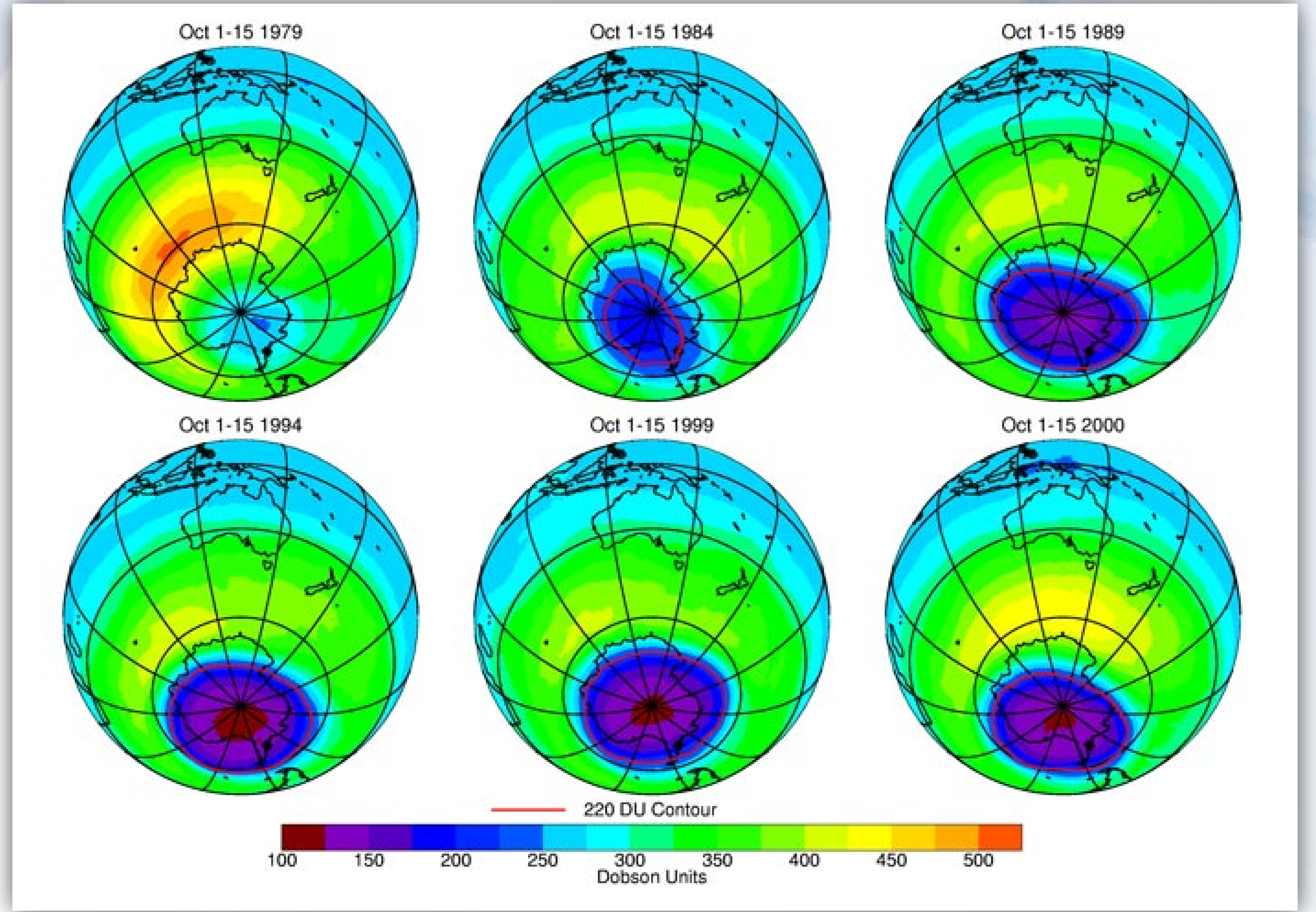
III. Úbytek stratosférického ozónu



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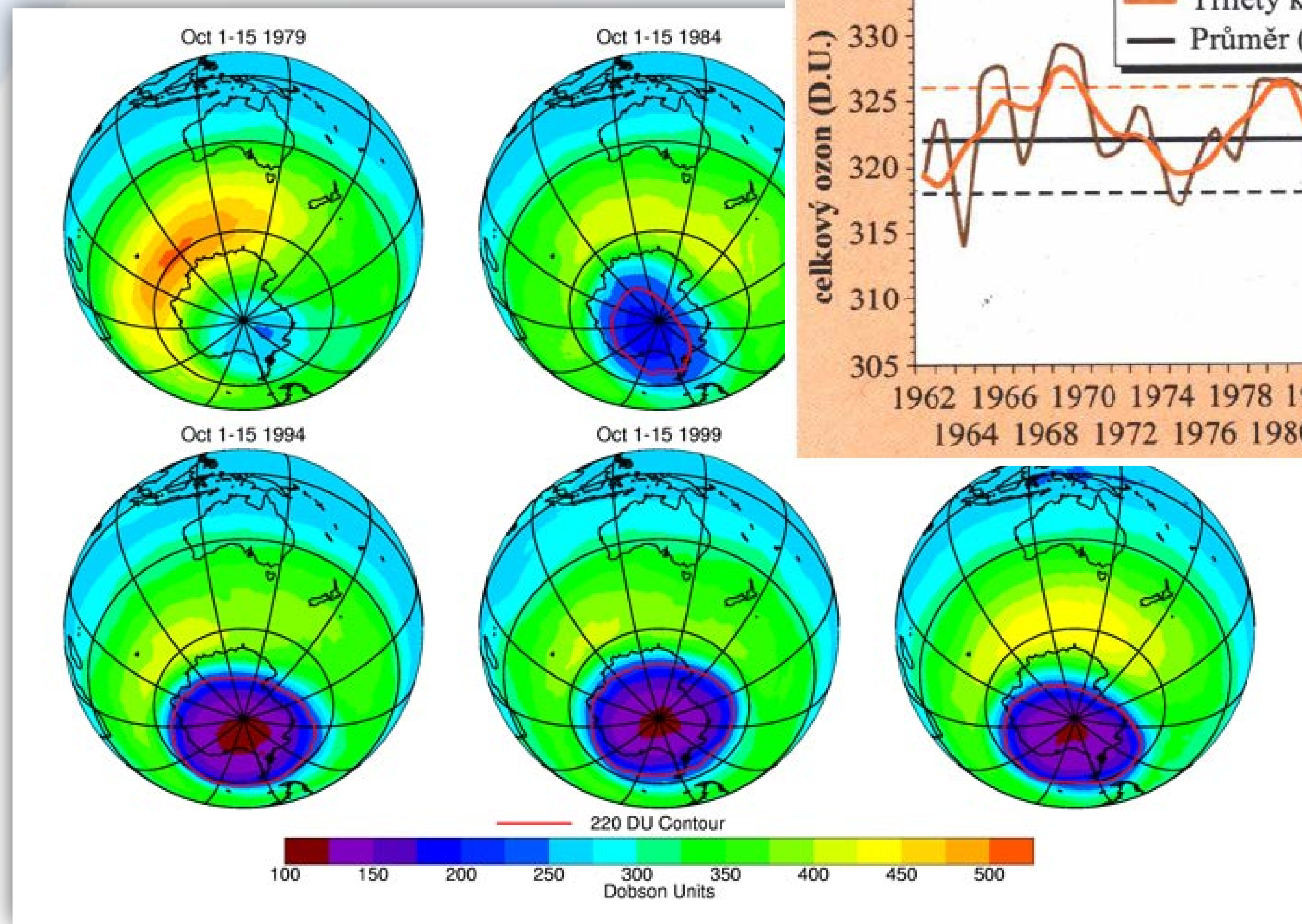
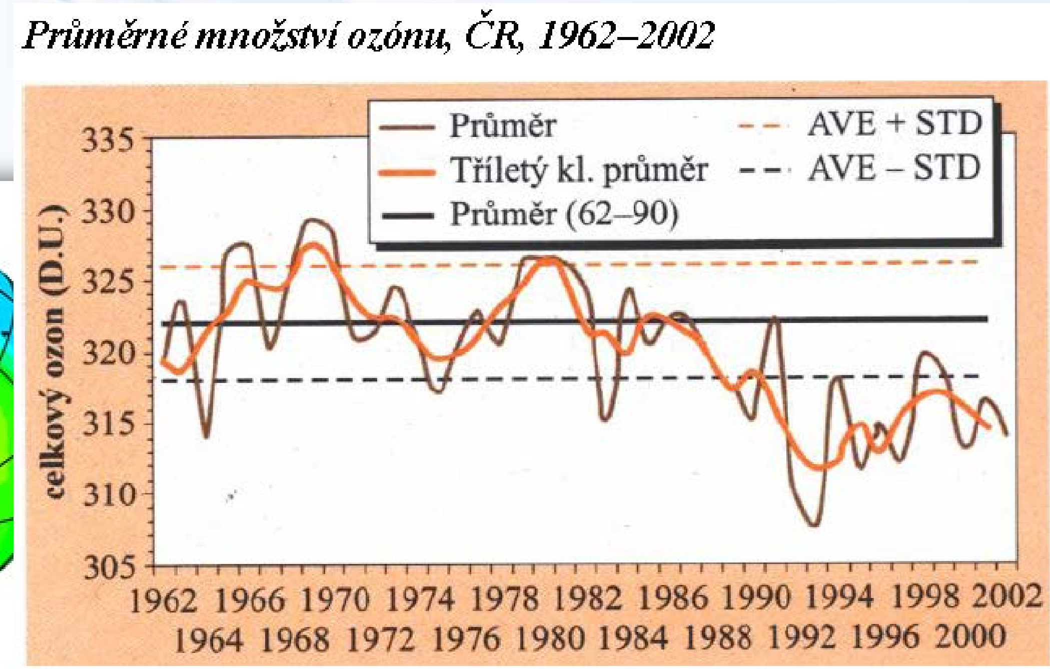


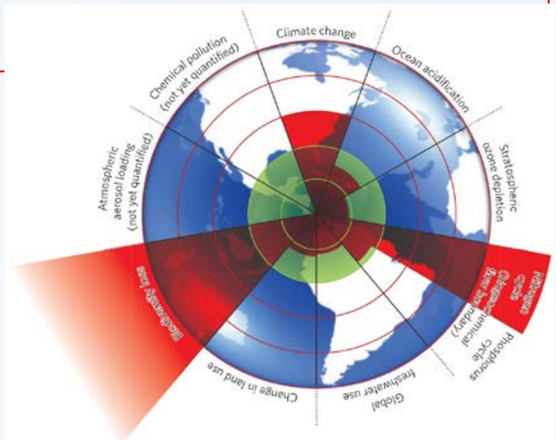


III. Úbytek stratosférického ozónu

Diagnóza:

Earth System process	Control variable	Threshold avoided or influenced by slow variable	Planetary Boundary (zone of uncertainty)	State of knowledge*
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU	Severe and irreversible UV-B radiation effects on human health and ecosystems.	<5% reduction from pre-industrial level of 290 DU (5%–10%)	1. Ample scientific evidence. 2. Threshold well established. 3. Boundary position implicitly agreed and respected.

Boundary: Average conc. of stratospheric O_3 no lower than 276 Dobson units
Current level: 283 Dobson units
Diagnosis: Safe, and improving



Centrum pro výzkum toxických látek v prostředí

Historie objevů

Historie objevů spojených s úbytkem O_3

1974

Stratospheric Chlorine: a Possible Sink for Ozone

R. S. Stolarski and R. J. Cicerone

Space Physics Research Laboratory, The University of Michigan, Ann Arbor, Michigan 48105

Received January 18, 1974

This study proposes that the oxides of chlorine, ClO_x, may constitute an important sink for stratospheric ozone. A photochemical scheme is devised which includes two catalytic cycles through which ClO_x destroys odd oxygen. The individual ClX constituents (HCl, Cl, ClO, and OClO) perform analogously to the respective constituents (HNO_3, NO, NO_2, and NO_3) in the NO_x catalytic cycles, but the ozone destruction efficiency is

(Reprinted from Nature, Vol. 249, No. 5460, pp. 810–812, June 28, 1974)

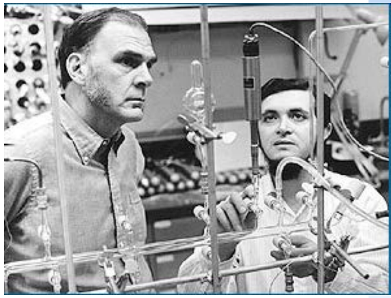
Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone

Mario J. Molina & F. S. Rowland

Department of Chemistry, University of California, Irvine, California 92664

Chlorofluoromethanes are being added to the environment in steadily increasing amounts. These compounds are chemically inert and may remain in the atmosphere for 40–150 years, and concentrations can be expected to reach 10 to 30 times present levels. Photodissociation of the chlorofluoromethanes in the stratosphere produces significant amounts of chlorine atoms, and leads to the destruction of atmospheric ozone.

effective rates of vertical diffusion of molecules at these altitudes are also subject to substantial uncertainties. Vertical mixing is frequently modelled through the use of 'eddy' diffusion coefficients[10,16–18], which are presumably relatively insensitive to the molecular weight of the diffusing species. Calculated using a time independent one-dimensional vertical diffusion model with eddy diffusion coefficients of magnitude $K \sim (3 \times 10^3)$–10^4 cm^2 s^{-1} at altitudes 20–40 km (refs 10, 15–18), the atmospheric lifetimes of $CFCl_3$ and CF_2Cl_2 fall into the range of 40–150 yr. The time required for approach toward a steady state is thus measured in decades, and the concentrations of chlorofluoromethanes in the atmosphere can be expected to reach



- 1 atom Cl rozloží zhruba 100 000 molekul O_3

Historie objevů spojených s úbytkem O_3

1978 – CFC jako hnací plyn ve sprejích zakázán (v USA)
- spotřeba v dalších aplikacích však stále prudce roste

1991

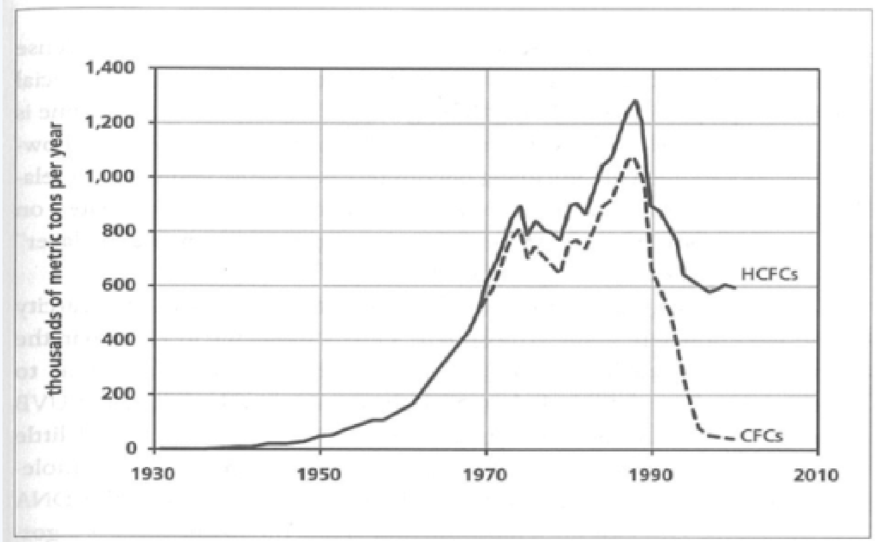


FIGURE 5-1 World Production of Chlorofluorocarbons

Historie objevů spojených s úbytkem O_3

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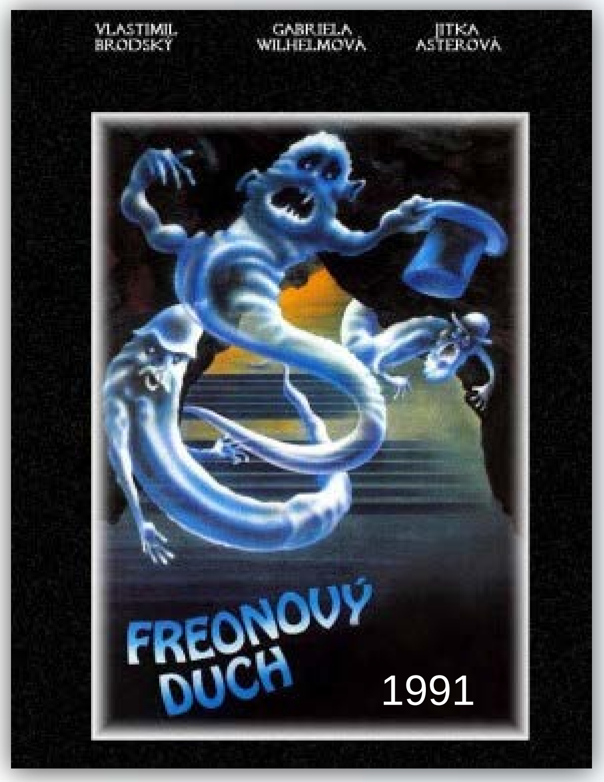

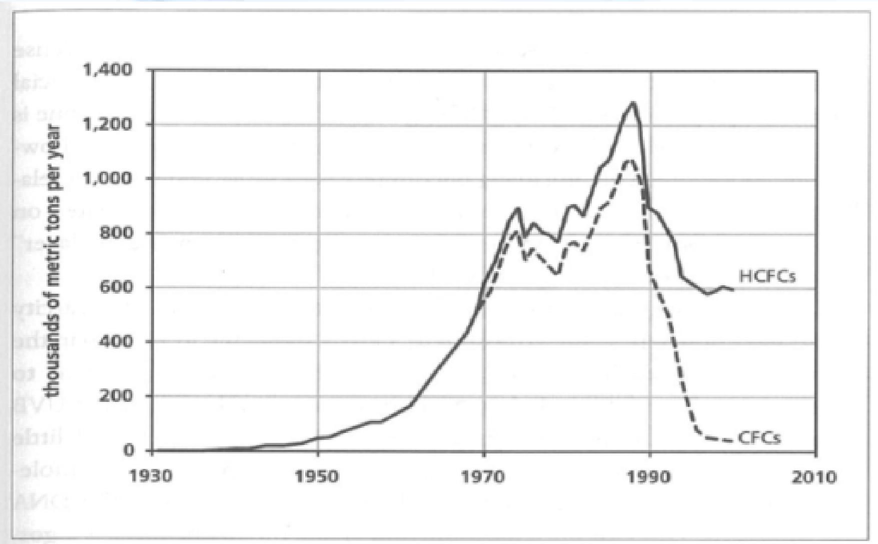

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Centrum pro výzkum toxických látek v prostředí

Historie objevů spojených s úbytkem O_3

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1984 - V Halley Bay v Antarktidě naměřen 40% úbytek O_3

- tak dramatickému úbytku nevěřili a hledali způsob ověření
- dramatický pokles ověřen i v další stanici 1000 mil daleko

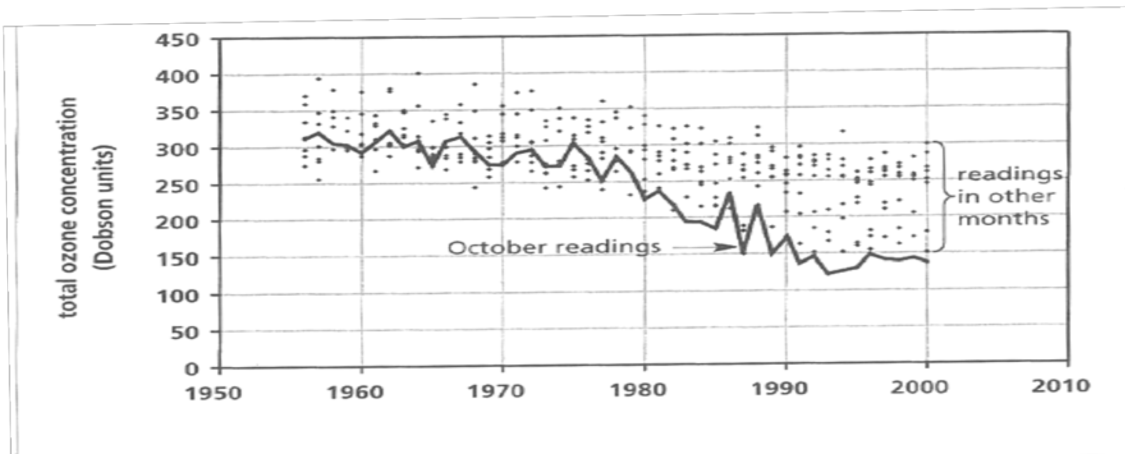

FIGURE 5-4 Ozone Measurements at Halley, Antarctica

Large losses of total ozone in Antarctica reveal seasonal ClO_x/NO_x interaction

J. C. Farman, B. G. Gardiner & J. D. Shanklin

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

Recent attempts[1,2] to consolidate assessments of the effect of human activities on stratospheric ozone (O_3) using one-dimensional models for 30° N have suggested that perturbations of total O_3 will remain small for at least the next decade. Results from such models are often accepted by default as global estimates[3]. The inadequacy of this approach is here made evident by observations that the spring values of total O_3 in Antarctica have now fallen considerably. The circulation in the lower stratosphere is apparently unchanged, and possible chemical causes must be considered. We suggest that the very low temperatures which prevail from midwinter until several weeks after the spring equinox make the Antarctic stratosphere uniquely sensitive to growth of inorganic chlorine, ClX, primarily by the effect of this growth on the NO_2/NO ratio. This, with the height distribution of UV

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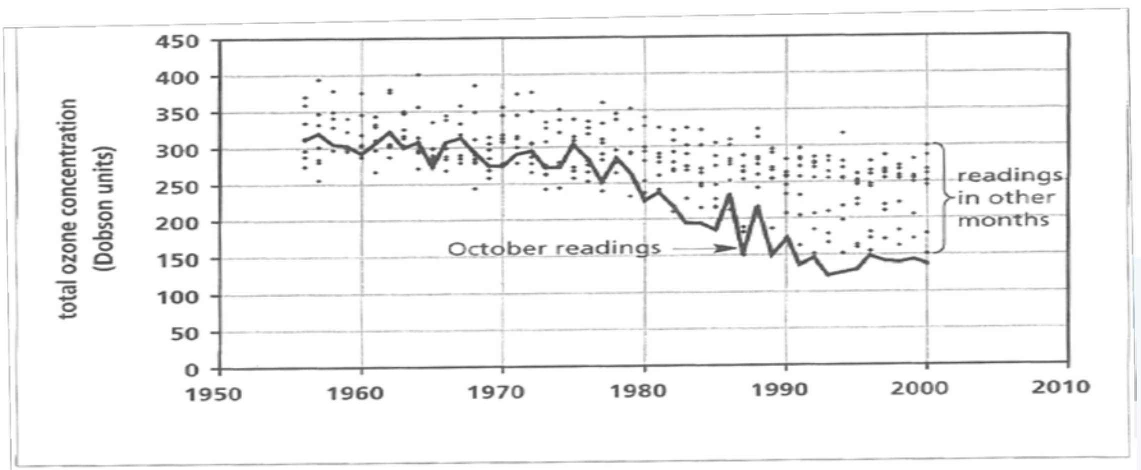
– nezvratný důkaz, že nad sebou likvidujeme ozonový štít???



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Historie objevů spojených s úbytkem O_3

1985 - **Nimbus 7** – satelit NASA měřící O_3 od roku 1978 ale žádnou díru neeviduje

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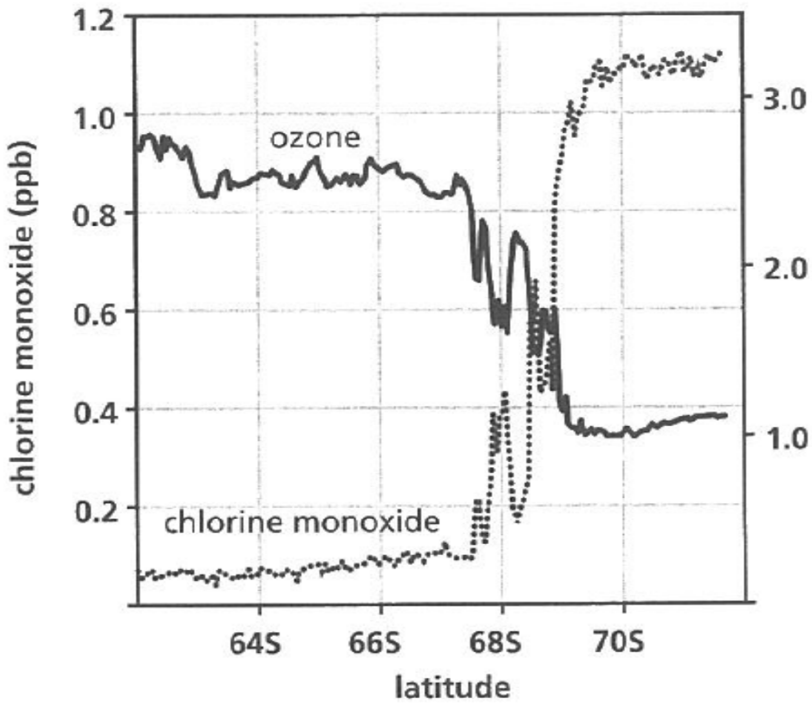
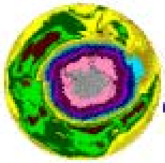
1987 – potvrzení chlor-ozonové hypotézy – průlet letadlem ozonovou dírou měřící koncentraci O_3 a ClO

- silná korelace mezi koncentrací obou měřených látek

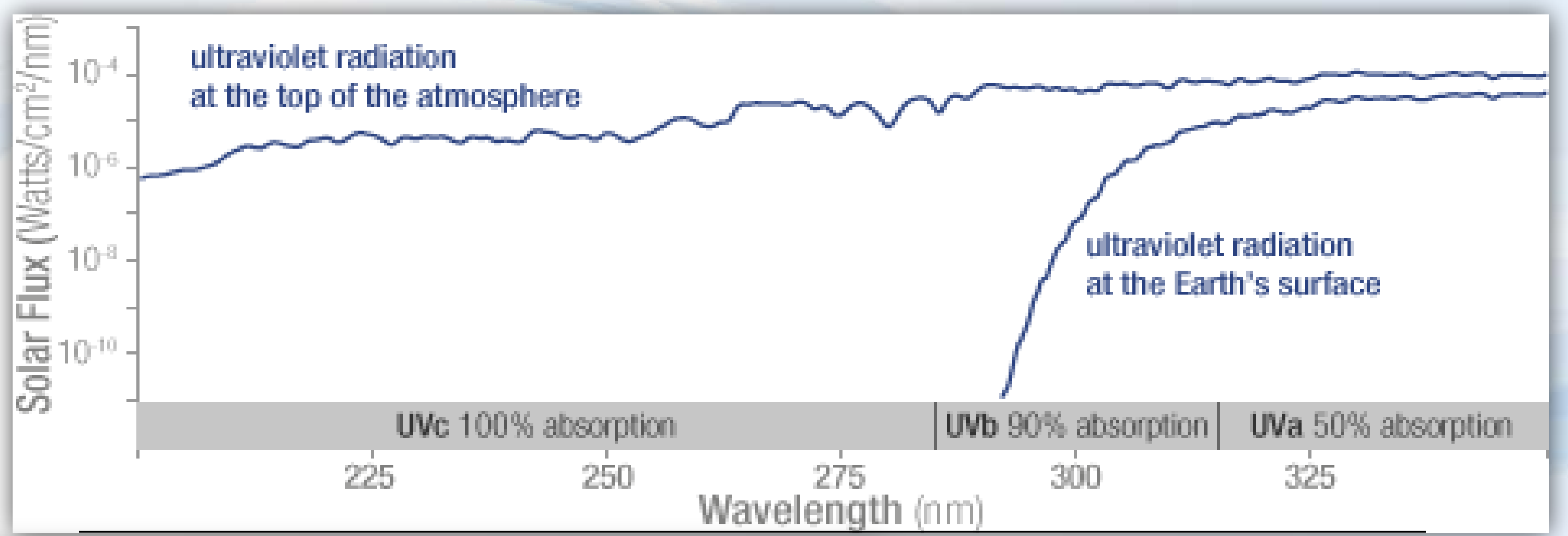


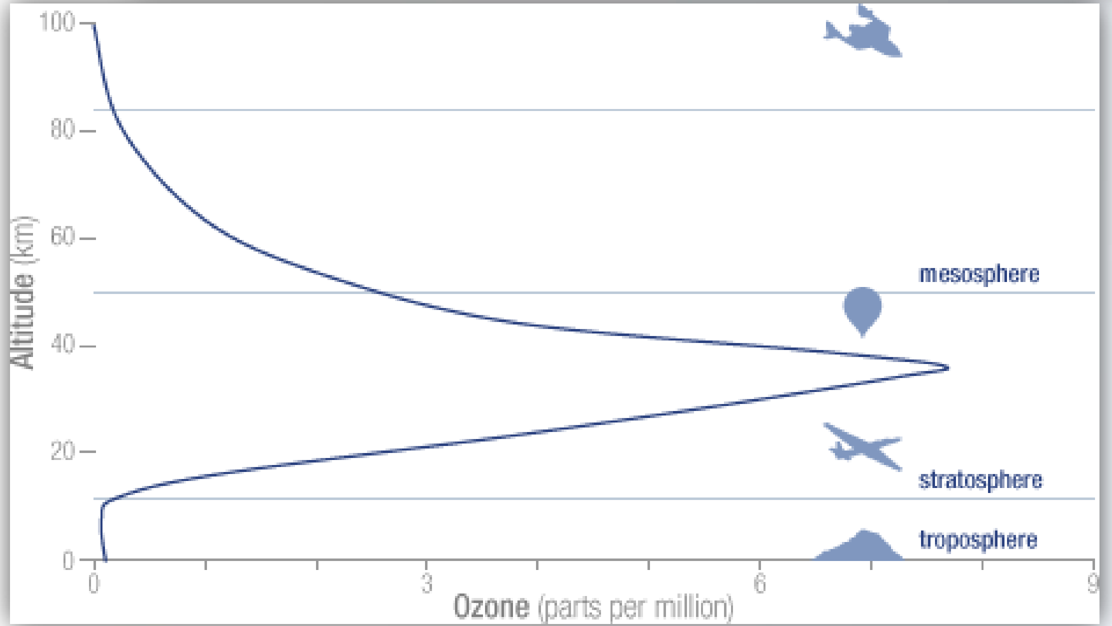
Centrum pro výzkum toxických látek v prostředí

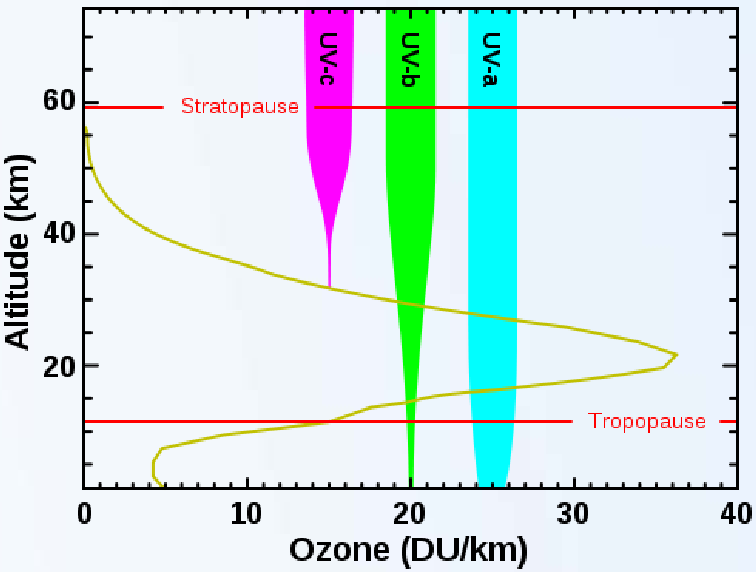
Fyzikální základ jevu

The zone Hole

O_3 – ochrana biosféry před nebezpečným UVB zářením

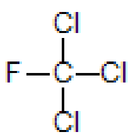






Poškozování ozónové vrstvy země

- freony, halony a další určité halogenované látky



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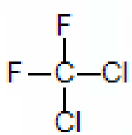

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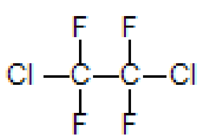

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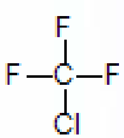
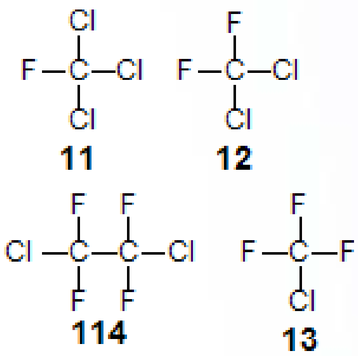


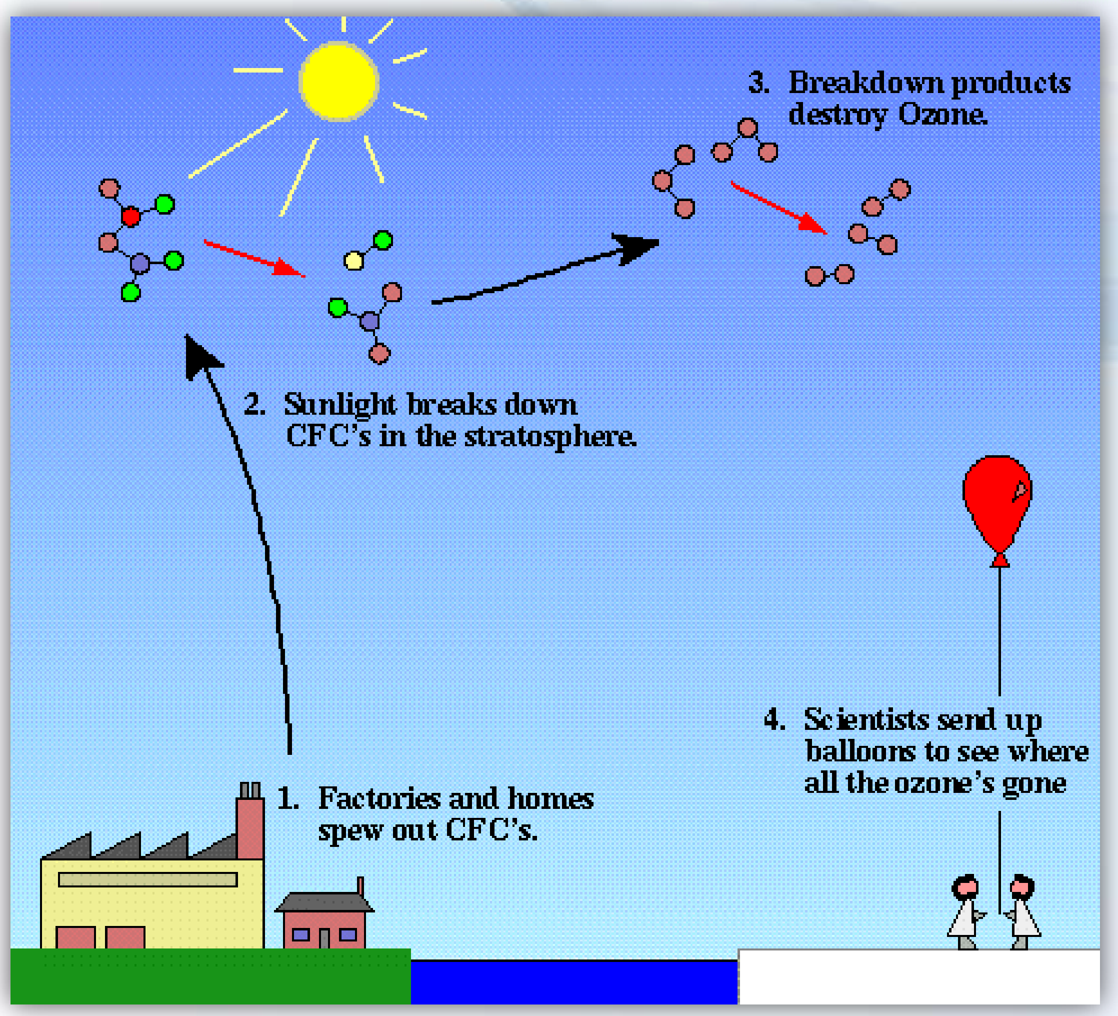
13

Poškozování ozónové vrstvy země

- freony, halony a další určité halogenované látky

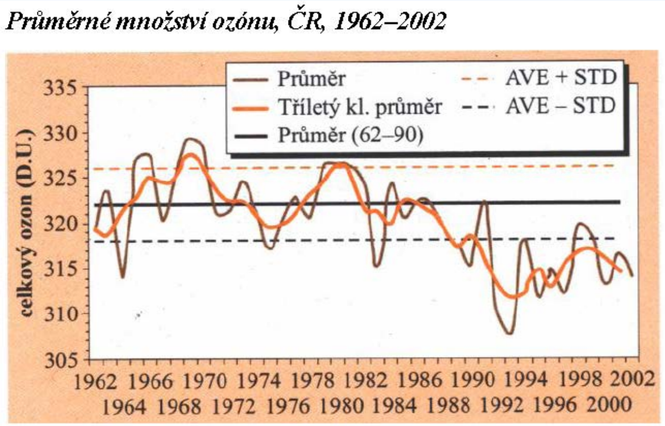
- freony - netoxické, inertní, nízkovroucí kapaliny, výborné izolanty

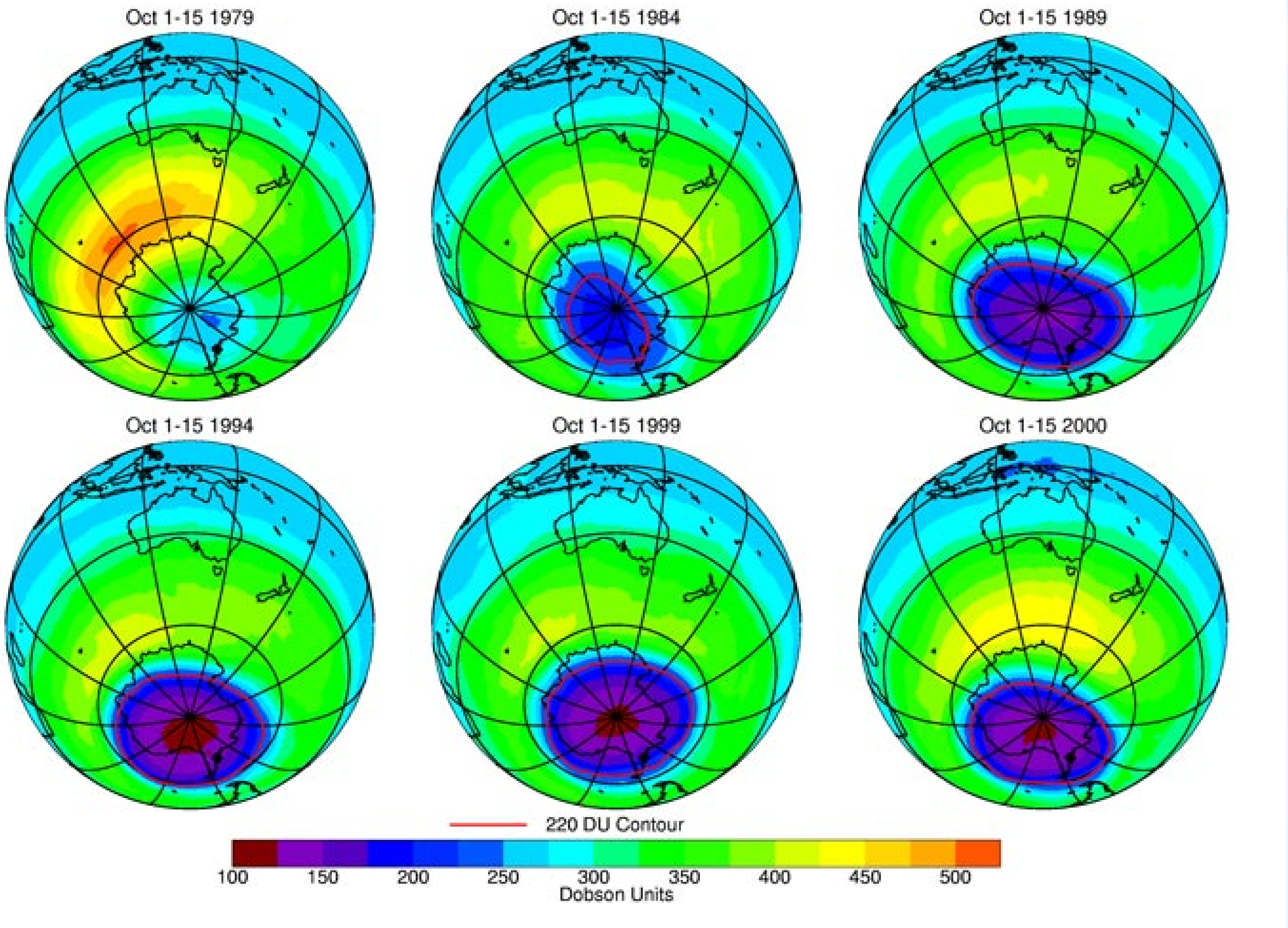


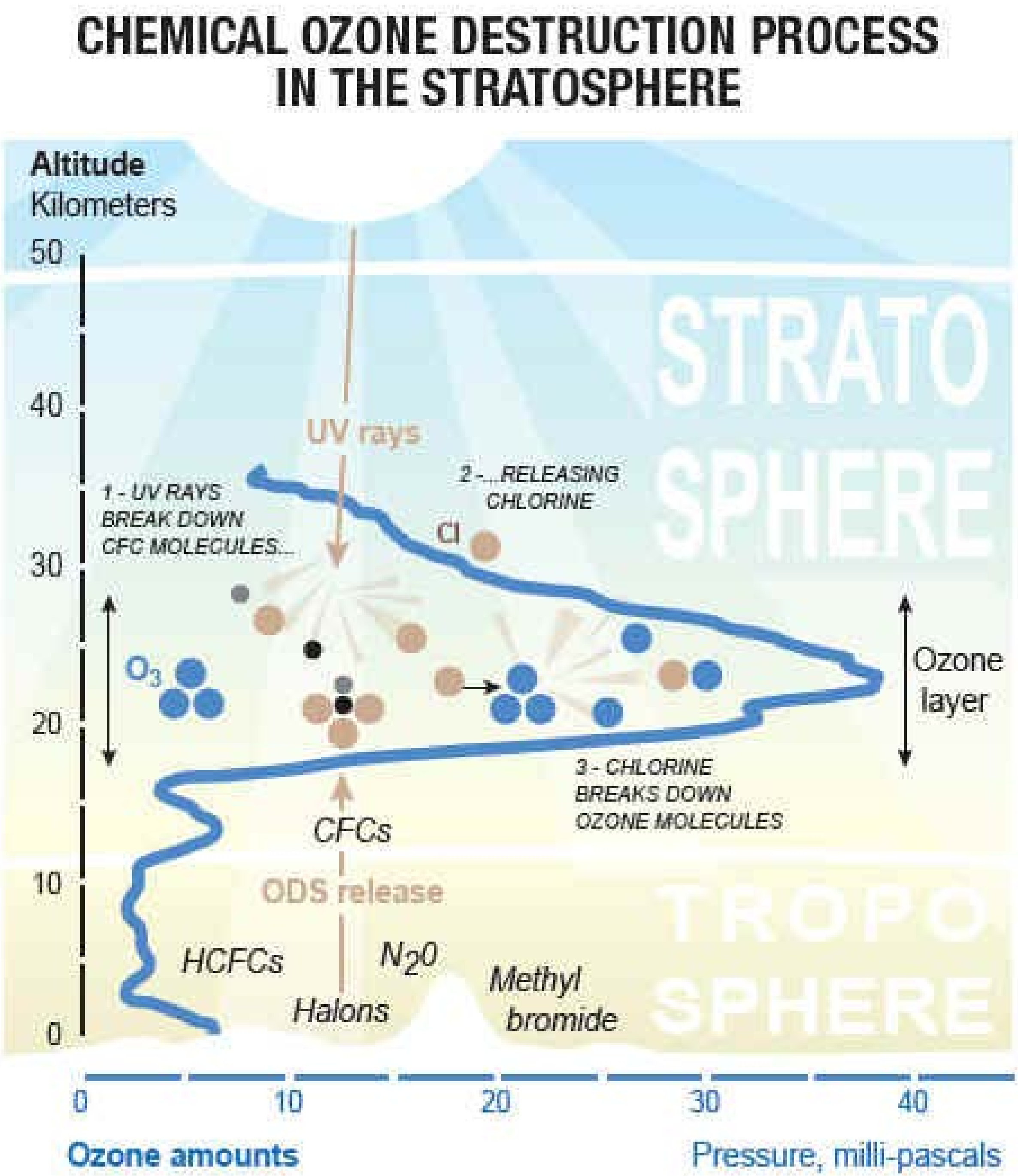


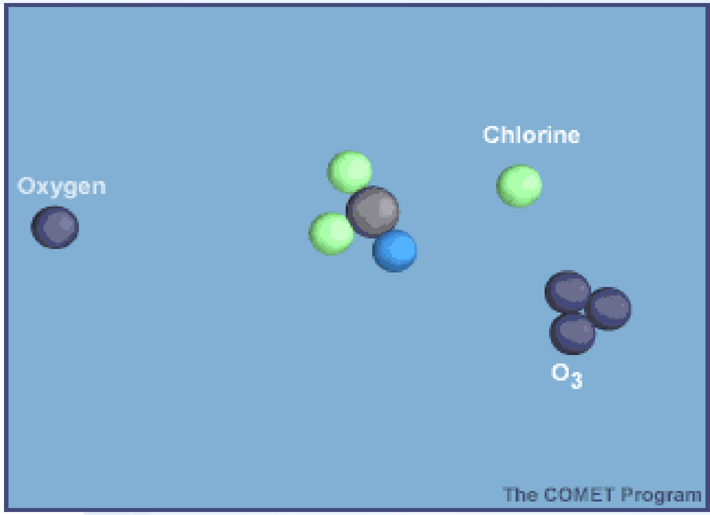
Ozónová díra

- výrazný úbytek ozónu především nad polárními oblastmi

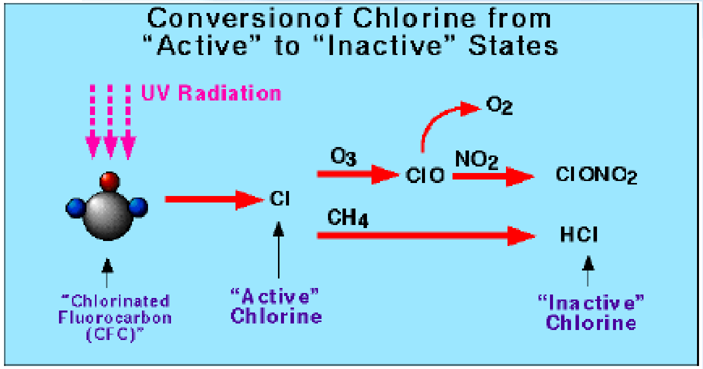


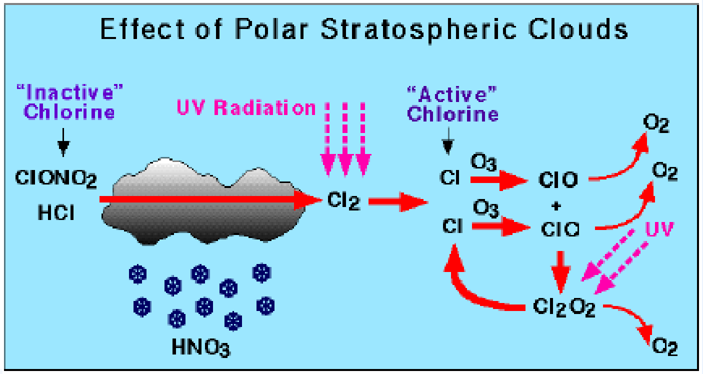




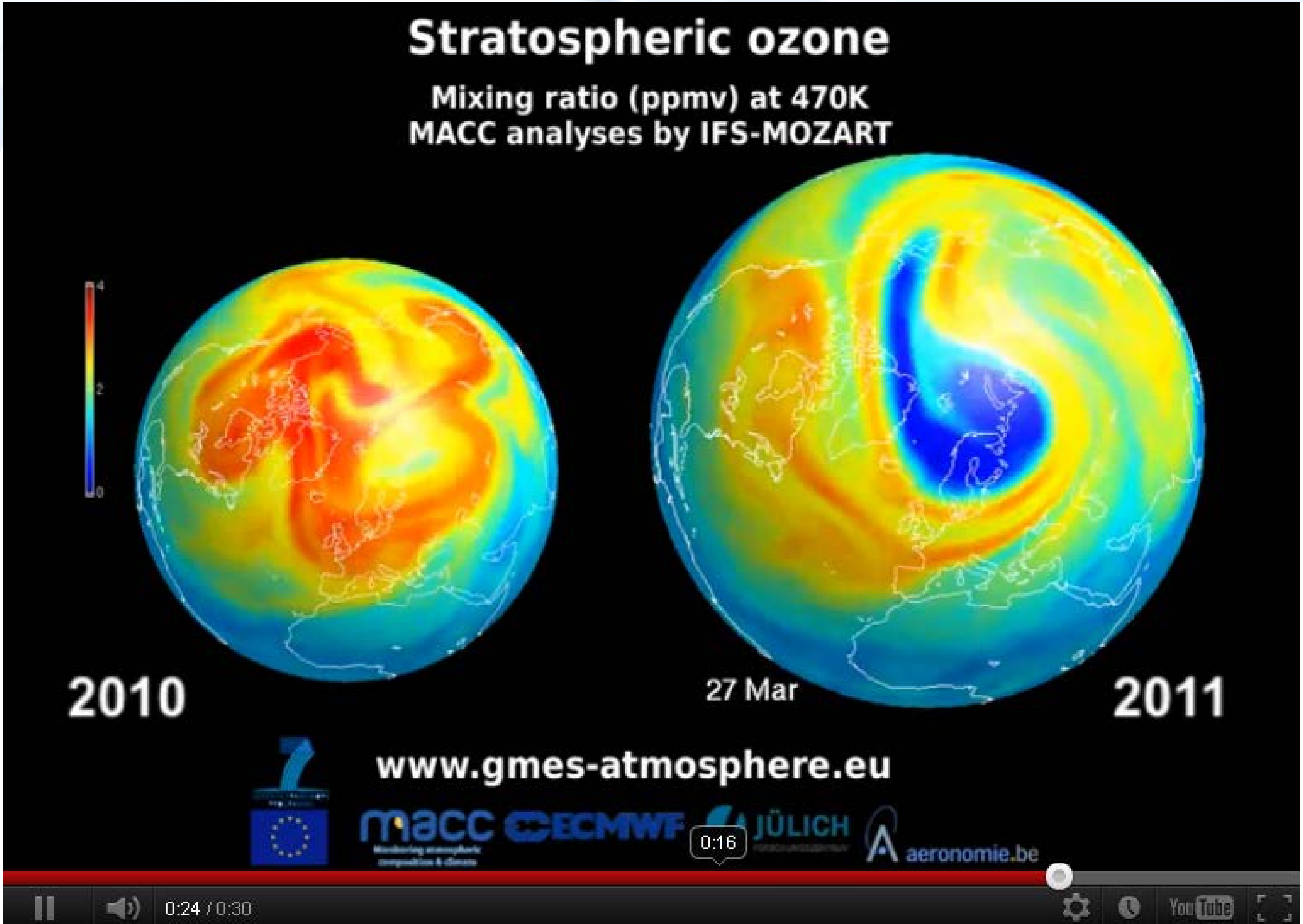


Proč nad póly?





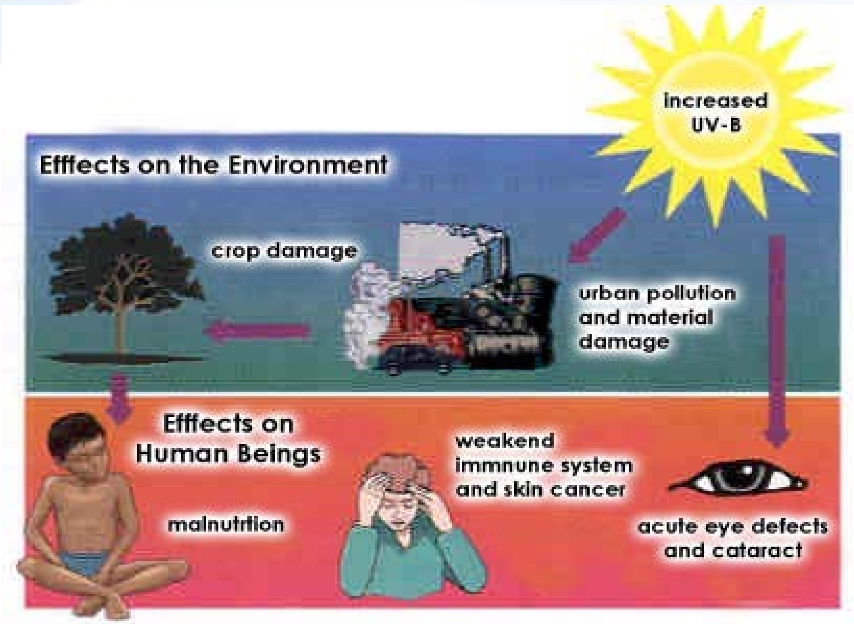
Úbytek stratosférického O_3 nad Arktidou



Důsledky úbytku O_3

Důsledky úbytku strat. O_3

1% ↓ konc. O_3 ≈ 2% ↑ intenzity UVB ≈ 4% ↑ rizika rakov. kůže

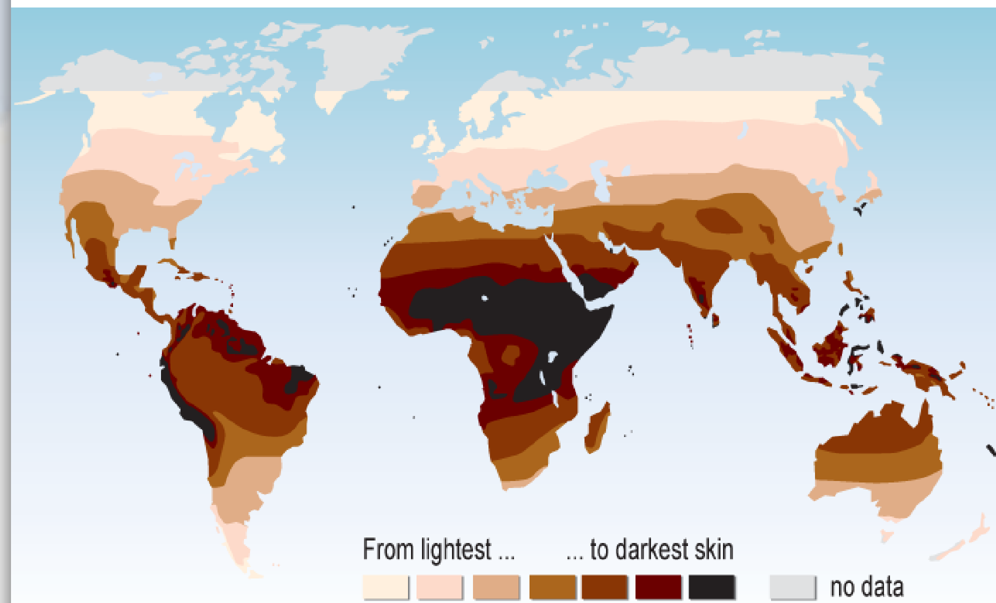


- většina melanomů vzniká na osluněné části kůže
- nejčastější výskyt u Australanů

VULNERABILITIES

Skin colour map (indigenous people)

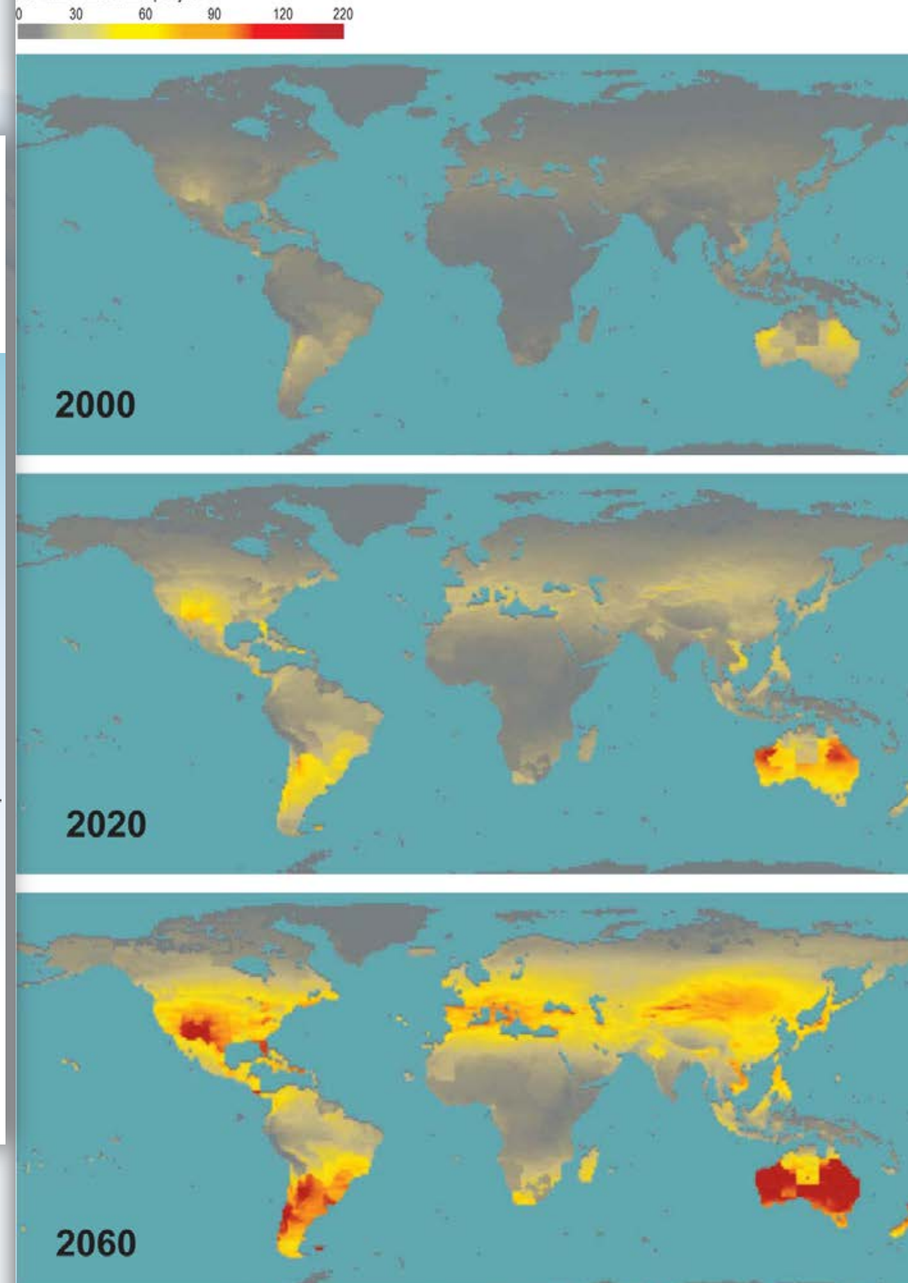
Predicted from multiple environmental factors



Source: Chaplin G.©, *Geographic Distribution of Environmental Factors Influencing Human Skin Coloration*, American Journal of Physical Anthropology 125:292–302, 2004; map updated in 2007.

Number of extra skin cancer cases related to UV radiation

Per million inhabitants per year



Source: Dutch National Institute for Public Health and the Environment (RIVM), Laboratory for Radiation Research (www.rivm.nl/milieuStoffen/straling/zomerthema_uv/), 2007

Centrum pro výzkum toxických látek v prostředí

Dopad zvýšené UVB radiace na plodiny

Possible changes in plant characteristics	Consequences	Selected sensitive crops
■ Reduced **photosynthesis** ■ Reduced **water-use efficiency** ■ Enhanced **drought stress sensitivity** ■ Reduced **leaf area** ■ Reduced **leaf conductance** ■ Modified **flowering** (either inhibited or stimulated) ■ Reduced **dry matter production**	Enhanced plant fragility Growth limitation Yield reduction	Rice Oats Sorghum Soybeans Beans

NB: Summary conclusions from artificial exposure studies.

Source: modified from Krupa and Kickert (1989) by Runeckles and Krupa (1994) in: Fakhri Bazzaz, Wim Sombroek, *Global Climate Change and Agricultural Production*, FAO, Rome,1996.

UNEP GRID ARENDAL

Centrum pro výzkum toxických látek v prostředí

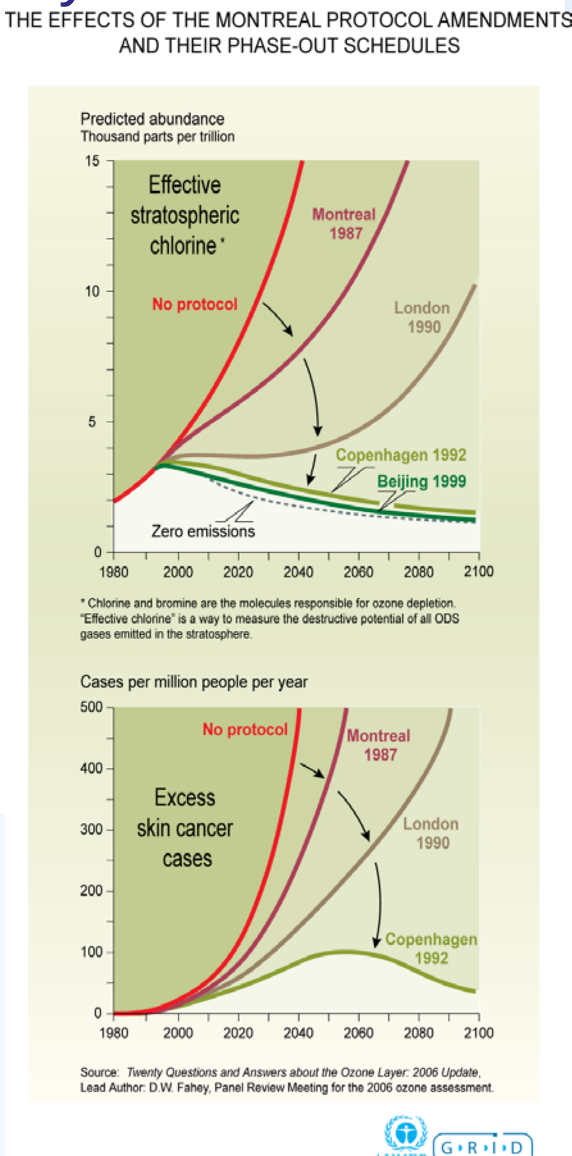
Ozonová díra

- možná řešení?

Řešení a důsledky

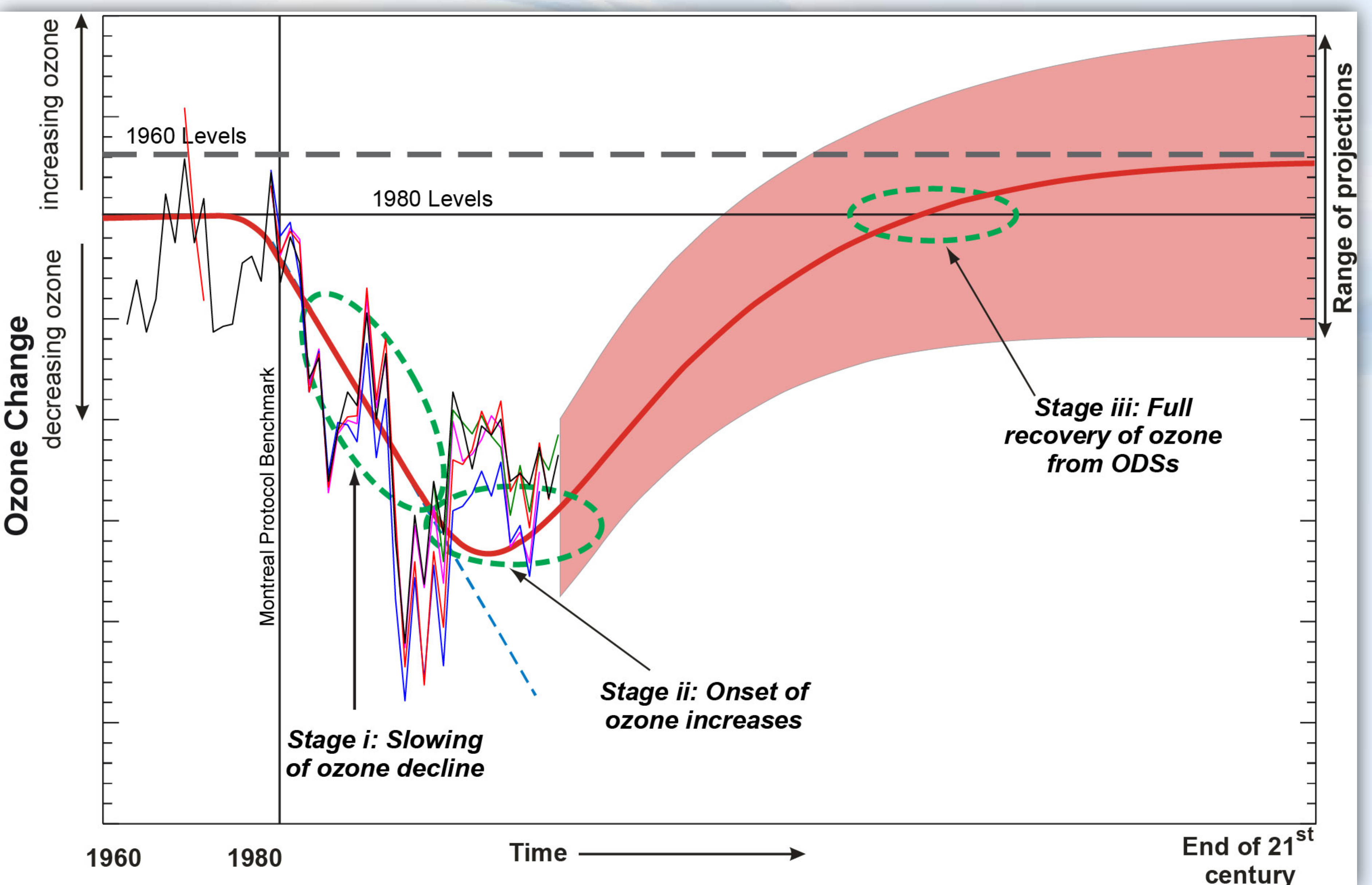
1985 – Vídeňská smlouva na ochranu O_3 vrstvy

1987 – Montrealský protokol + další dodatky



Centrum pro výzkum toxických látek v prostředí

Časová prodleva – ozón a jeho obnova



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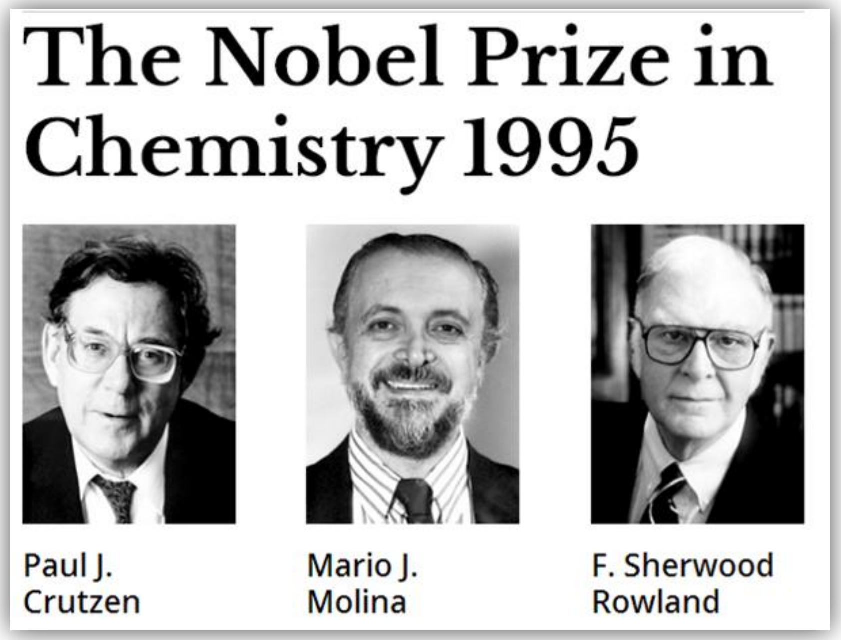
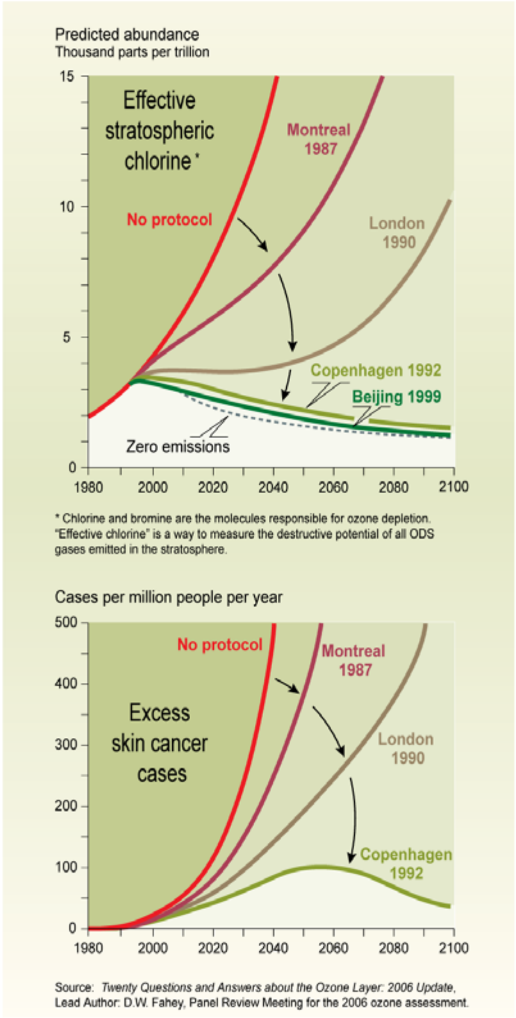


„for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.“

THE EFFECTS OF THE MONTREAL PROTOCOL AMENDMENTS AND THEIR PHASE-OUT SCHEDULES



Řešení a důsledky

1985 – Vídeňská smlouva na ochranu O_3 vrstvy
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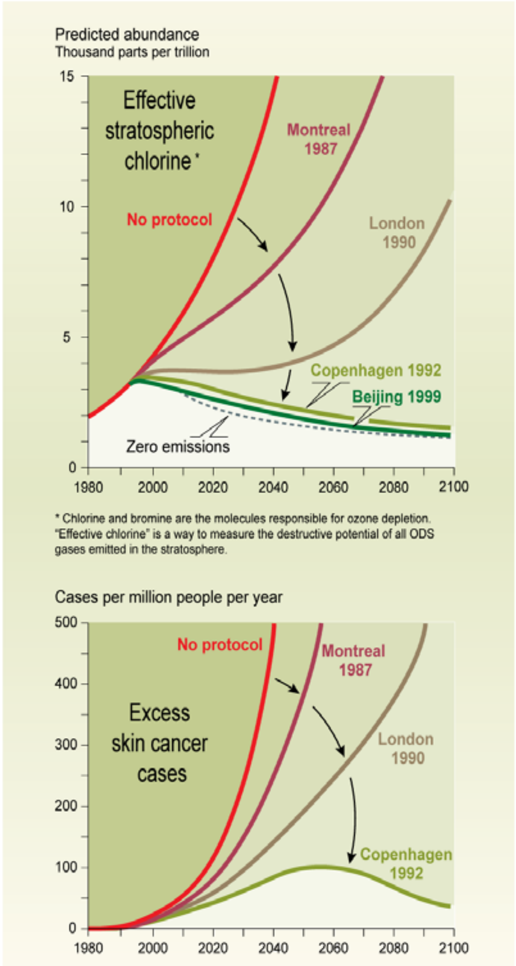
Náklady opuštění CFC

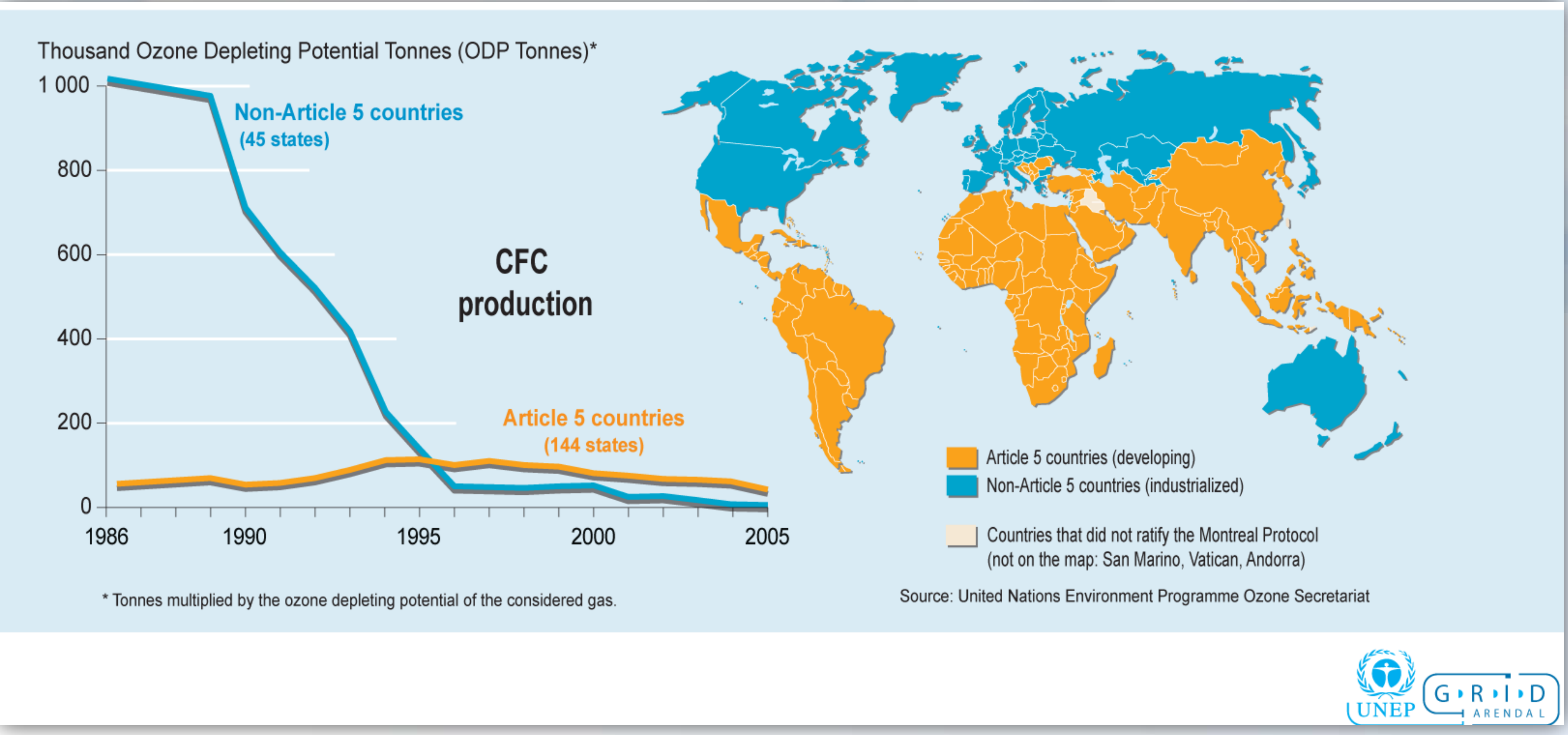
- 1988-2000 - pokles produkce na desetinu
- celkové náklady zhruba 40 miliard $
- ke ztrátám zaměstnání nedošlo
- 1/3 snížení prostou úsporou
- nahrazování CFC snadnější, často i za snížení nákladů (náhrady levnější)
- nové HFC v autech navýšily cenu o 50-150 $ (předpovězeno 1000-1500 $
- CH_3Br pro sterilizaci půd nahrazen např. střídáním plodin
- CH_3Br pro fumigaci skladů nahrazen CO_2

THE EFFECTS OF THE MONTREAL PROTOCOL AMENDMENTS
AND THEIR PHASE-OUT SCHEDULES



Source: Twenty Questions and Answers about the Ozone Layer: 2006 Update, Lead Author: D.W. Fahey, Panel Review Meeting for the 2006 ozone assessment.

Společná, ale diferencovaná zodpovědnost



Centrum pro výzkum toxických látek v prostředí

Ponaučení z úspěšného řešení globálního problému

- spolupráce zúčastněných aktérů:

- vědecké objevy a monitoring – **upozornění na problém**
- UNEP – **mezinárodní koordinátor politických opatření**
- environmentální aktivisté vyvíjející **tlak na řešení problému**
- uvědomělí konzumenti nakupující dle **env. informovanosti**
- techničtí experti vyvíjející **technologie šetrné k ŽP**
- flexibilní a **zodpovědný průmysl**

Science & Environment

'Healing' detected in Antarctic ozone hole

By Matt McGrath
Environment correspondent

30 June 2016 | Science & Environment

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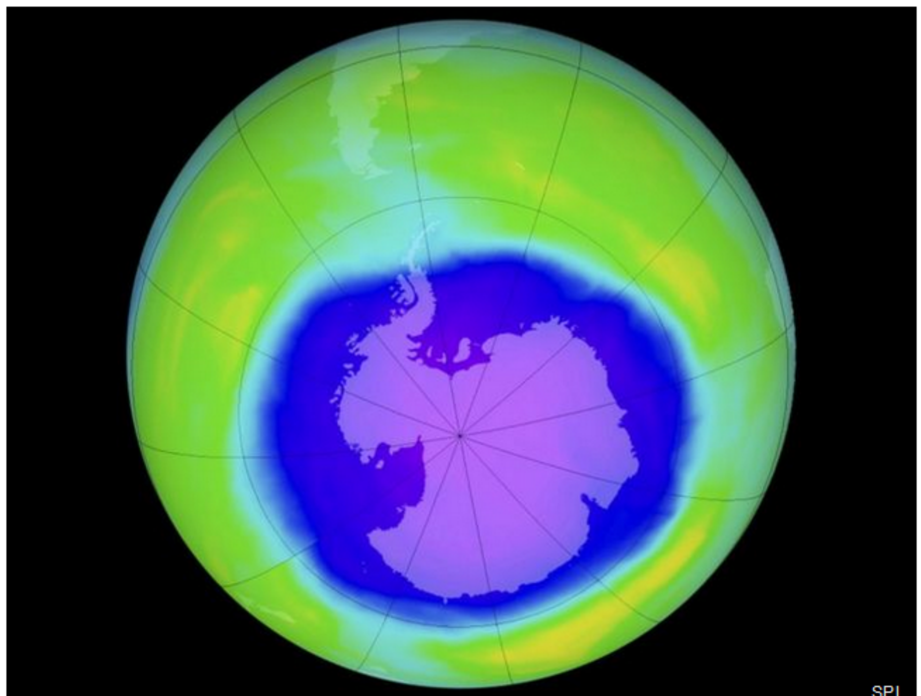


The researchers believe that healing of the ozone hole has begun in the stratosphere above Antarctica

Researchers say they have found the first clear evidence that the thinning in the ozone layer above Antarctica is starting to heal.

Centrum pro výzkum
toxických látek
v prostředí

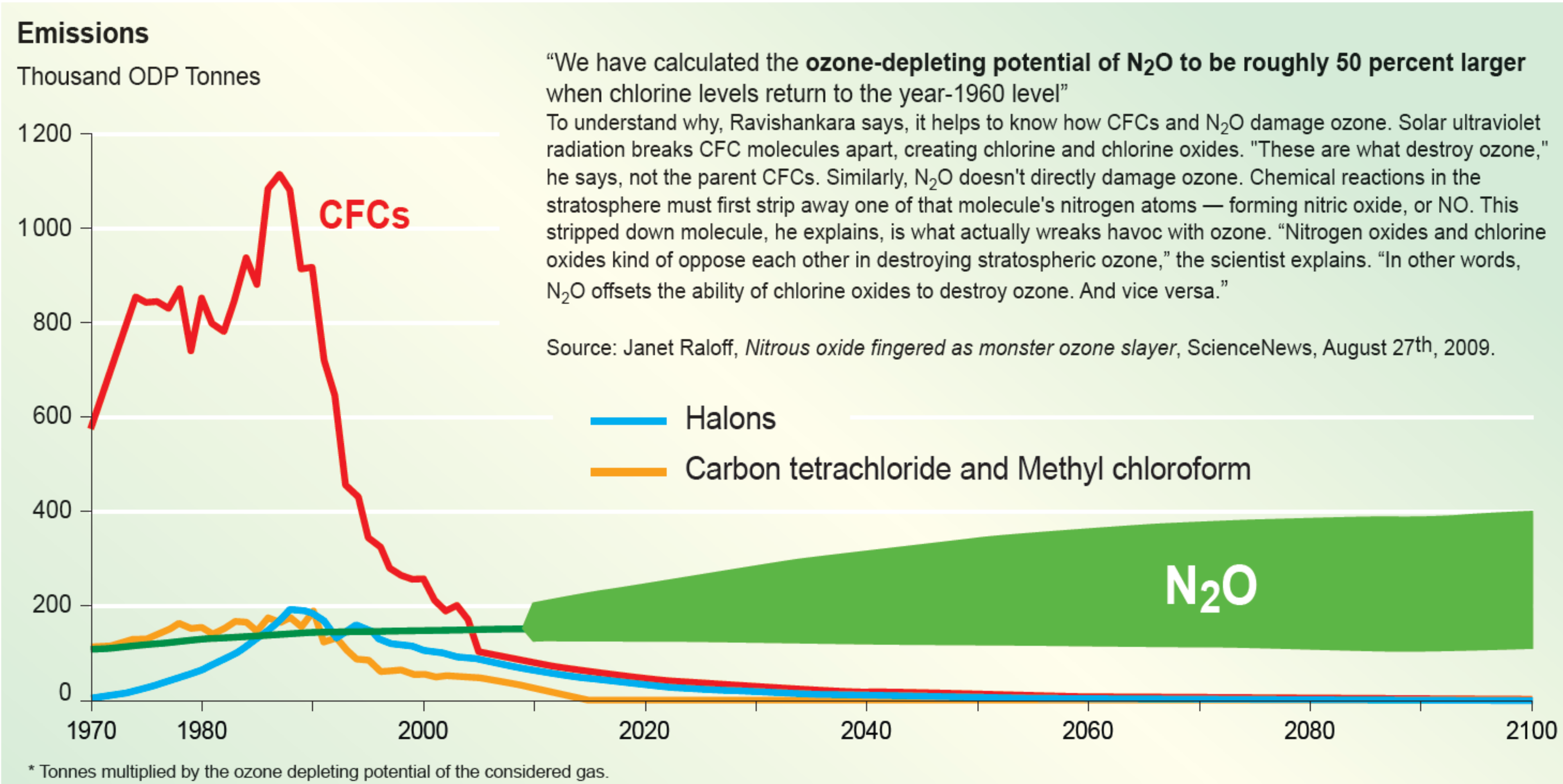
Aktuální problém – N_2O

NITROUS OXIDE: A MAJOR CULPRIT AFTER 2010

“We have calculated the **ozone-depleting potential of N_2O to be roughly 50 percent larger** when chlorine levels return to the year-1960 level”

To understand why, Ravishankara says, it helps to know how CFCs and N_2O damage ozone. Solar ultraviolet radiation breaks CFC molecules apart, creating chlorine and chlorine oxides. "These are what destroy ozone," he says, not the parent CFCs. Similarly, N_2O doesn't directly damage ozone. Chemical reactions in the stratosphere must first strip away one of that molecule's nitrogen atoms — forming nitric oxide, or NO. This stripped down molecule, he explains, is what actually wreaks havoc with ozone. “Nitrogen oxides and chlorine oxides kind of oppose each other in destroying stratospheric ozone,” the scientist explains. “In other words, N_2O offsets the ability of chlorine oxides to destroy ozone. And vice versa.”

Source: Janet Raloff, *Nitrous oxide fingered as monster ozone slayer*, ScienceNews, August 27th, 2009.



* Tonnes multiplied by the ozone depleting potential of the considered gas.

Source: A. R. Ravishankara, John S. Daniel, Robert W. Portmann, *Nitrous oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century*, Science, August 2009.

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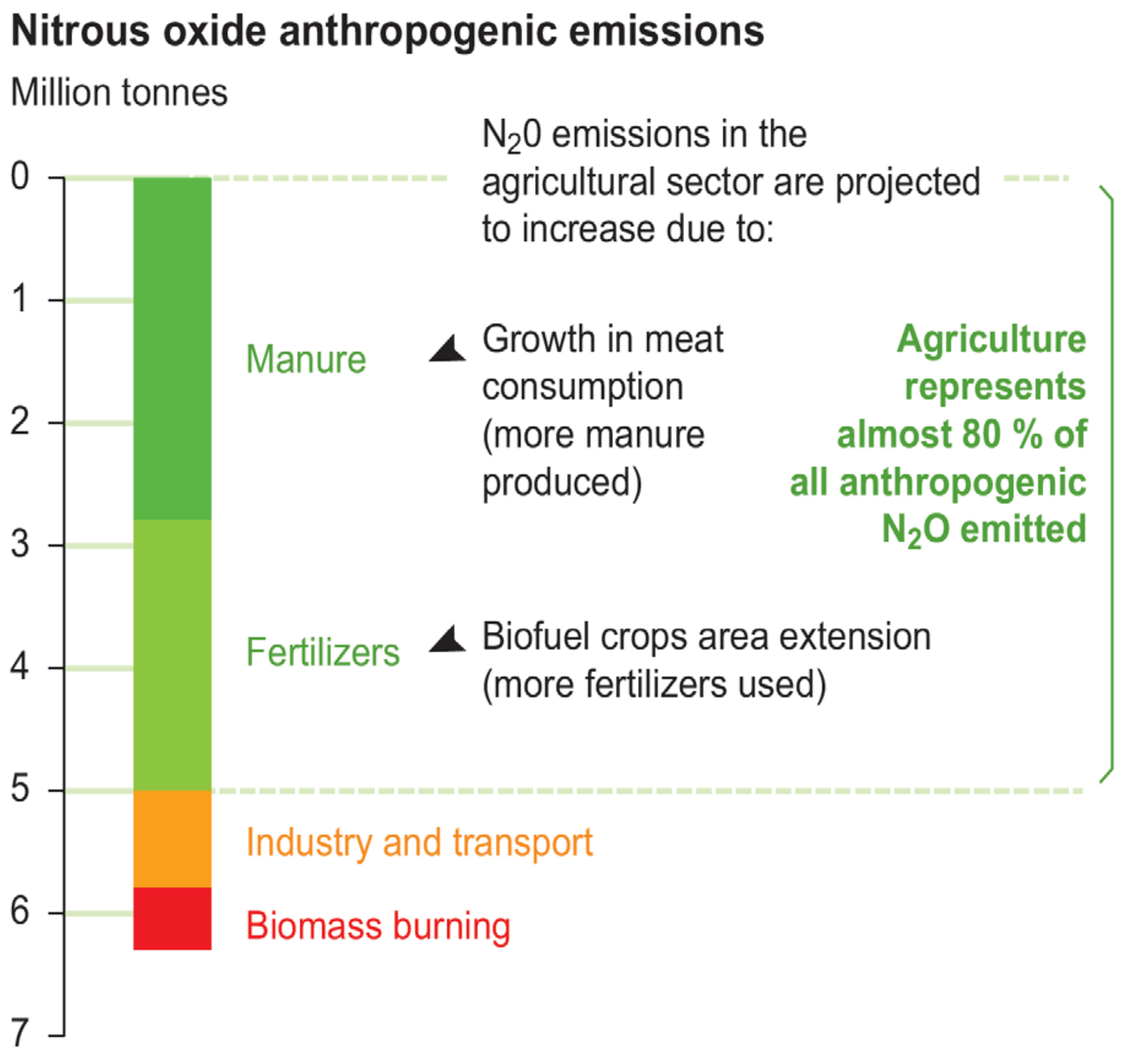
Aktuální problém – N_2O



Source: Eric A. Davidson, *The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860*, Nature Geoscience, August 2009.

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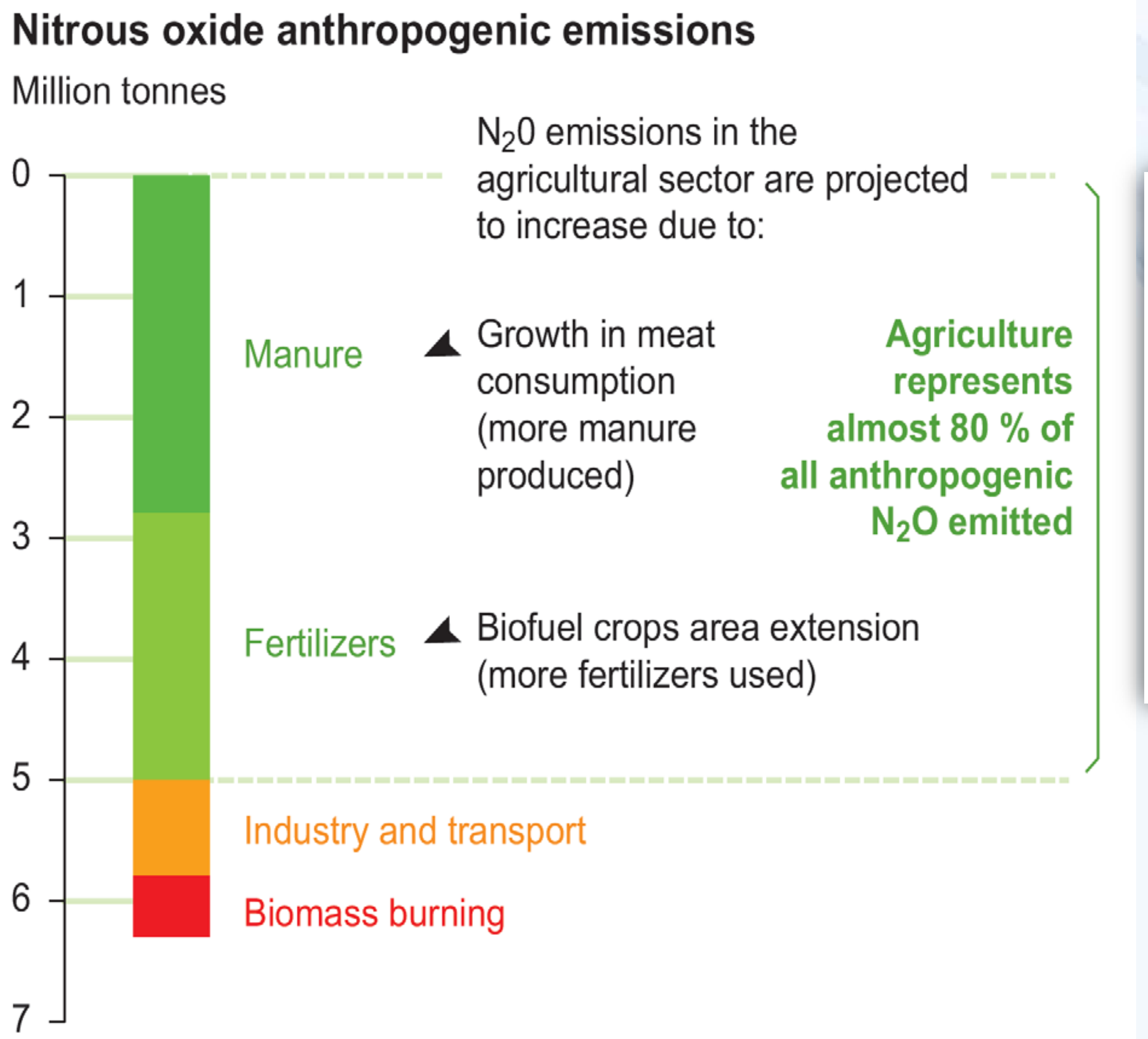

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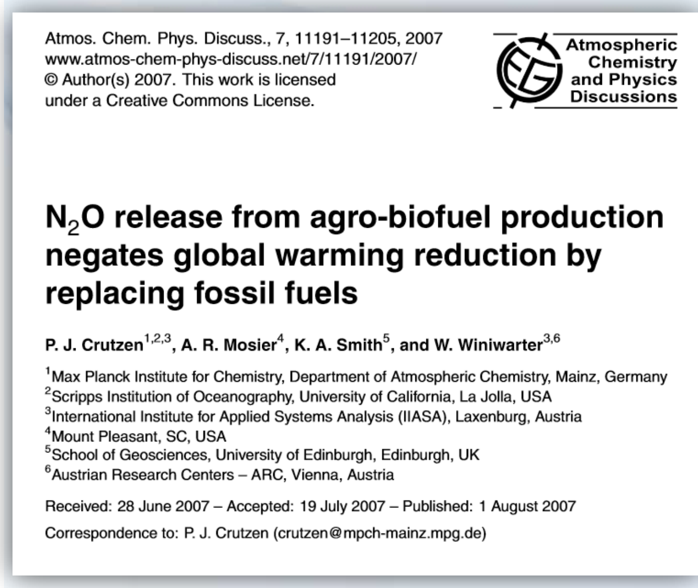

Atmos. Chem. Phys. Discuss., 7, 11191–11205, 2007
www.atmos-chem-phys-discuss.net/7/11191/2007/

Atmospheric Chemistry and Physics Discussions

N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

P. J. Crutzen[1,2,3], A. R. Mosier[4], K. A. Smith[5], and W. Winiwarter[3,6]

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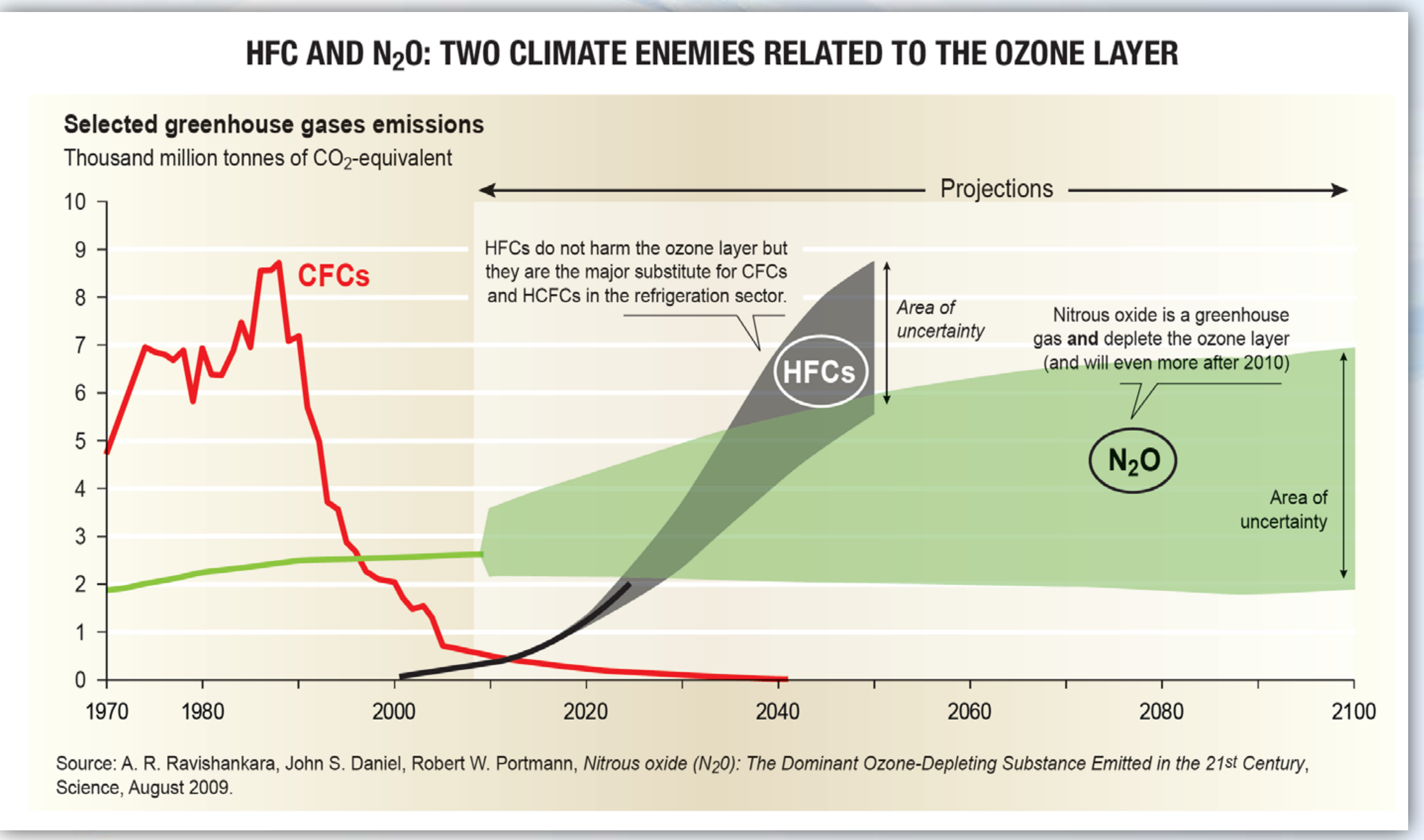
Received: 28 June 2007 – Accepted: 19 July 2007 – Published: 1 August 2007

Correspondence to: P. J. Crutzen (crutzen@mpch-mainz.mpg.de)

Globální oteplování x úbytek stratosférického ozónu



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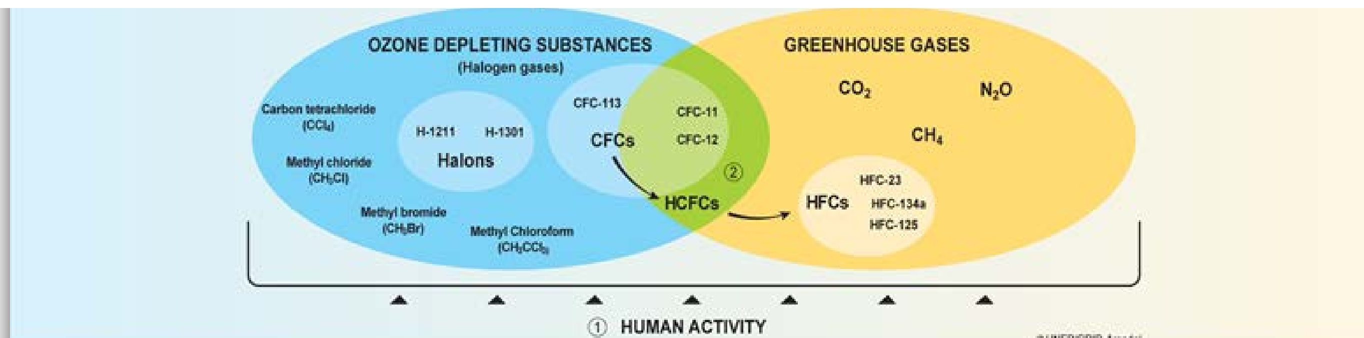


Ozone depletion and climate change are two distinct problems but as they both modify global cycles, they cannot be totally separated. There are still many uncertainties concerning the relations between the two processes.

Several links have been identified, in particular:

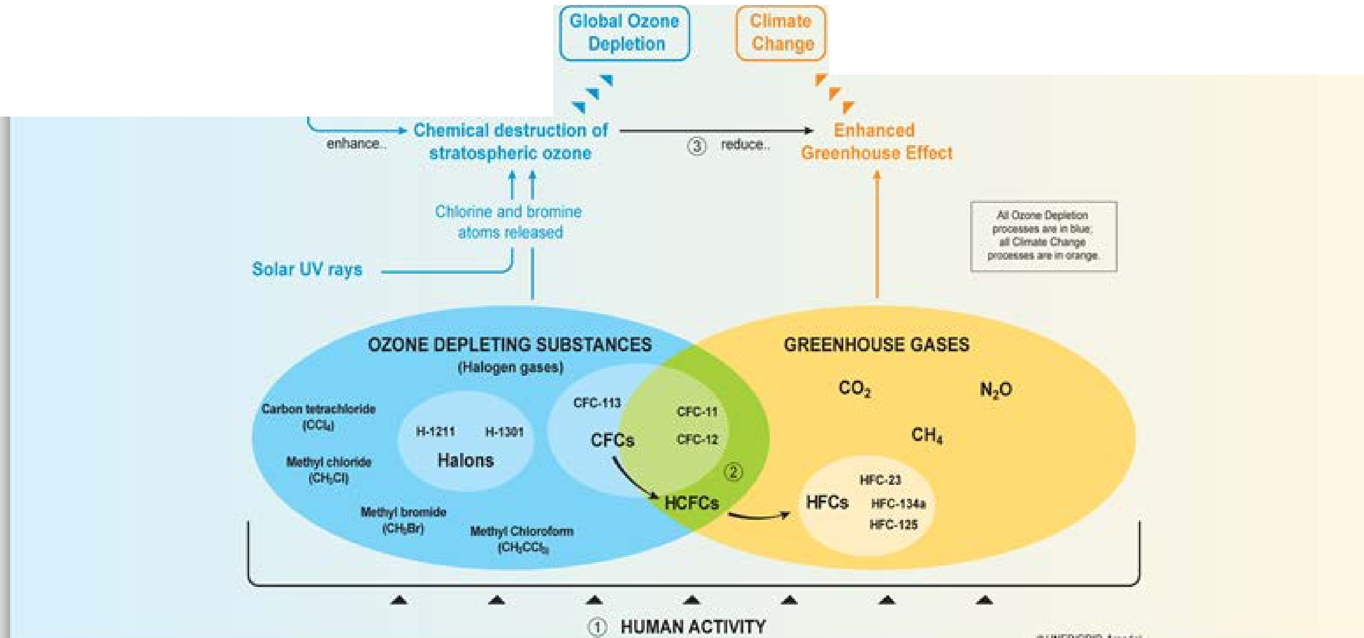
① Both processes are due to human-induced emissions.

② Many ozone depleting substances are also greenhouse gases, like CFC-11 and CFC12. HFCs, promoted to substitute CFCs, are sometimes stronger greenhouse gases than the CFCs they are replacing, but do not deplete the ozone layer. This fact is taken into account in the negociations and decisions in both the Montreal and the Kyoto Protocol.

③ Ozone itself is a greenhouse gas. Therefore, its destruction in the stratosphere indirectly helps to cool the climate, but only to a small extent.

④ The global change in atmospheric circulation could be the cause of the recently observed cooling of stratospheric temperature. These low temperatures drive the formation of polar stratospheric clouds above the poles in the winter, greatly enhancing chemical ozone destruction and the formation of the "hole".

⑤ Human vulnerability to UV-B radiation is related to the albedo.The global warming context reduces white surfaces that are more likely to harm us.



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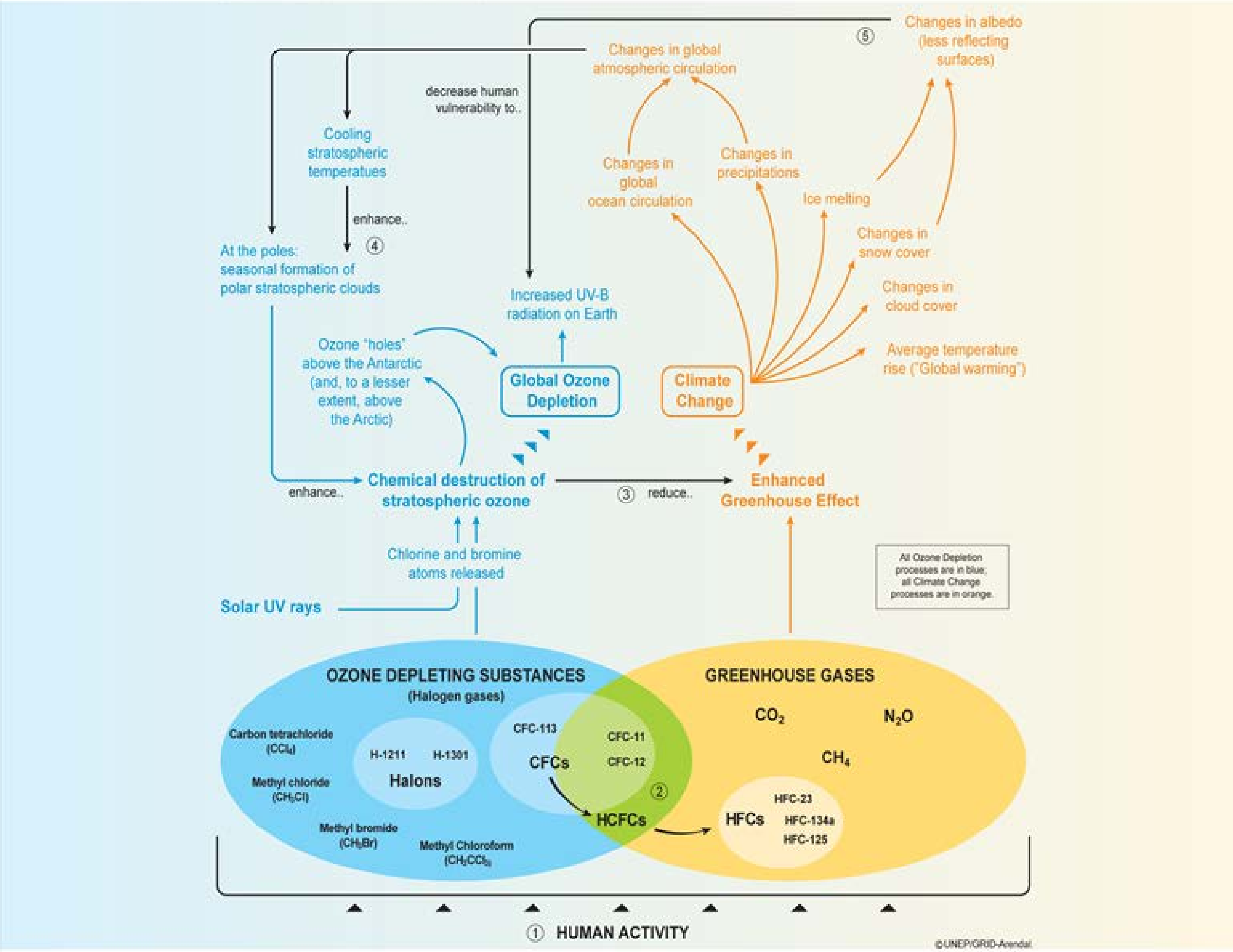
OZONE DEPLETION AND CLIMATE CHANGE



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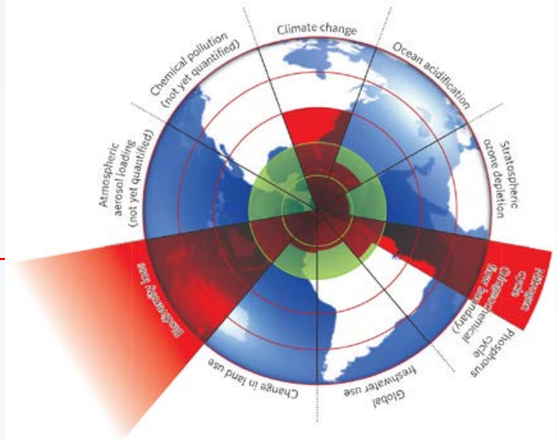
IV. Okyselování oceánů

Earth System process	Control variable	Threshold avoided or influenced by slow variable	Planetary Boundary (zone of uncertainty)	State of knowledge*
Ocean acidification	Carbonate ion concentration, average global surface ocean saturation state with respect to aragonite (Ω_{arag})	Conversion of coral reefs to algal-dominated systems. Regional elimination of some aragonite- and high-magnesium calcite-forming marine biota Slow variable affecting marine carbon sink.	Sustain ≥80% of the pre-industrial aragonite saturation state of mean surface ocean, including natural diel and seasonal variability (≥80%–≥70%)	1. Geophysical processes well known. 2. Threshold likely. 3. Boundary position uncertain due to unclear ecosystem response.

Boundary: Global average aragonite "saturation ratio" no lower than 2.75:1
Pre-industrial level: 3.44:1
Current level: 2.90:1
Diagnosis: Safe for now, but some oceans will cross threshold by mid-century



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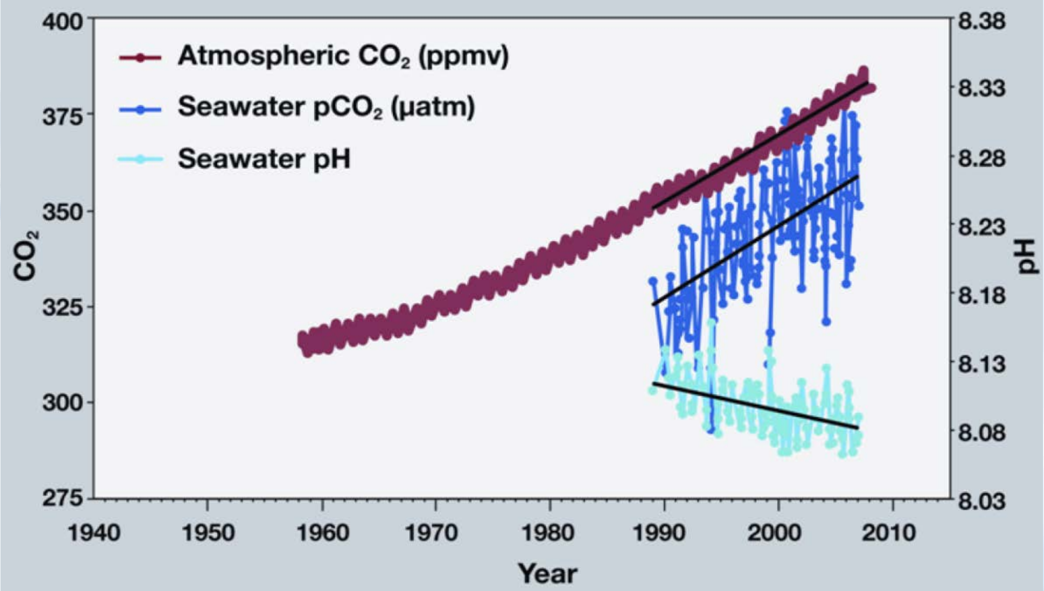
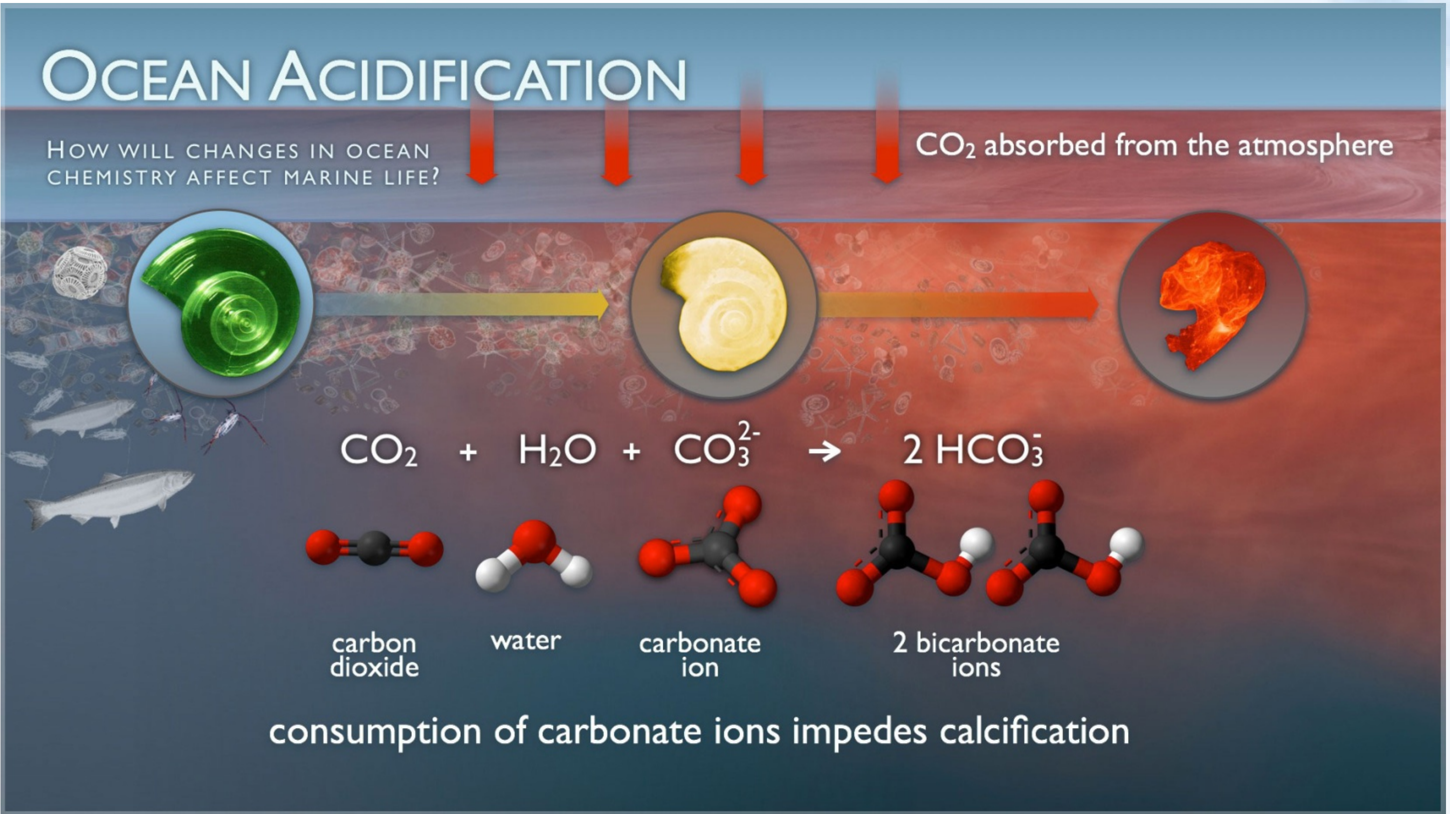
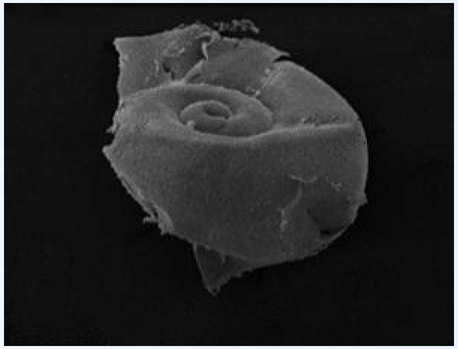
Okyselování oceánů

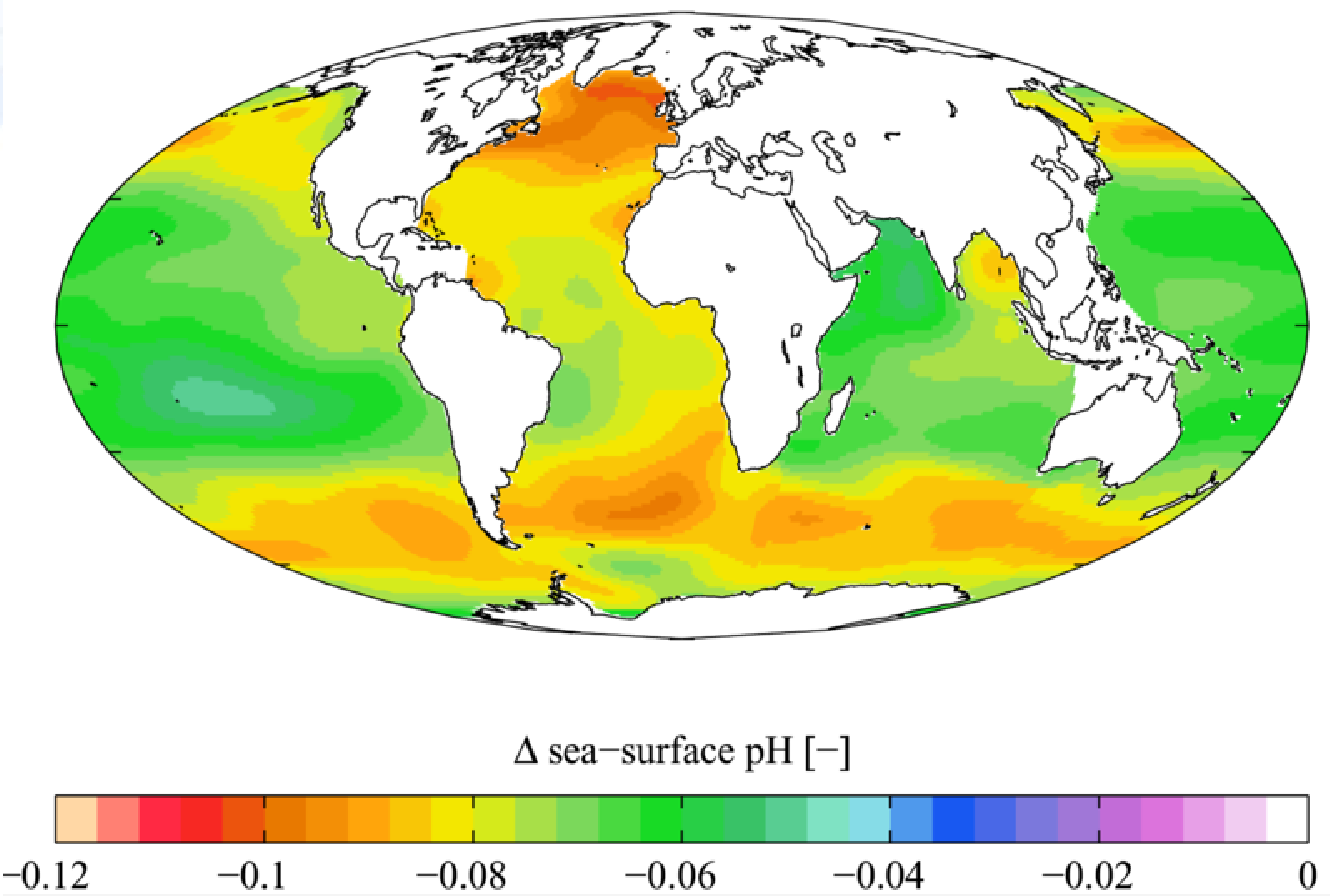
- čím je způsobené?



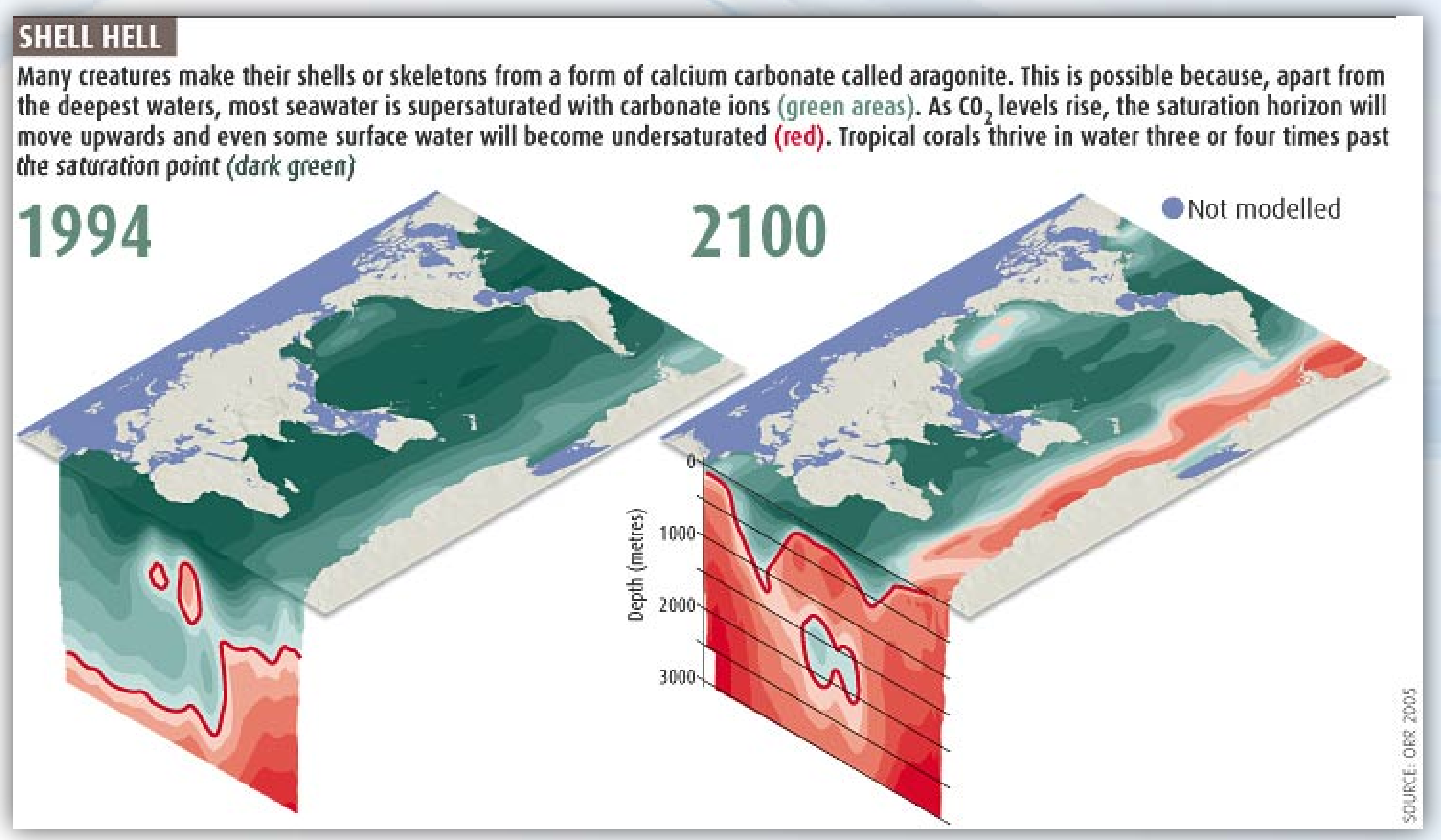




Změna pH oceánů 1700-2000



Změna pH oceánů - 3D rozvrstvení



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Natural lab shows sea's acid path

By Richard Black
Environment correspondent, BBC News website

Scientists study conditions at the bottom of the Mediterranean Sea

Natural carbon dioxide vents on the sea floor are showing scientists how carbon emissions will affect marine life.

Dissolved CO_2 makes water more acidic, and around the vents, researchers saw a fall in species numbers, and snails with their


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26 March 2014 Last updated at 23:03 GMT   Share

How climate change will acidify the oceans

By Roger Harrabin
BBC environment analyst, Normanby Island

Off the remote eastern tip of Papua New Guinea a natural phenomenon offers an alarming glimpse into the future of the oceans, as increasing concentrations of CO_2 in the atmosphere make sea water more acidic.

Streams of volcanic CO_2 bubbles emerge from deep under the seabed here, like a giant jacuzzi.

As the bubbles of carbon dioxide dissolve into the water, carbonic acid is

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The oceans are heating, acidifying and choking

› 19:58 04 October 2013 by Fred Pearce
› For similar stories, visit the Climate Change Topic Guide

We know the oceans are warming. We know they are acidifying. And now, to cap it all, it turns out they are suffocating, too. A new health check on the state of the oceans warns that they will have lost as much as 7 per cent of their oxygen by the end of the century.

Getting harder to breathe underwater *(Image: Incredible Features/Barcroft Media)*

The cascade of chemical and biological changes now under way could see coral reefs irreversibly destroyed in 50 to 100 years, with marine ecosystems increasingly taken over by jellyfish and toxic algal blooms.

The review is a repeat of a study two years ago by the International Programme on the State of the Ocean (IPSO), a coalition of scientists. It concludes that things have become worse since the first study.

"The health of the oceans is spiralling downwards far more rapidly than we had thought, exposing organisms to intolerable and unpredictable evolutionary pressure," says Alex Rogers at the University of Oxford, the scientific director of IPSO.

Deadly trio

Rogers describes a "deadly trio" of linked global threats. The first is global warming: surface sea water has been warming almost as fast as the atmosphere. The second is acidification – a result of the water absorbing ever more CO_2 from the atmosphere. The third is deoxygenation.