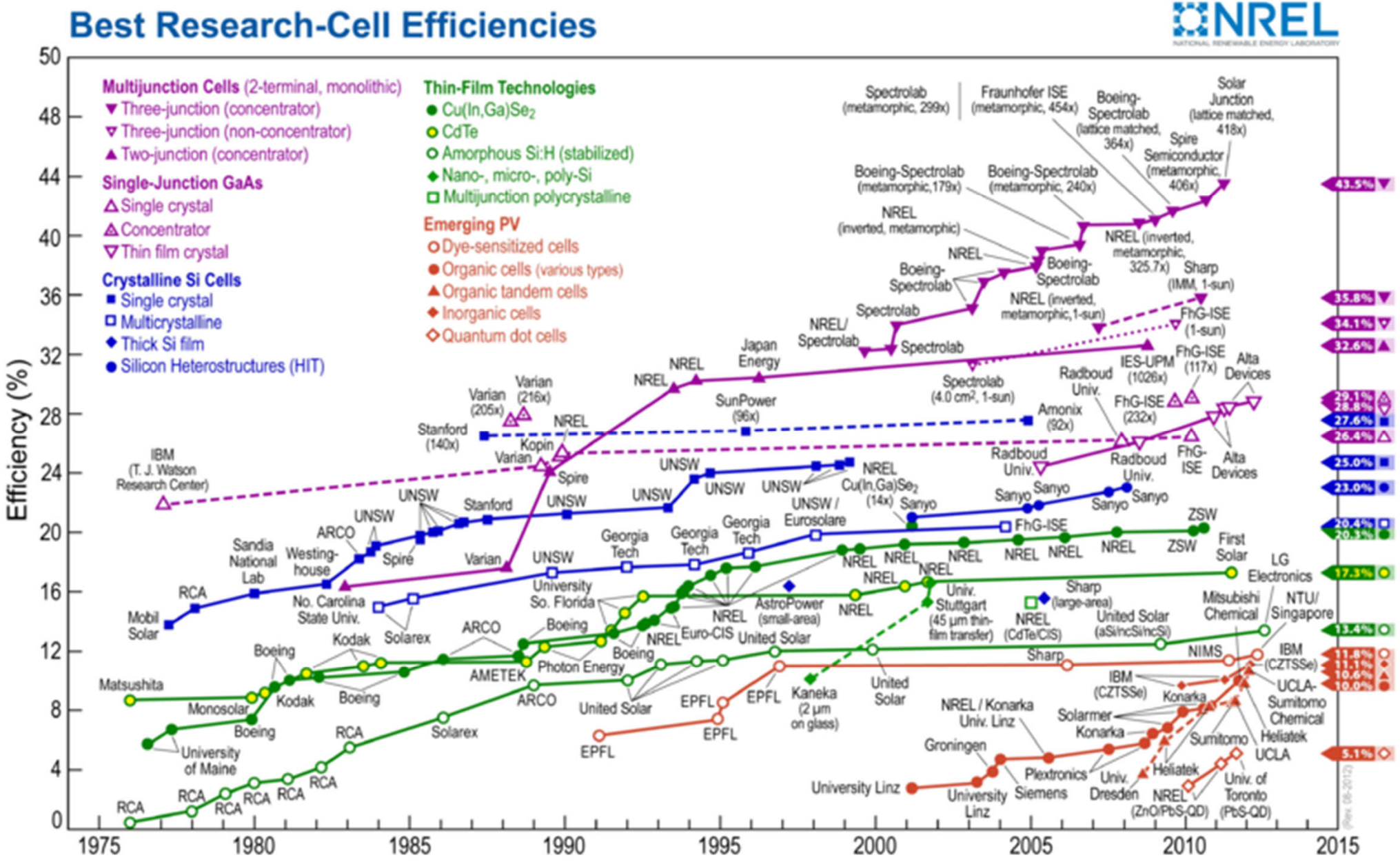
Country	Windpower production (TWh)	% world total
United States	95.2	27.6
China	55.5	15.9
Spain	43.7	12.7
Germany	36.5	10.6
India	20.6	6.0
United Kingdom	10.2	3.0
France	9.7	2.8
Portugal	9.1	2.6
Italy	8.4	2.5
Canada	8.0	2.3
(rest of world)	48.5	14.1
World total	**344.8 TWh**	**100%**

„Ogniwo” fotowoltaiczne





Ogniwa fotowoltaiczne: sprawność

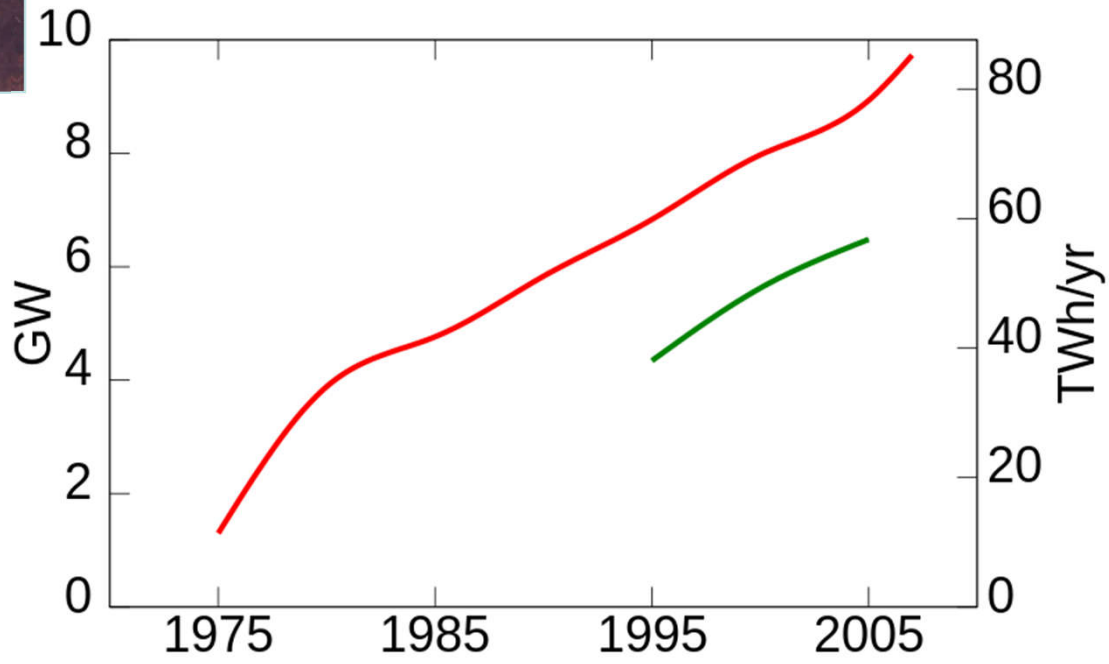


Energia fotovoltaica – rendimento tecnico

16% nei moduli in eterogiunzione;
14% nei moduli in silicio monocristallino;
13% nei moduli in silicio policristallino;
10% nei moduli in silicio microsferico;
6% nei moduli in silicio amorfo.

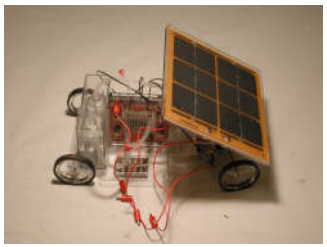
Geotermiczna: niewiele, oprócz Islandii

Pozzuoli (Volterra)

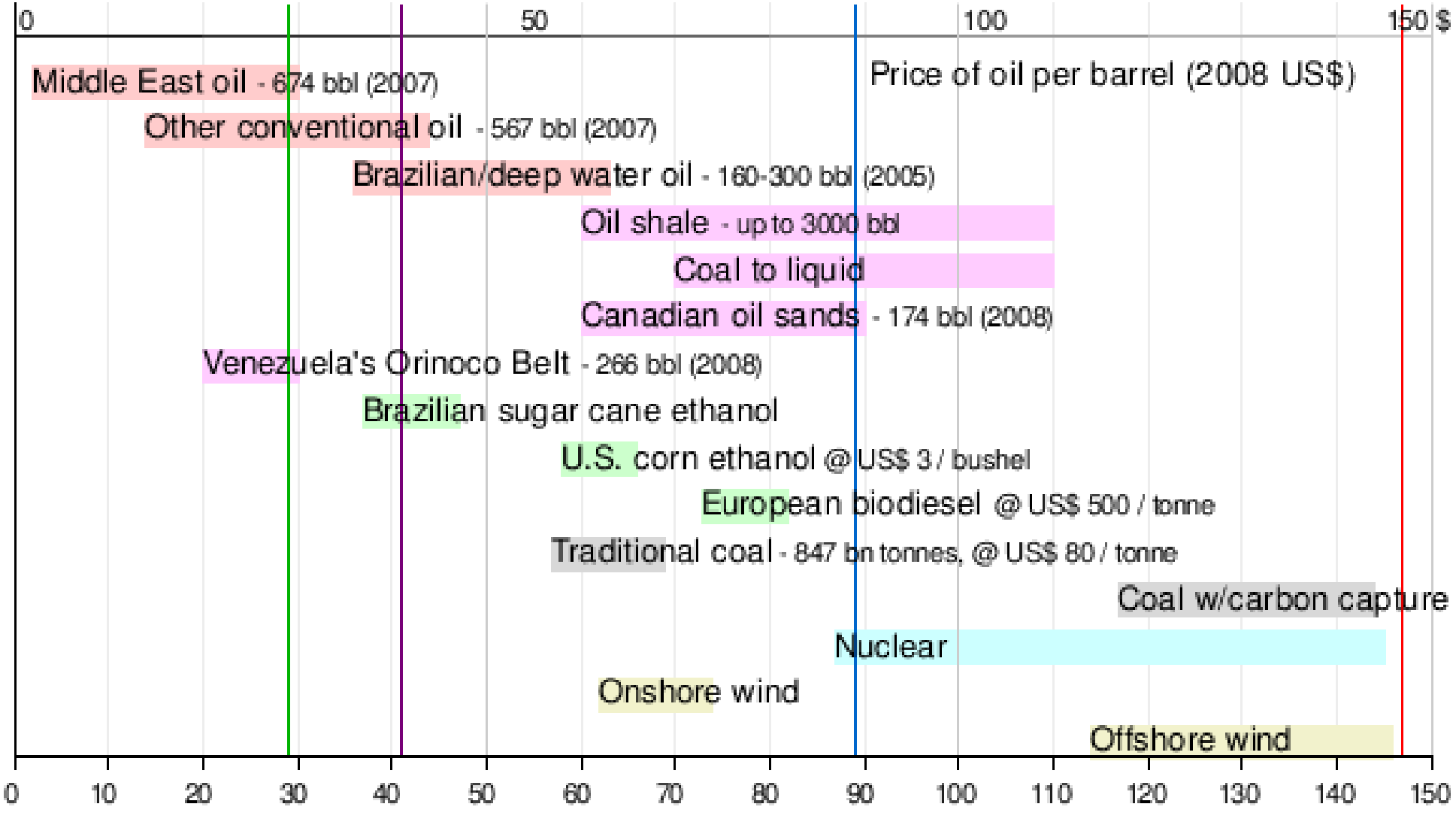


Energy flux: 65 mW/m^2

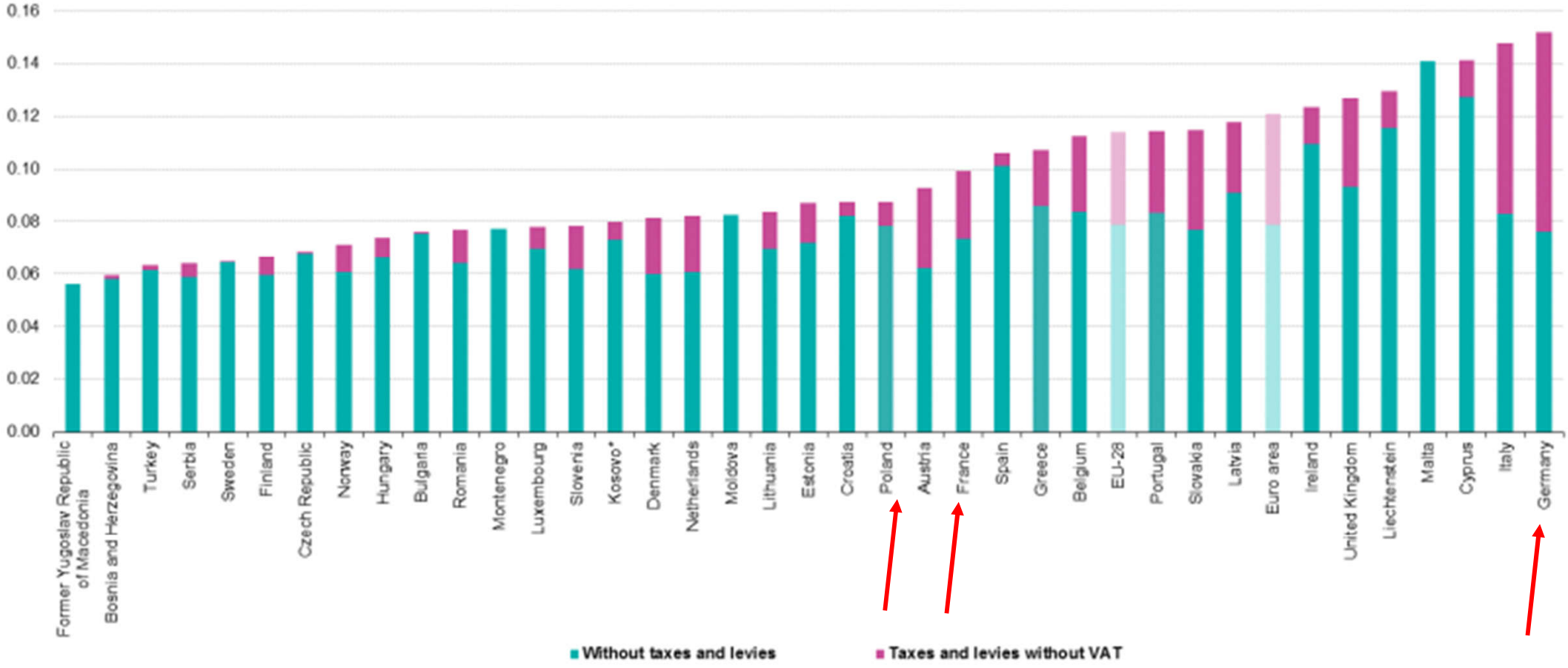
Renewable energy - costs

	2006	2014
	15 $/barile	12 $/barile
	25 $/barile	25 $/barile
	15 $/barile	18 $/barile
	20 $/barile	15 $/barile
Petrol:	30 $/barile	40-45 $/barile
Nuclear:	60 $/barile	100-120 $/barile

Koszty energii (USA 2010)



Ceny prądu dla przemysłu + VAT



*This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Source: Eurostat (online data code: nrg_pc_205)

Polska ma wyższe ceny niż Francja czy RFN

Settling the fracking question

Energy firms have not convinced sceptics that shale-gas extraction, or "fracking", is safe for the environment. **Jon Cartwright** examines whether physics could help

Hydraulic fracturing, or "fracking", is by any measure controversial. The process – which involves pumping sand and liquid into deep shale deposits to liberate natural gas – has been touted by its proponents as an energy saviour. For them, fracking allows energy companies to tap into reserves that are otherwise difficult, if not impossible, to get gas from. Yet the process has been slammed by opponents as being hugely damaging to the environment.

While fracking has taken off rapidly in the US, it has been banned in France and Bulgaria. Unfortunately, this polarized debate about fracking is not helped by a shortage of facts. No-one is sure to what extent fracking can contaminate groundwater, either with methane or with toxic chemicals. There is also a concern that fracking can trigger moderate earthquakes. While there may be no hard-and-fast answers, it seems that geophysics may be able to prod the debate in a constructive direction.

Without geophysics, of course, fracking would not be possible at all. Shale is a fine, clay-based sedimentary rock that has low permeability, so it will not release its gas into a well easily. To get at the gas, therefore, energy companies have to display their engineering prowess by drilling wells 1500–3000 m deep into a shale deposit and then running a perforated steel pipe horizontally. Millions of litres of water are pumped into the pipe, together with sand and chemicals, at

Heading underground The International Energy Agency suggests the world might be en route to "a golden age of gas" thanks to the emergence of hydraulic fracturing, or "fracking" – a rig for which is pictured here in Colorado.

2.4 trillion m^3, according to the US Geological Survey, which is one of the more modest estimates. Colorado-based business-information company HIS, for example, puts the figure at about 42 trillion m^3.

The US is not, though, the only nation with large deposits. UK energy firm Cuadrilla Resources estimates around 5.6 trillion m^3 of shale-gas reserves in the UK. Hardly surprising, then, that a report last year from the International Energy Agency suggested the world might be en route to "a golden age of gas".

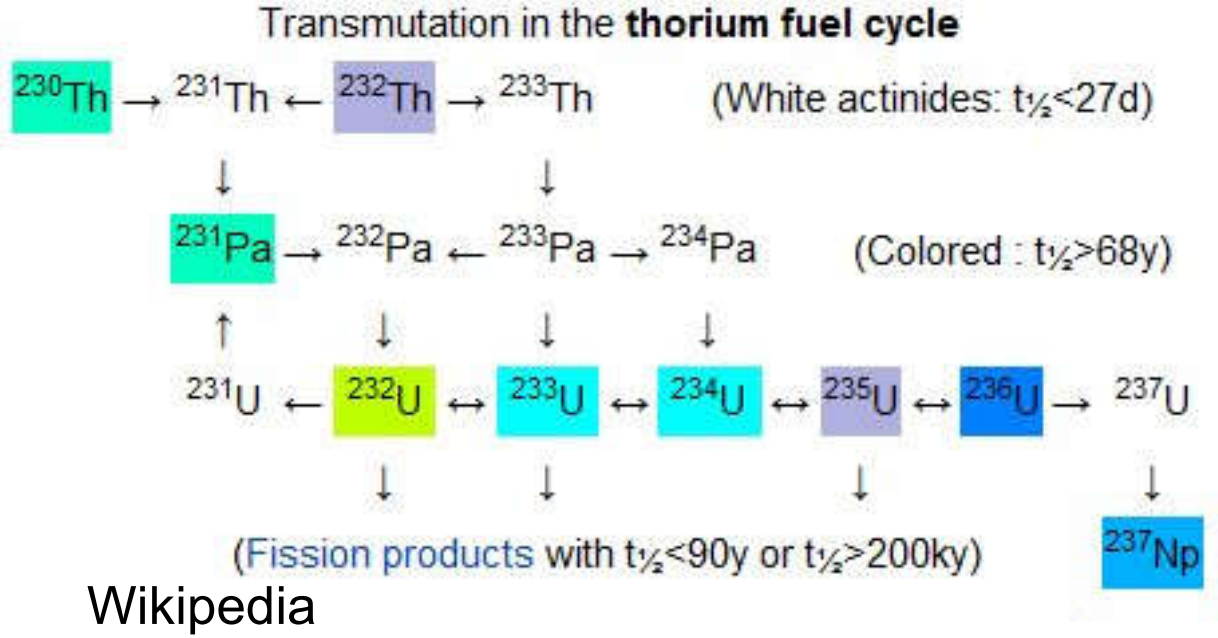
Shale gas?

Big environmental damage!

Physics World, 12.03.2012

Reaktor torowy (Carlo Rubbia)

- $_{90}Th^{232}$ ($T_{1/2}$=1.405×10^{10} y) + $n \rightarrow {}^{233}Th \rightarrow {}_{91}Pa^{233} + e^-$
- ${}^{233}Pa \rightarrow {}_{92}U^{233}$
- $_{92}U^{233} + n \rightarrow$ fission



Wikipedia

Reakcje rozszczepienia toru wymaga zewnętrznego „zapłonu” - źródła protonów

Energy amplifier, C. Rubbia 1996

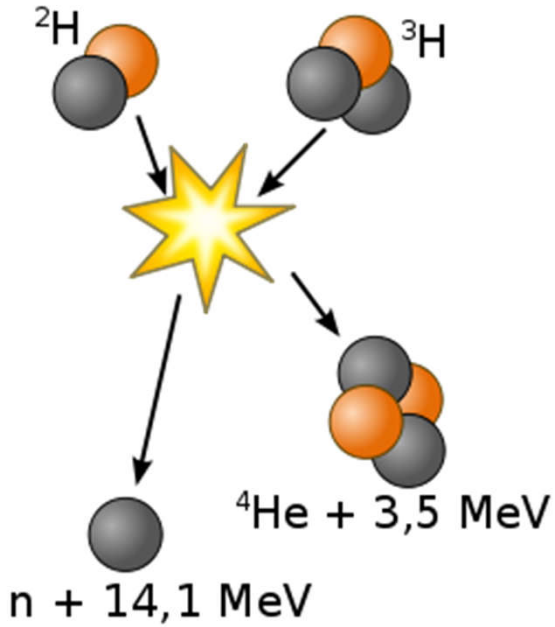
Table 9. Total Direct investment costs.

Item	*Best Estimate Million US$*	*Lower limit Million US$*	*Upper limit Million US$*
EGU	58.98	45.61	67.51
Secondary Loop	59.55	45.69	72.21
Auxiliary Systems	7.69	6.15	9.23
Accelerator System	184.45	165.45	217.10
Mech. & Electrical Classical Eq.	233.50	210.15	256.85
General Assembly	37.88	30.30	45.45
Instrumentation & Control	35.00	28.00	42.00
Structures & Civil Work	175.00	140.00	210.00
Total	792.05	671.35	920.35

Kraje UE nie wykazują szczególnego zainteresowania…
W tor szczególnie bogate są piaski bałtyckie…

GK: „Tor, alternatywa dla uranu”, Dziennik Bałtycki, dawno temu…

Fuzja termojądrowa

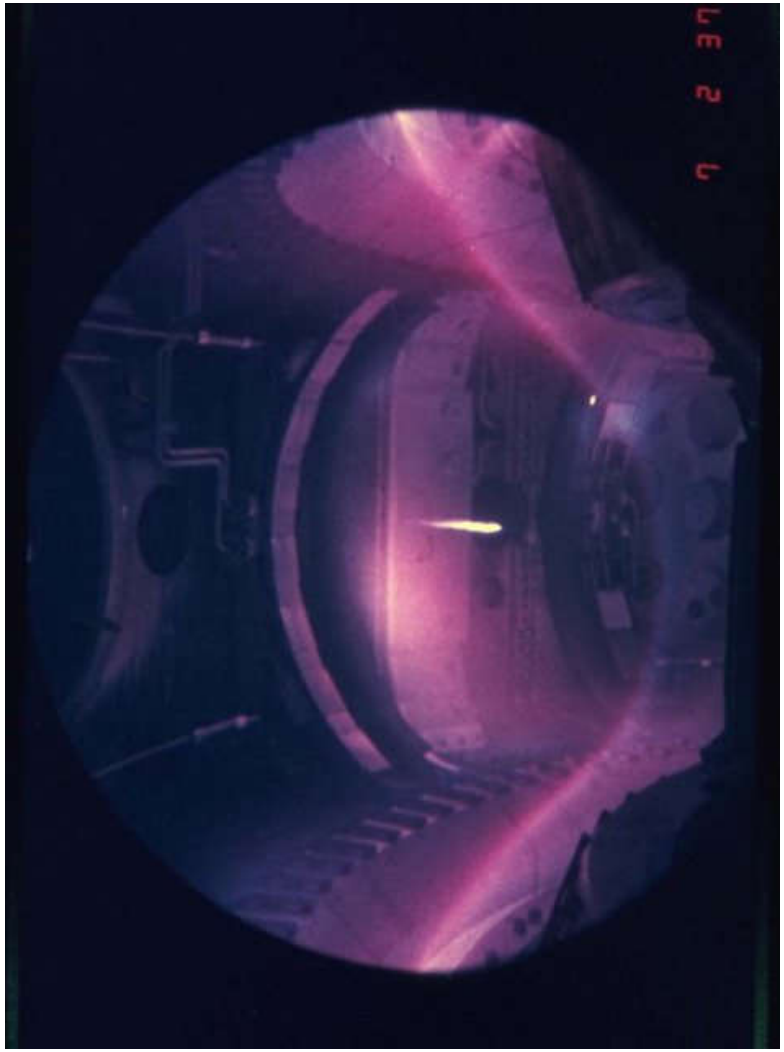


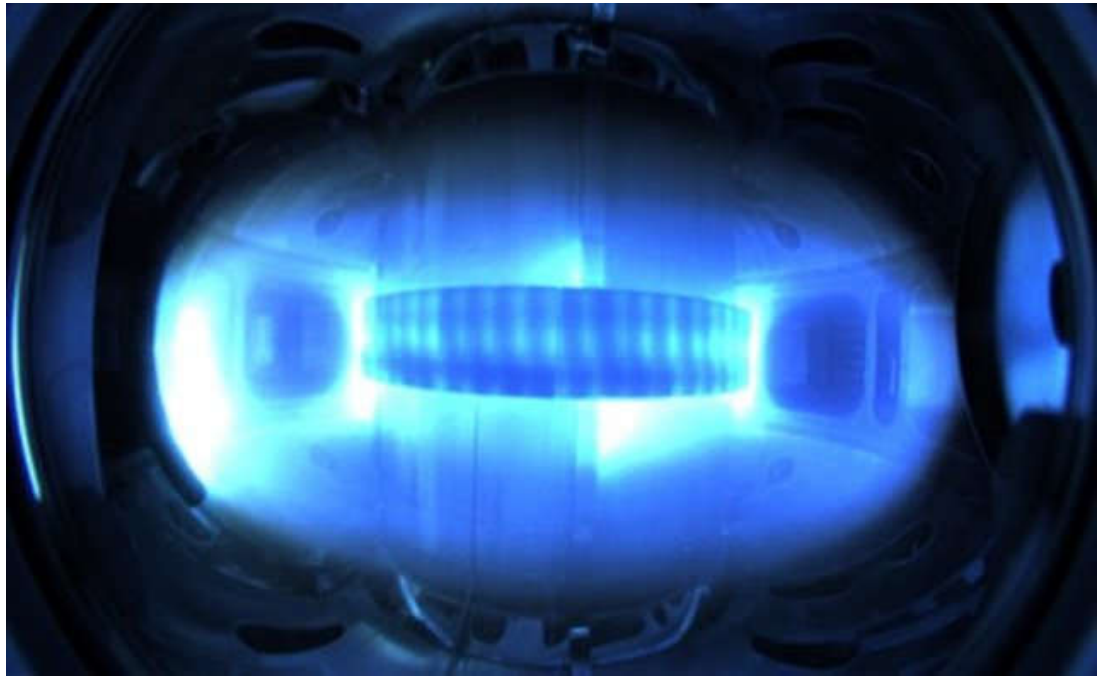
$$Li + n \rightarrow {}^3H + {}^4He$$

1GWy: 2,7 bln t coal
or 250 kg ^{2}H + ^{3}H

The projected design for the next-step demonstration fusion power plant, or DEMO, designed to produce 2000-4000MW of power.

150 mln K plasma





International Atomic Energy Agency
Atomic Molecular Data Services
Provided by the Nuclear Data Section

Narodowe Laboratorium Technologii Kwantowych

플라즈마물성데이터센터
Data Center for Plasma Properties

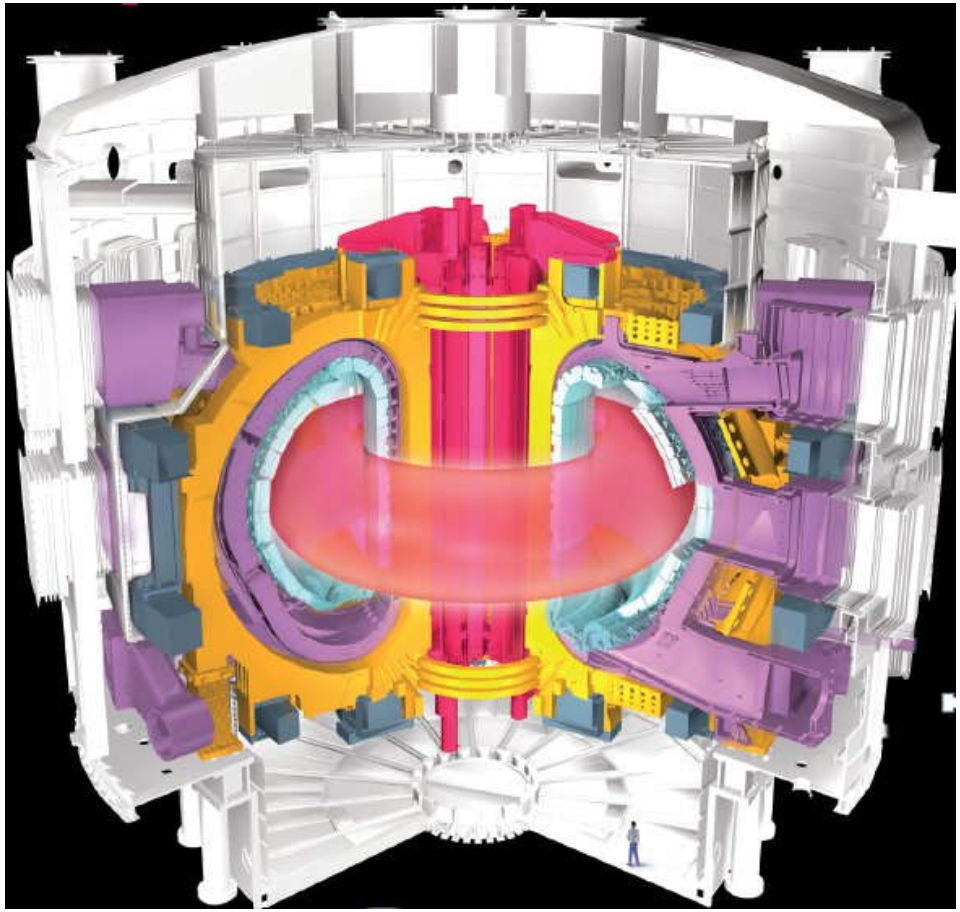
Atomic Physics at ITER

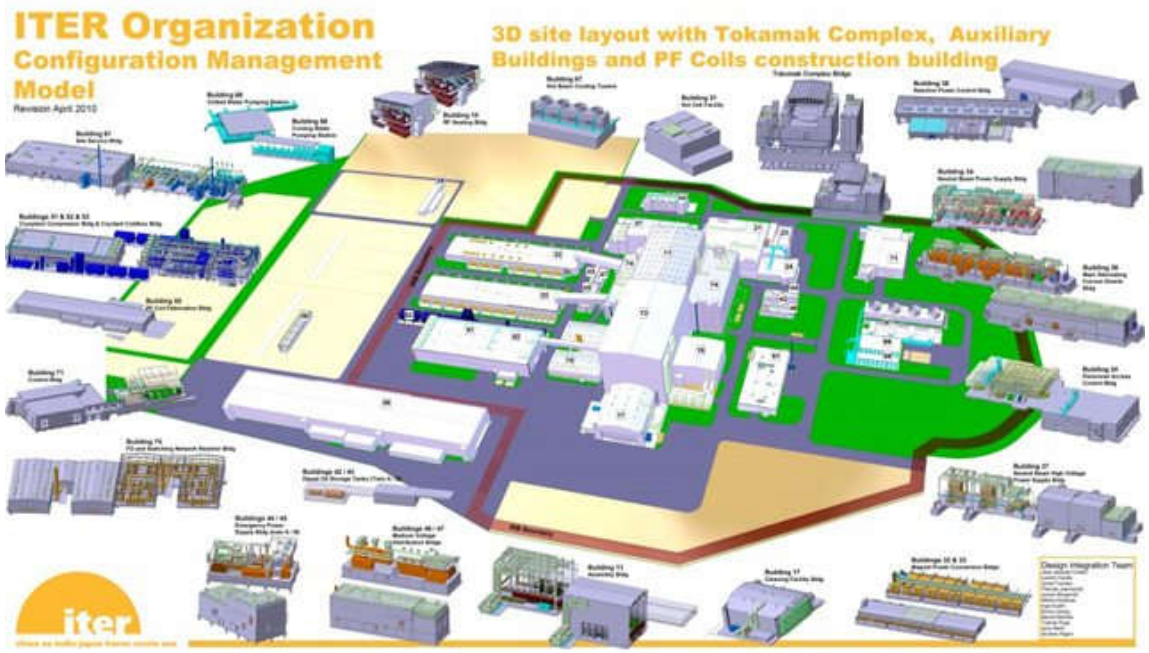
Grzegorz Karwasz

Uniwersytet Mikołaja Kopernika w Toruniu

Progress Report from IAEA Decennial Meeting,
Daejeon, Korea, 15-19.12. 2014

ITER, France, Cadarache





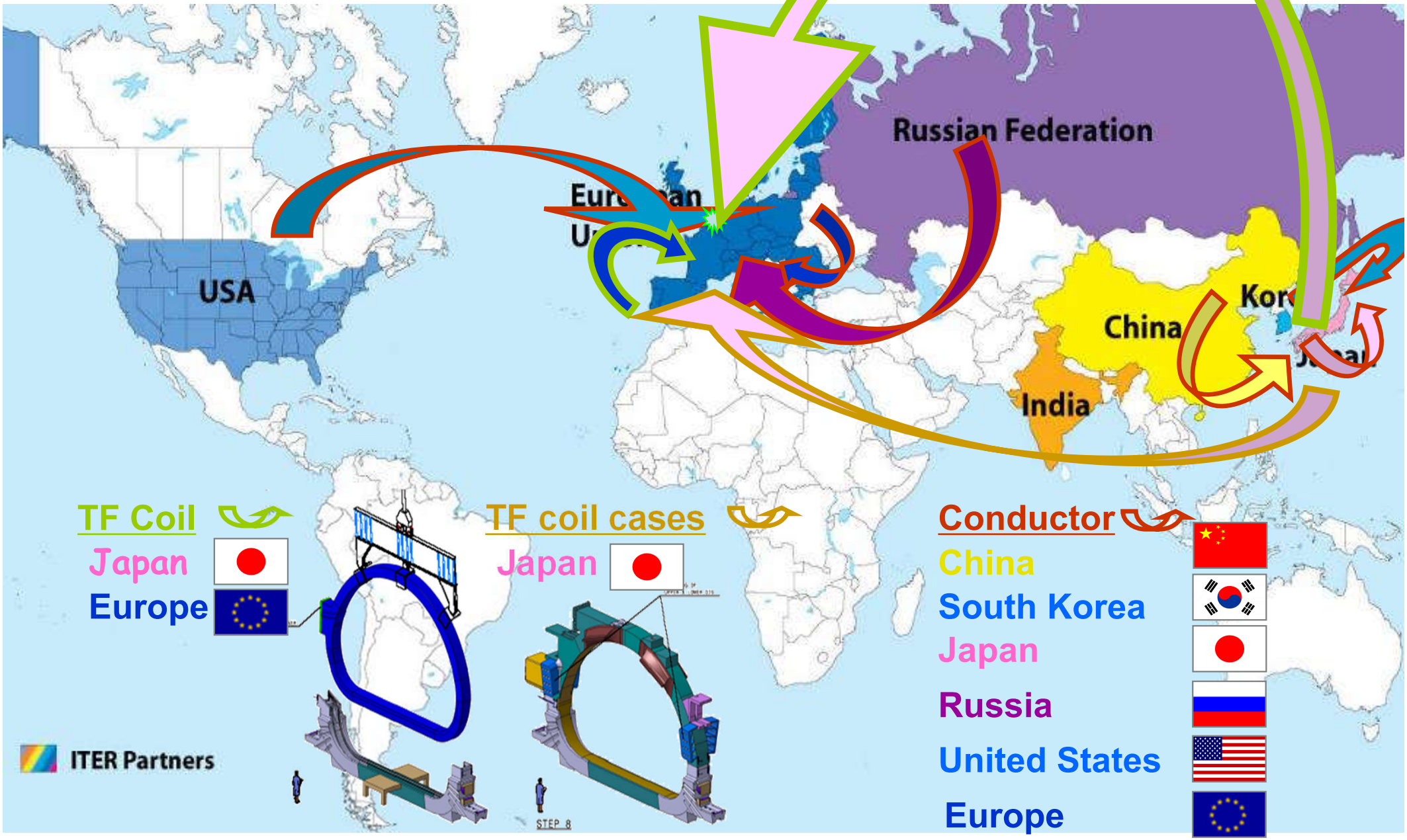
50 MW input → 500 MW output

13 mld €: największy (oprócz lotów kosmicznych) projekt badawczy ludzkości

It will be operative in 2020

DEMO (Korea) – first commercial reactor: **2050**

TF Coils – A Global Collaboration



Reaktor przemysłowy stanie w Korei w 2050 roku
We work for you...!


Dziękuję!