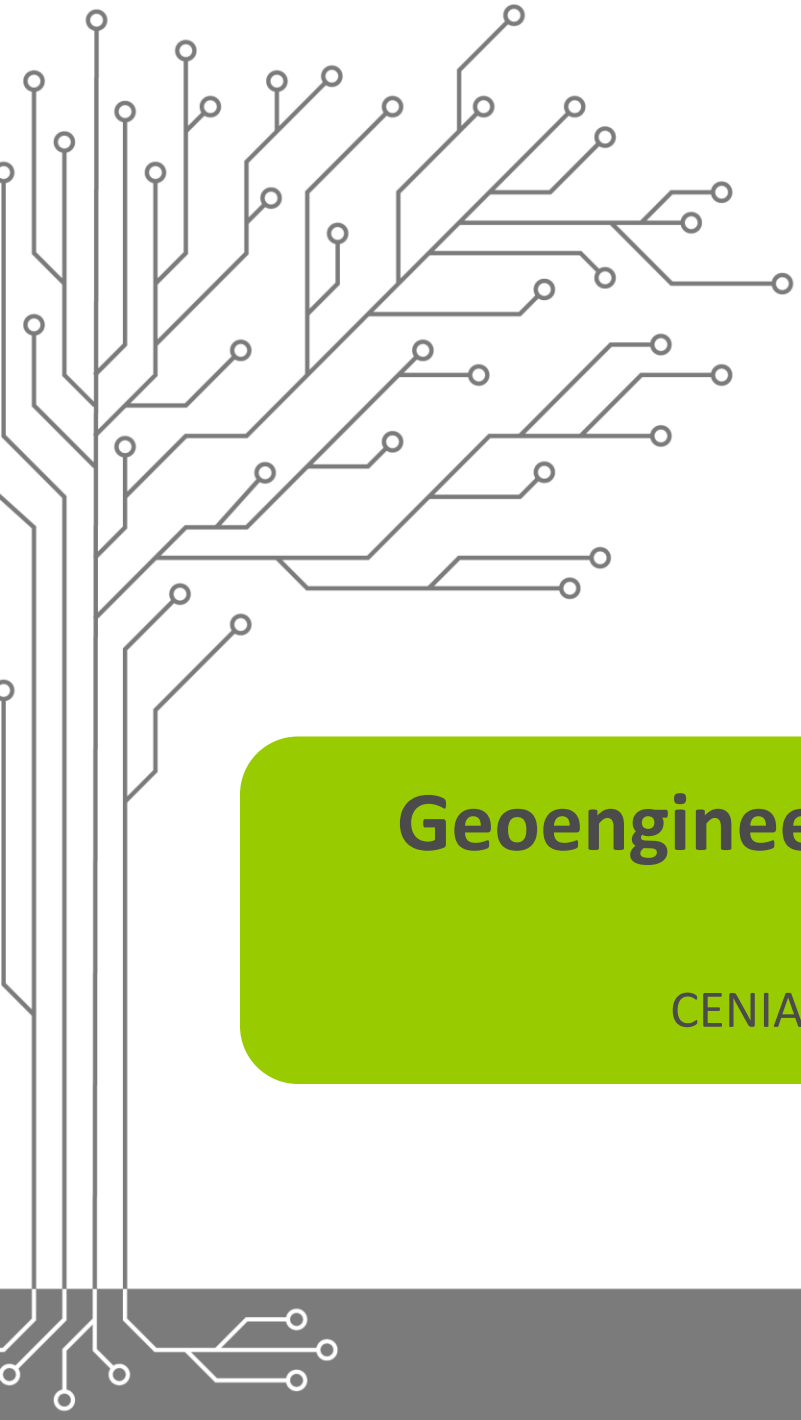


Spatium naturalis per humana vita

Geoengineering – spása, nebo ohrožení?

Mgr. Miroslav Havránek

CENIA, česká informační agentura životního prostředí

Cíl přednášky

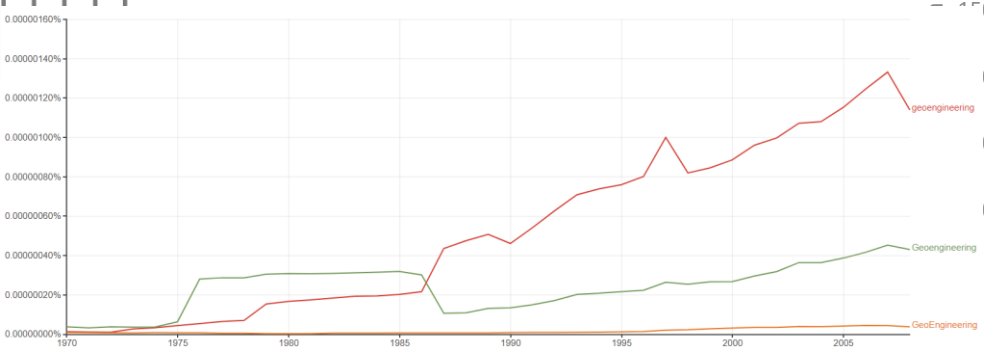
- Neprezentujeme originální výzkum
- Terminologie
- Informovat a otevřít diskusi o tématu které je:
  - Jedna z největších divokých karet lidstva pro 21 století (WEF, 2010)
  - Trendující
  - Bychom měli mít vydiskutováno jaká je naše pozice a proč
  - Zajímavé pole pro výzkum (akceptovatelnost, mechanismy, cena, geopolitika, bezpečnost …), kde dříve vyvinuté metody mohou být použity

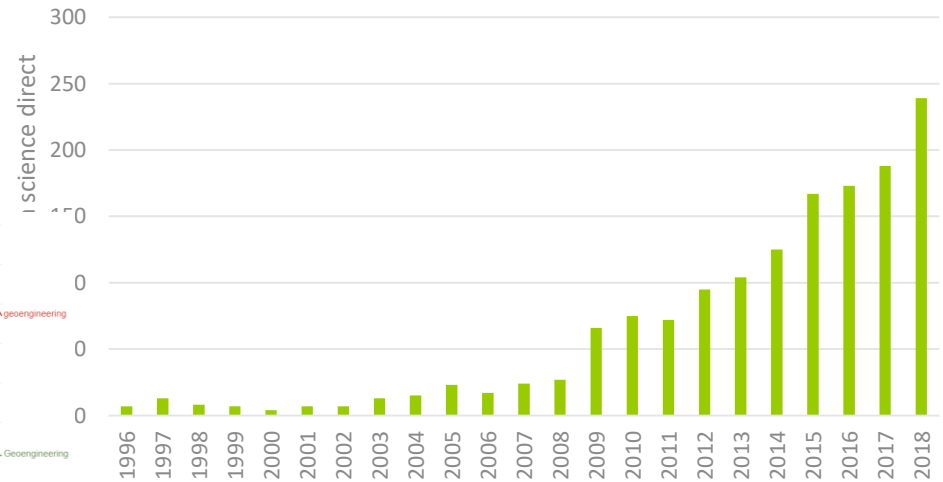
Proč geoinženýring?

- Mapování bílých míst státní politiky žp
- Projekt TAČR TITO MZP702 MEHOSTRADO
- Zesilující signály nastupujících trendů které mohou silně ovlivnit žp v ČR

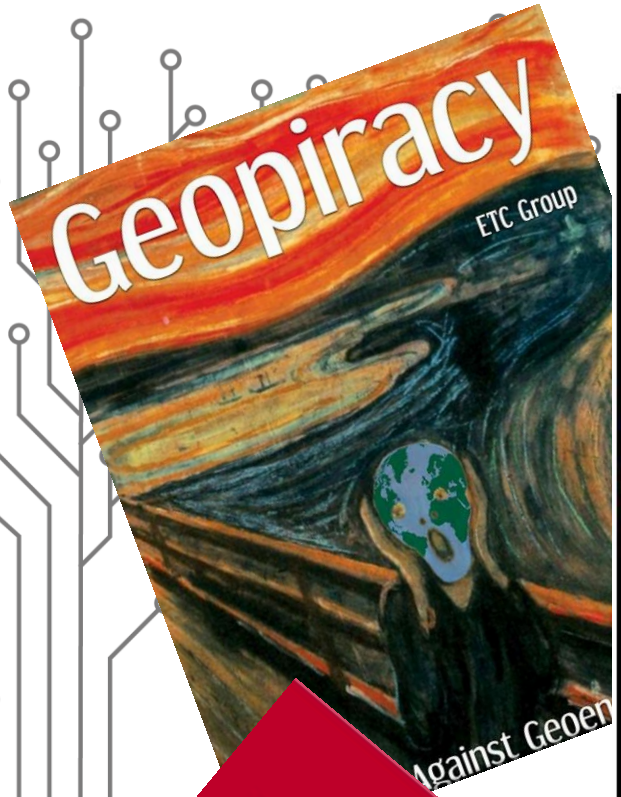
Jak identifikovat bílé místo?

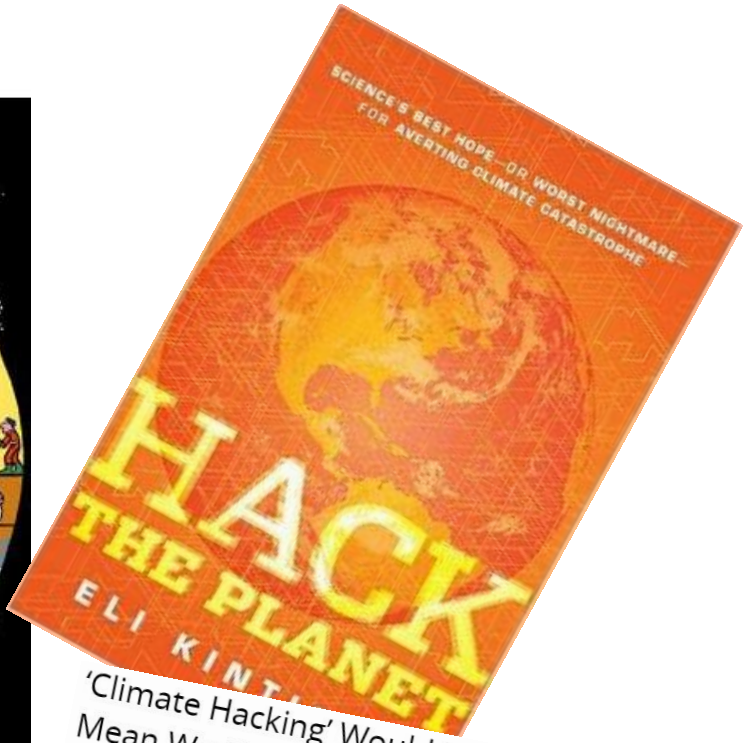
- Mix přístupů – sledovat instituce, individuality, články, zprávy (kde je míra?)





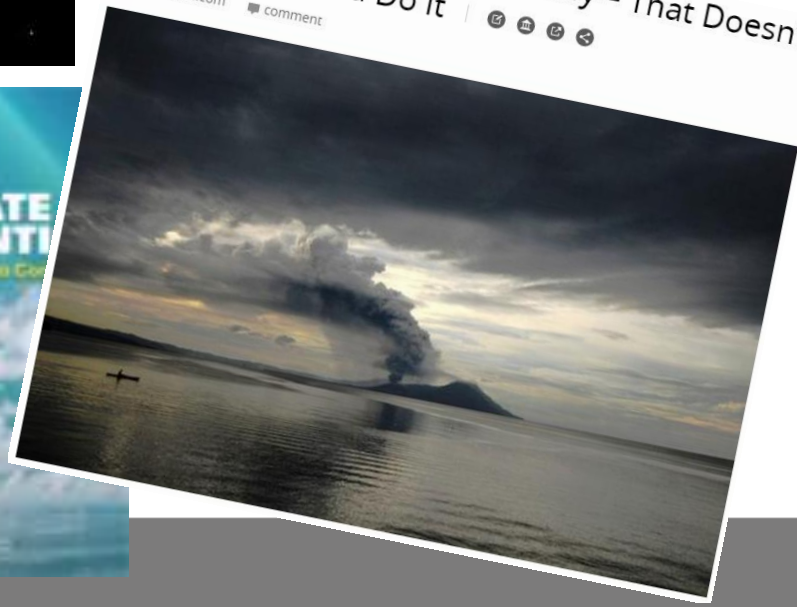
The Climate Fixers





'Climate Hacking' Would Be Easy – That Doesn
Mean We Should Do It

iflscience.com comment



Terminologie

Co je geoinženýring?

- Deliberate large-scale manipulation of the planetary environment (Keith, 2000)

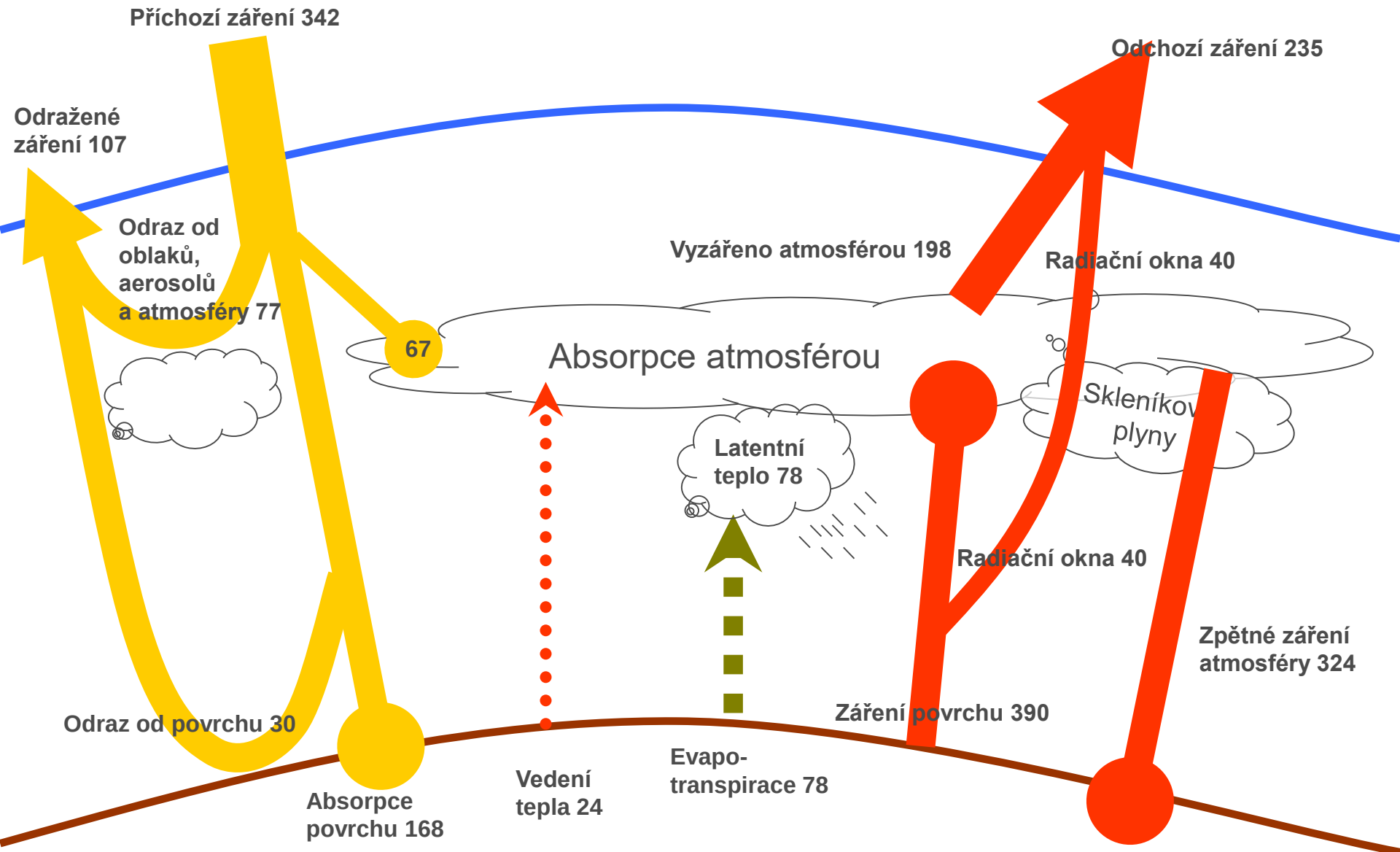
Co je klimatická intervence?

- Deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change

Energetická bilance planety

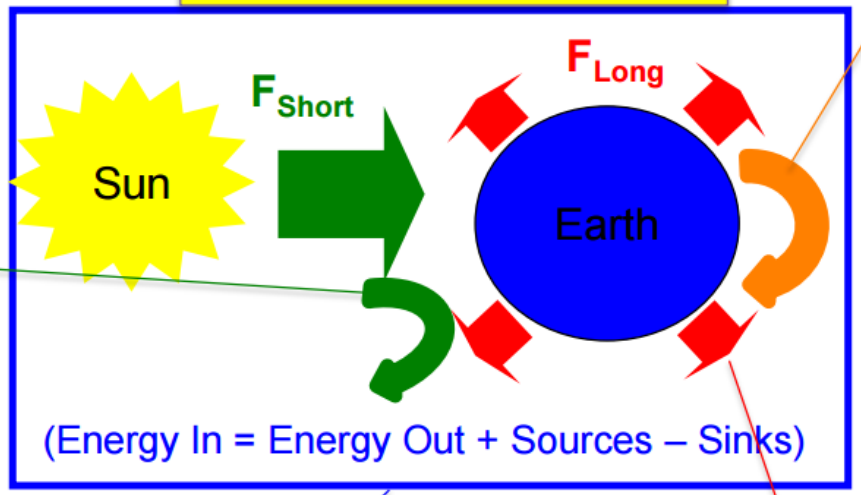
(údaje jsou ve W.m^{-2})

(dle Earth's Annual Global Mean Energy Budget; Kiehl, J. T. and Trenberth, K. E., 1997 *Bull. Amer. Meteor. Soc.*, 78, 197-208.)



Earth's "Energy Balance"

$S_0(1-\alpha_p) + F_{ghg} = \sigma T_{surf}^4$

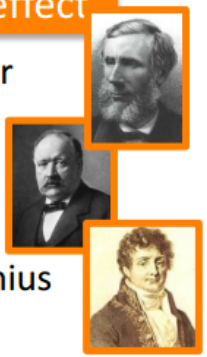


Aerosol-enhanced albedo effect
$F_{Short} = S_0(1-\alpha_p)$

- Hilding Köhler 1936
- Sean Twomey 1974

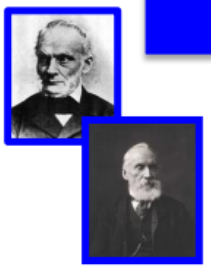
CO_2-enhanced greenhouse effect

- Joseph Fourier 1824
- John Tyndall 1858
- Svante Arrhenius 1896



1st Law of Thermodynamics
$F_{Short} = F_{Long}$

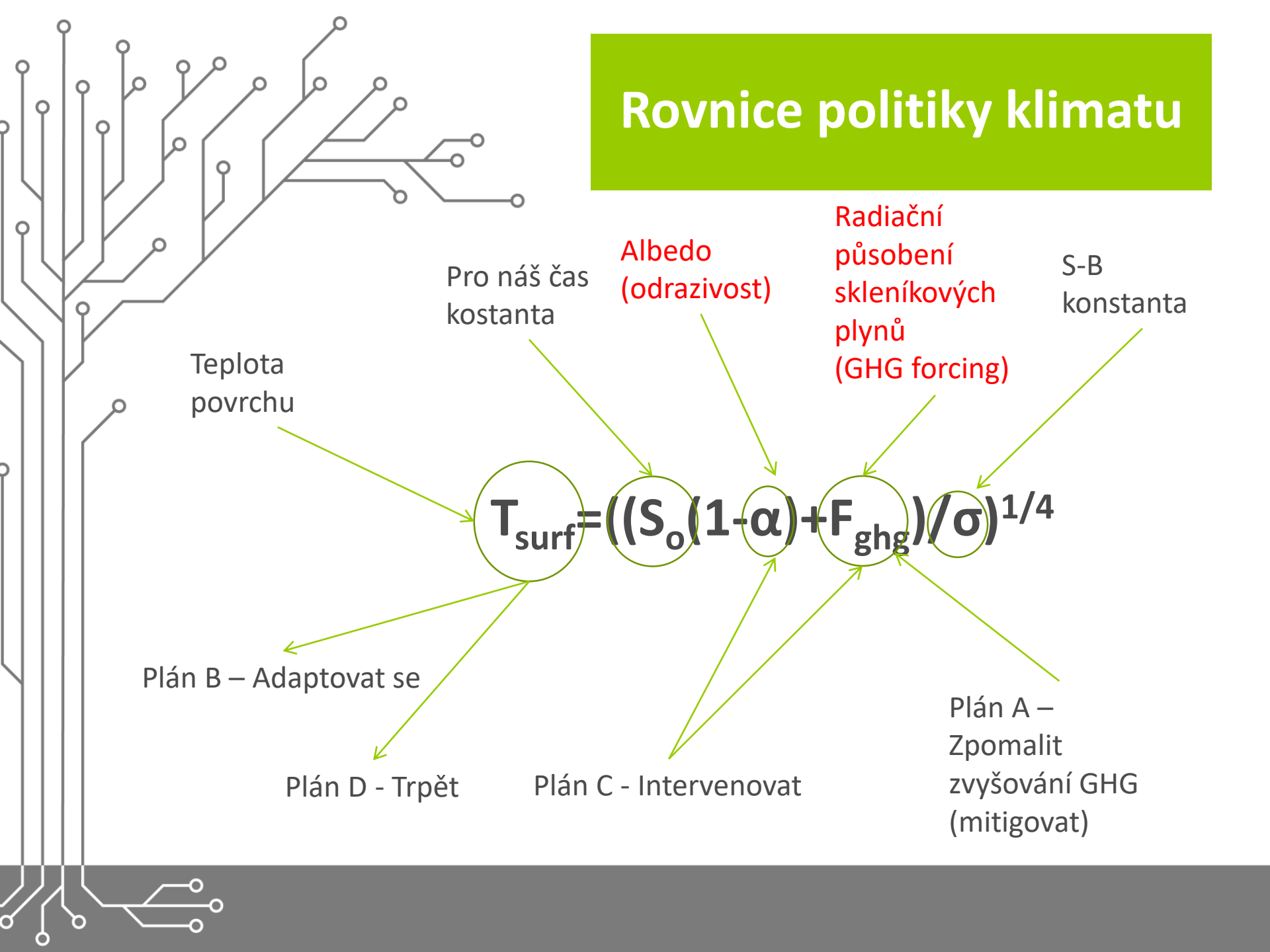
- Rudolf Clausius 1850
- William Thompson (Lord Kelvin) 1848



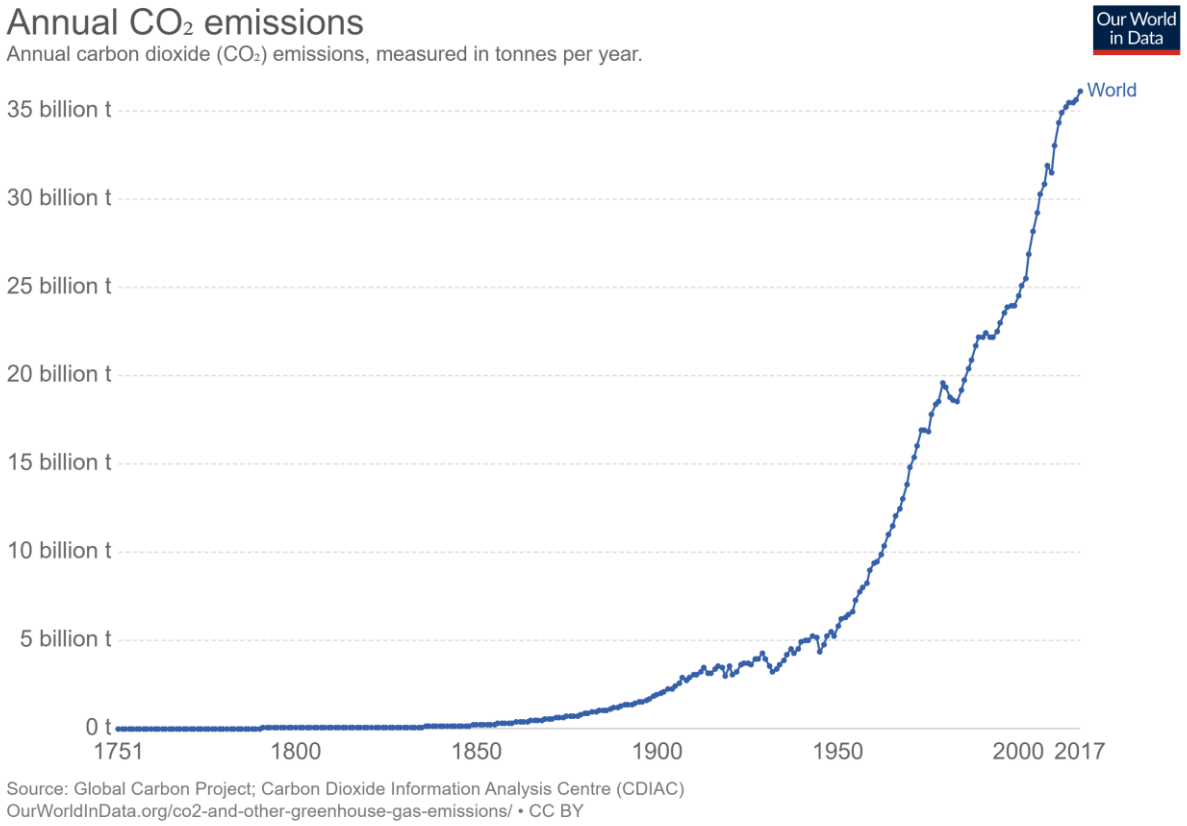
Stefan-Boltzmann Law
$F_{Long} = \sigma T_{surf}^4$

- Josef Stefan 1874
- Ludwig Boltzmann 1884
- Max Planck 1901

Rovnice politiky klimatu



Mitigujeme? Ne....

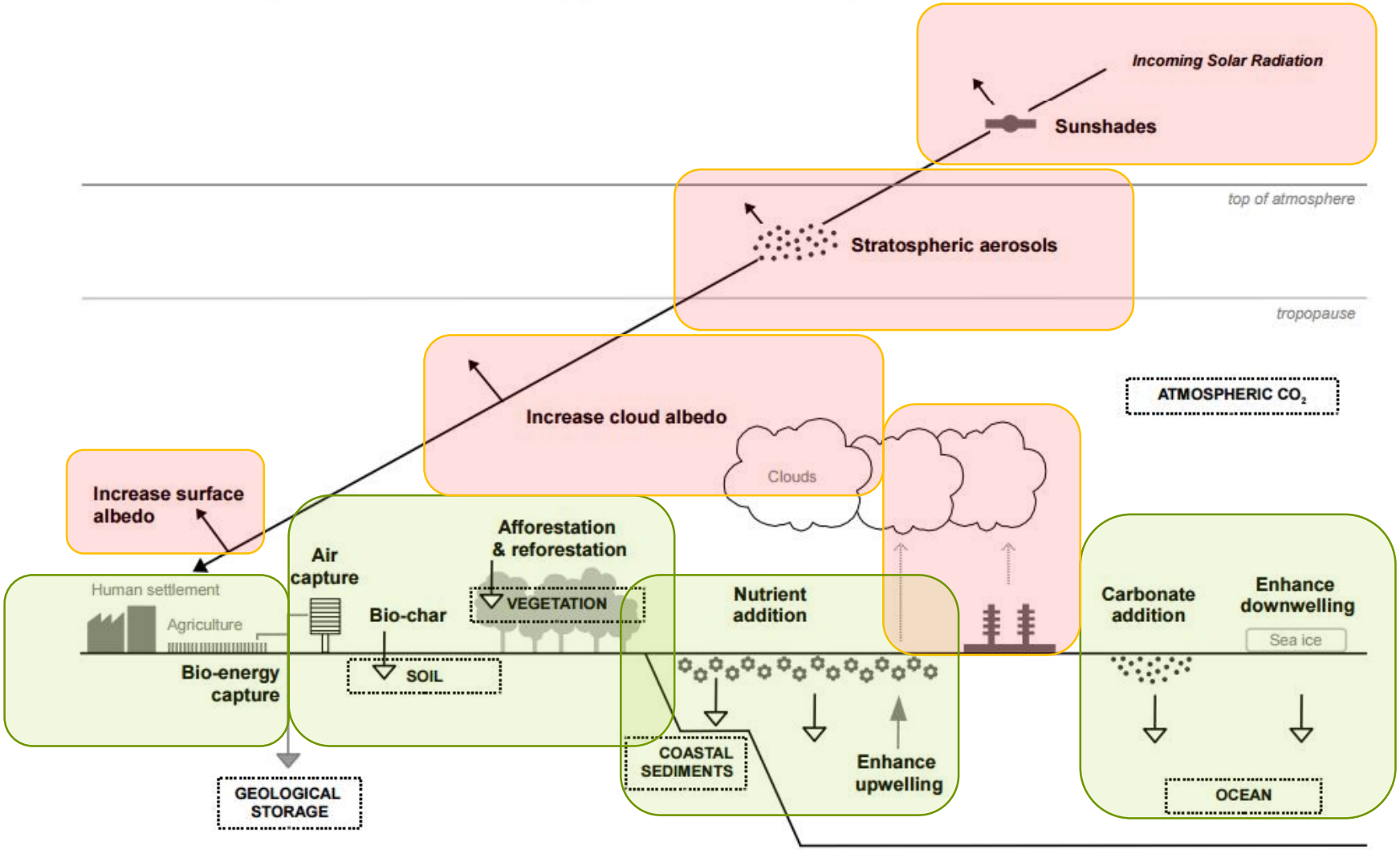


Adaptujeme se? Možná …

Jaké jsou tedy možnosti intervence?

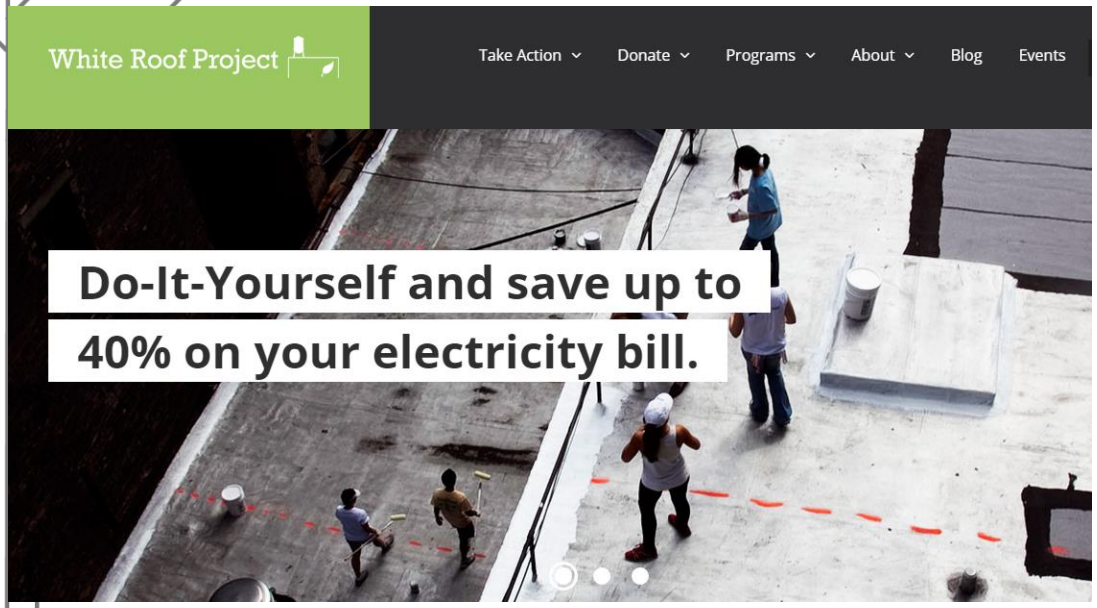
- Modifikace albeda
  - Změna reflektivity zemského povrchu a/nebo atmosféry
  - nebo změna solární konstanty….
- CO_2 sekvestrace
  - Actively removing carbon dioxide from atmosphere
- *Rozsáhlá změna proudění na planetě (fringe)*
  - *Barents sea, Bering strait*

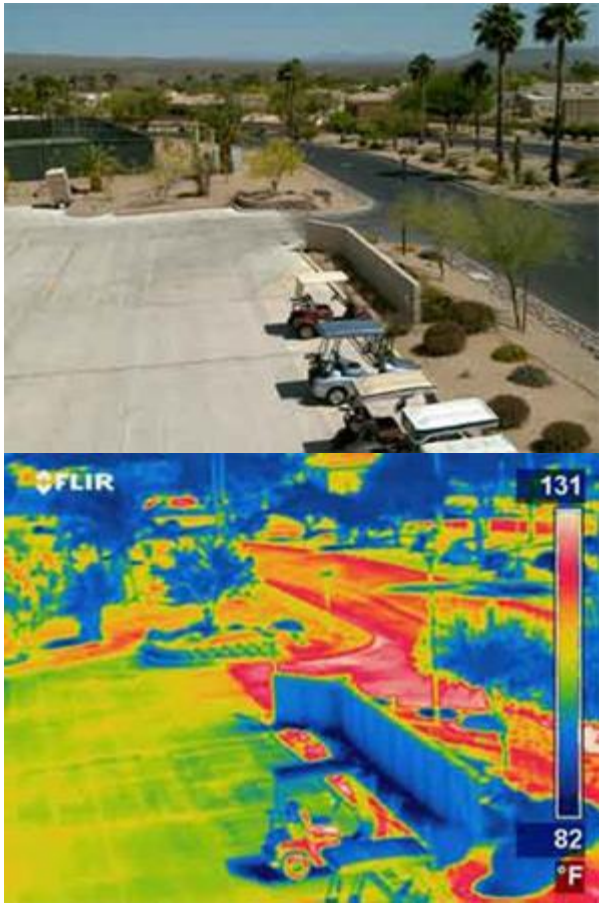
T. M. Lenton and N. E. Vaughan: Radiative forcing potential of climate geoengineering



SRM (solar radiation management)

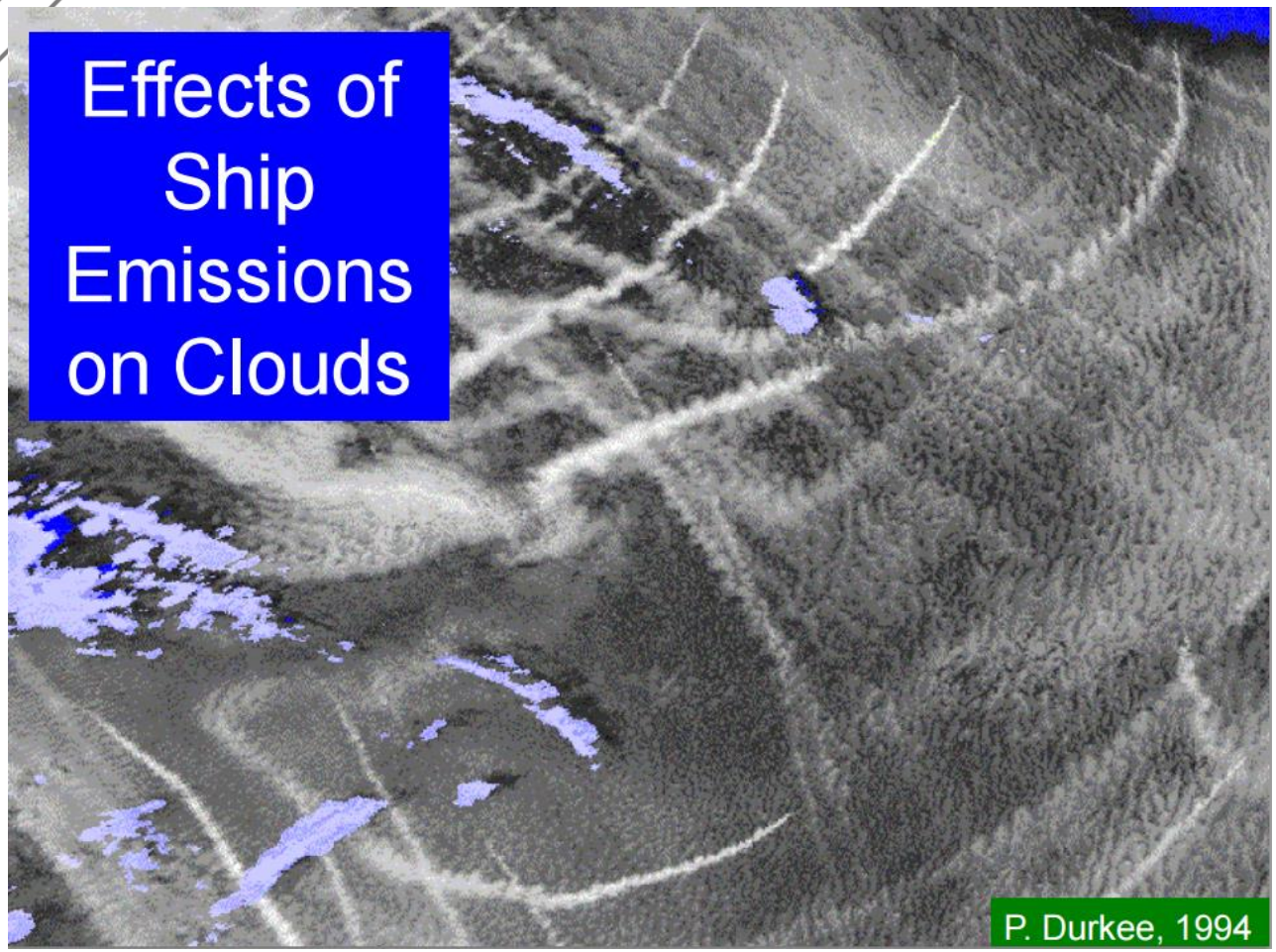
Zvýšení albeda lidských staveb



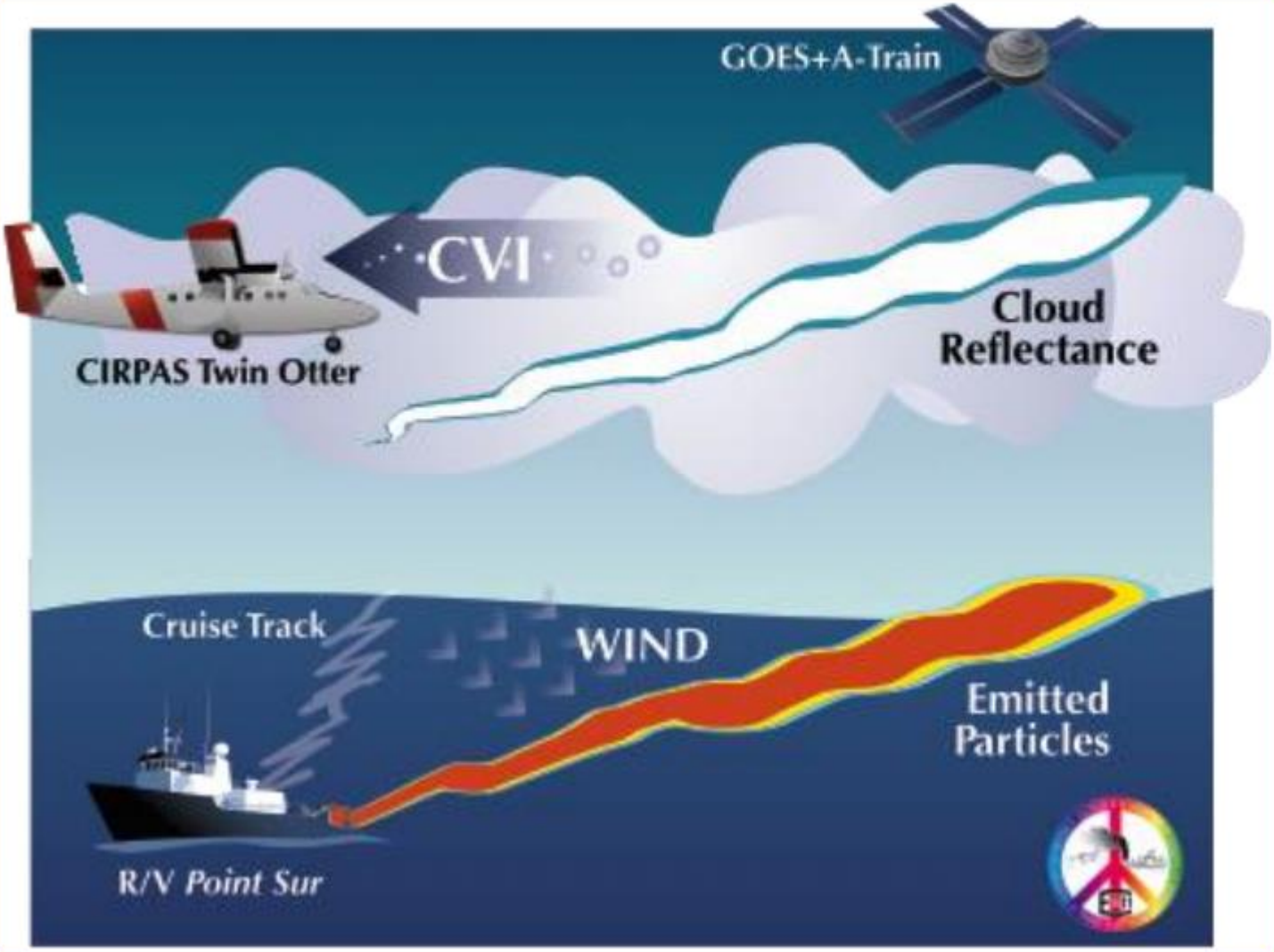


http://www.ecocem.ie/

Prosvětlování nízkou oblačností (marine stratocumulus seeding)



Eastern Pacific Emitted Aerosol Cloud Experiment (E-PEACE) 2011



Lynn M. Russell[1], Armin Sorooshian[3], John Seinfeld[2], Bruce Albrecht[5], Athanasios Nenes[4], Lars Ahlm[1], Yi-Chun Chen[2], Jill S Craven[2], Matthew Coggon[2], Amanda Frossard[1], Haf Jonsson[6], Eunsil Jung[5], Jack J Lin[4], Andrew R Metcalf[2], Robin Modini[1], J. Muelmenstaedt[1], Greg Roberts[1], Taylor Shingler[3], Siwon Song[5], Zhen Wang[3], Anna Wonaschuetz[3]

1.Scripps/UCSD,
2.Caltech,
3.Univ.Arizona,
4.GeorgiaTech,
5.Univ.Miami,
6.CIRPAS.

R/V *Point Sur* Smoke Operations

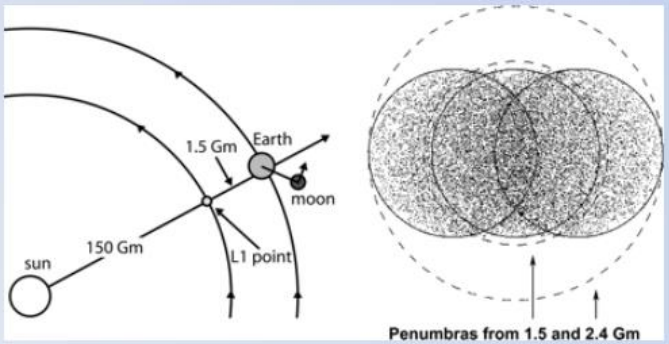
Lynn M. Russel, FOE 2012

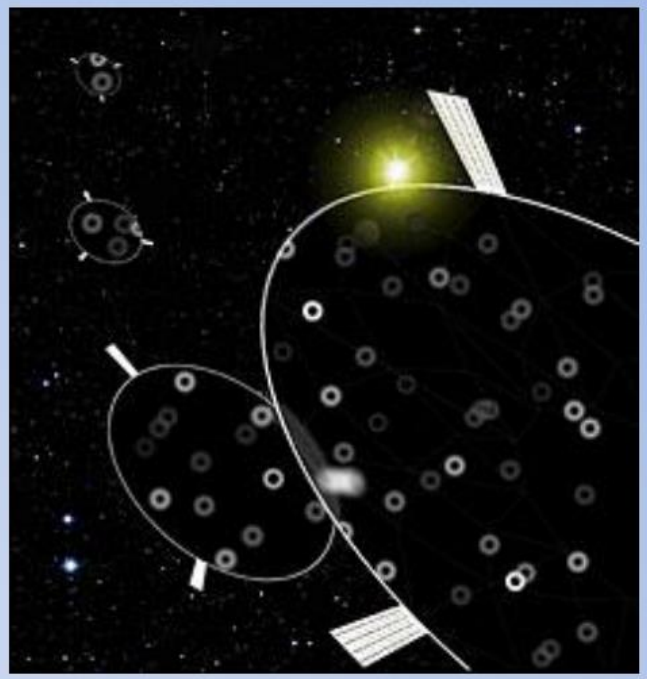
Globální stín

Blocking Sunlight:

- A 100,000 km cloud
- comprised of 16 trillion manhole-cover sized discs,
- ~3 million miles from earth,
- blocking 2% of the sun's rays.

$1 -$5 trillion depending on launch technology.



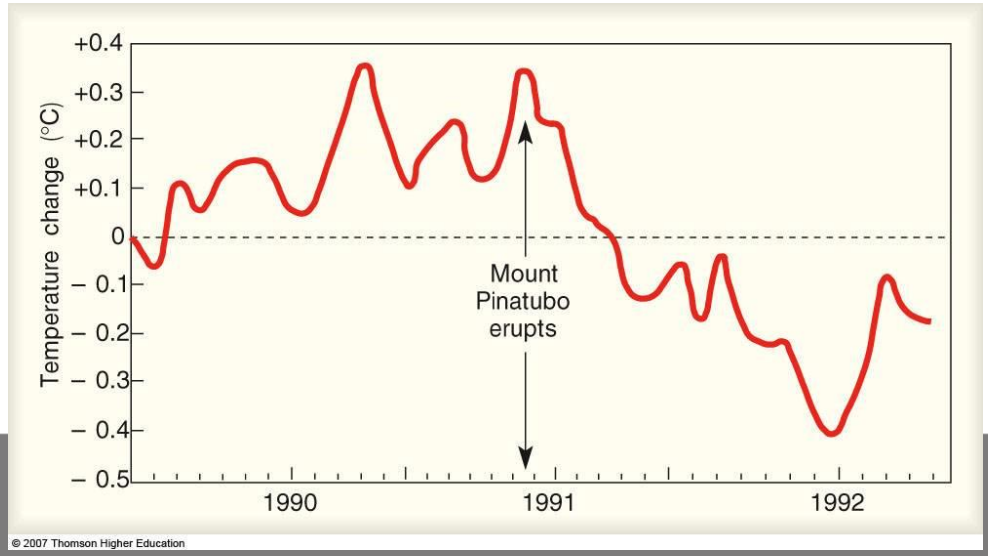


Eli Kintisch, FOE, 2012

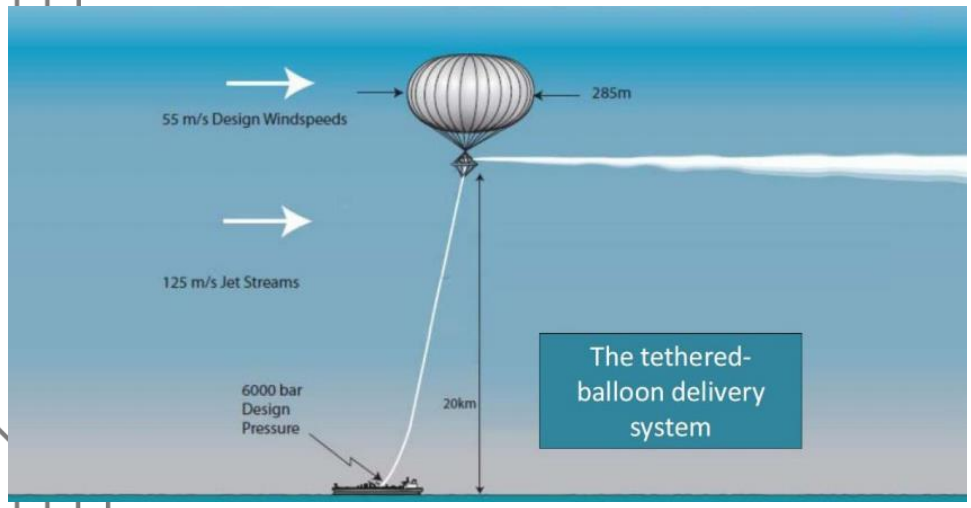
Injektáž stratosférického aerosolu (Mt. Pinaturbo Effect)

U.S. Geological Survey Photograph taken by Richard P. Hoblitt

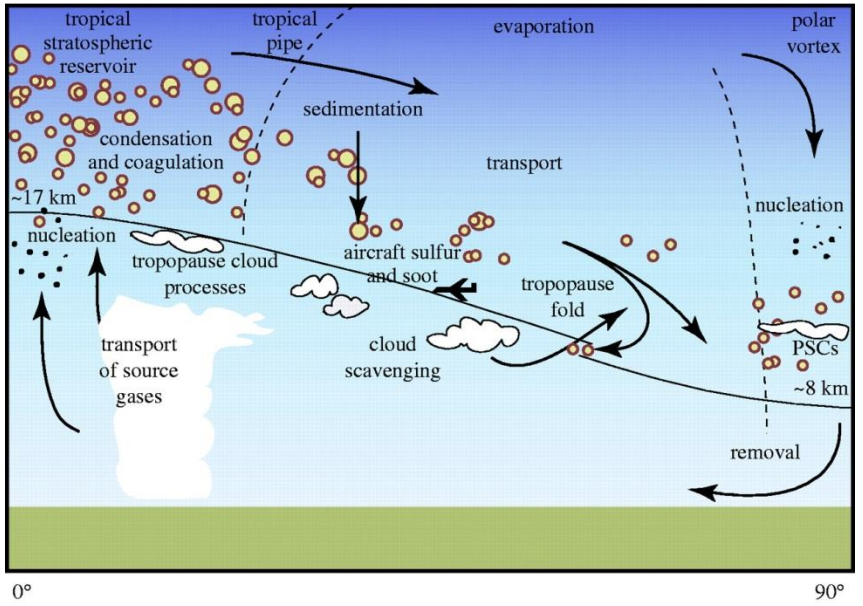
NASA



Injektáž stratosférického aerosolu

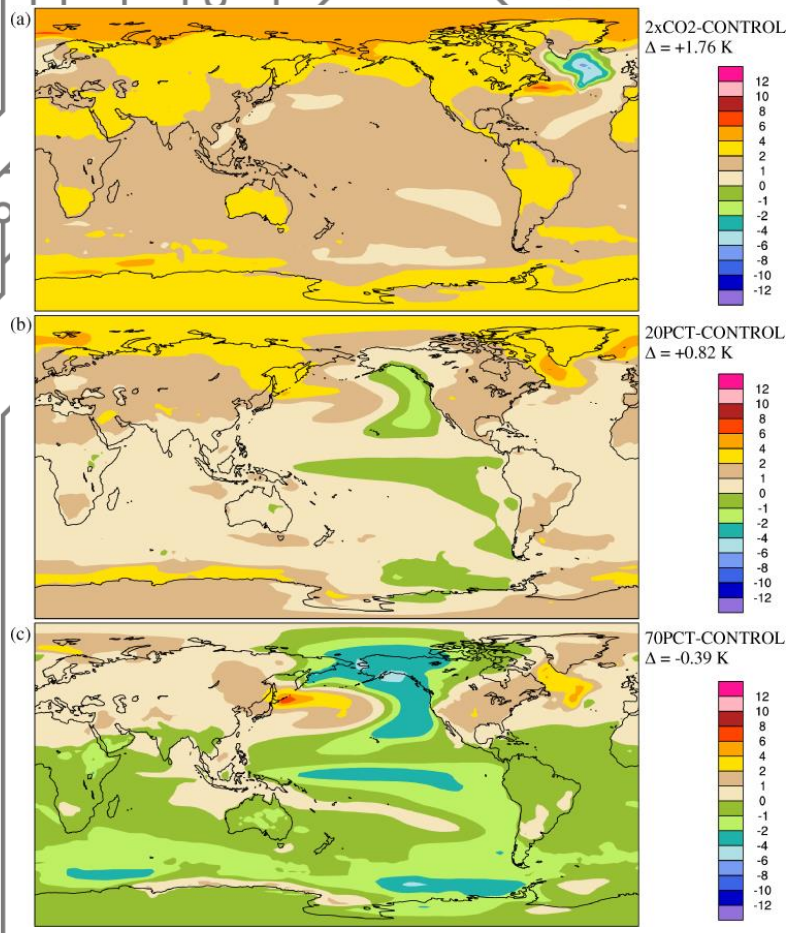


Eli Kintisch, FOE, 2012



An overview of geoengineering of climate using stratospheric sulphate aerosols
Philip J Rasch, Simone Tilmes, Richard P Turco, Alan Robock, Luke Oman, Chih-Chieh (Jack) Chen, Georgiy L Stenchikov, Rolando R Garcia
Phil. Trans. R. Soc. A 2008 366 4007-4037; DOI: 10.1098/rsta.2008.0131. Published 13 November 2008

Fungovalo by to?

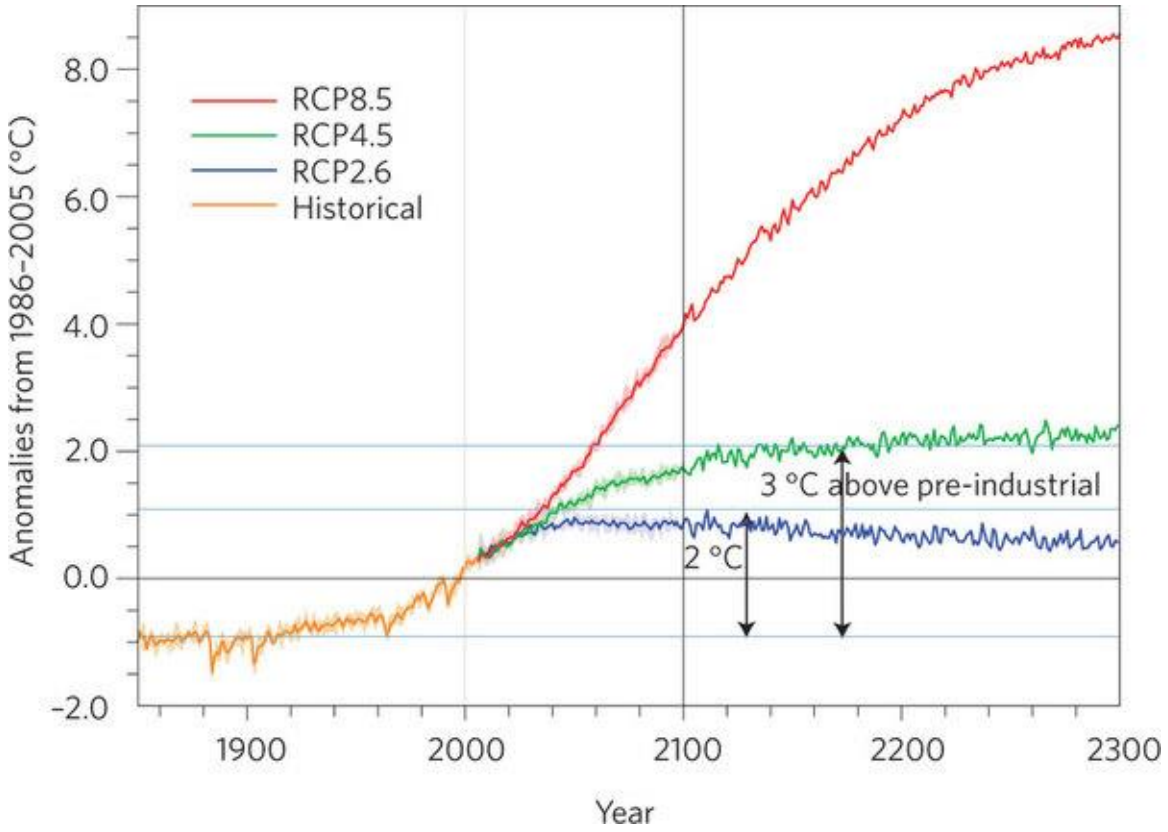


Geoengineering by cloud seeding: influence on sea ice and climate system
Philip J Rasch[1], John Latham[2,3] and Chih-Chieh (Jack) Chen[2,] Environ. Res. Lett. **4** (October-December 2009) 045112
doi:10.1088/1748-9326/4/4/045112

- Crutzen, P. J. (2006),Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma? *Clim. Change*, **77**,211–220, doi:10.1007/s10584-006-9101-y.

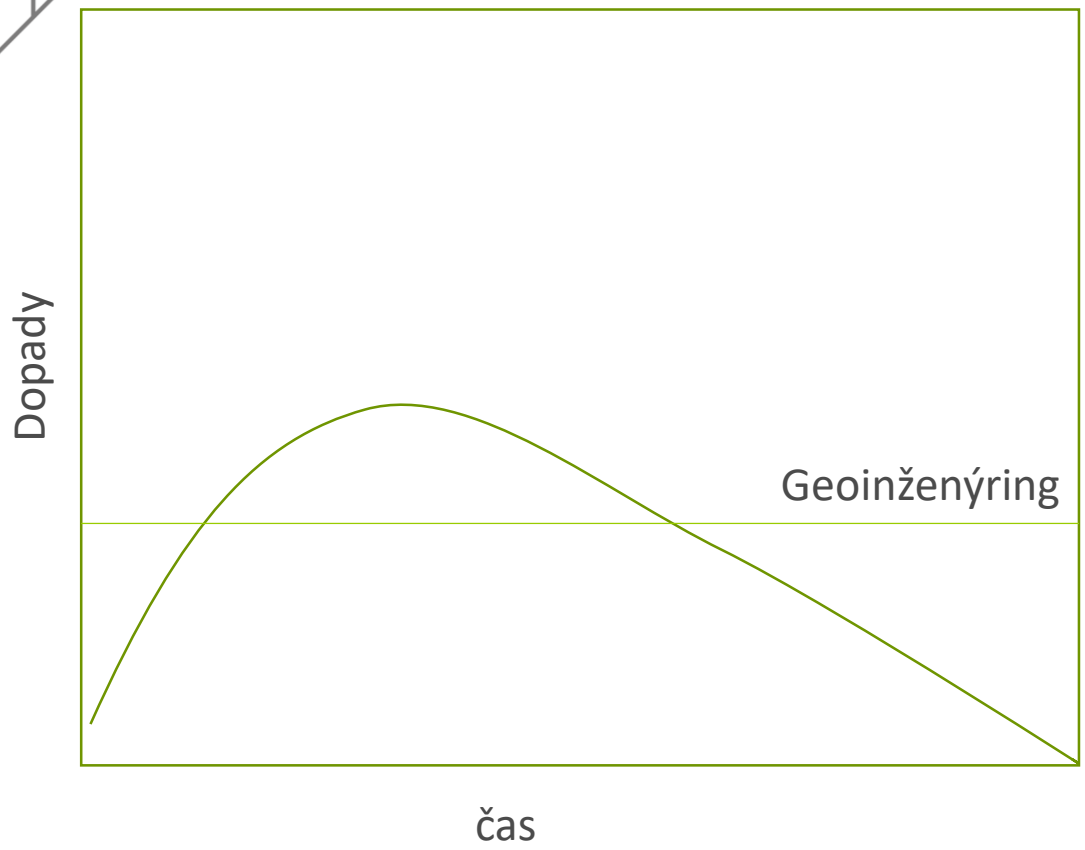
- Rasch, P. J., P. J. Crutzen, and D. B. Coleman (2008), Exploring the geoengineering of climate using stratospheric sulfate aerosols: The role of particle size, Geophys. Res. Lett., 35, L02809, doi:10.1029/2007GL032179

Proč je ale vhodné se tím zabývat…



Source: Relative outcomes of climate change mitigation related to global temperature versus sea-level rise, Gerald A. Meehl, Aixue Hu, Claudia Tebaldi, Julie M. Arblaster, Warren M. Washington, Haiyan Teng, Benjamin M. Sanderson, Toby Ault, Warren G. Strand & James B. White III, Nature Climate Change 2, 576–580 (2012) doi:10.1038/nclimate1529

Why do we might consider GE?



Proč to není možná nejlepší nápad?

- Sucho, zejména selhání monzunu v Asii a Africe
- Poškozování ozonové vrstvy
- Poskvrnění/zabarvení oblohy
- Může být ovlivněna tvorba mraků
- Účinek na ekosystémy !!!
- Vliv na sluneční energii
- Depoziční účinky
- Nerovnoměrné účinky
- Stratosférická změna teploty (ohřátí stratosféry)
- Další okyselení planety

CCS (carbon sequestration and storage)

Znovuzalesnění a zalesňování (biosequestration of atmospheric carbon dioxide)

NASA photo of deforestation in Tierras Bajas project, Bolivia, from ISS on April 16, 2001.

Letecké zalesňování?

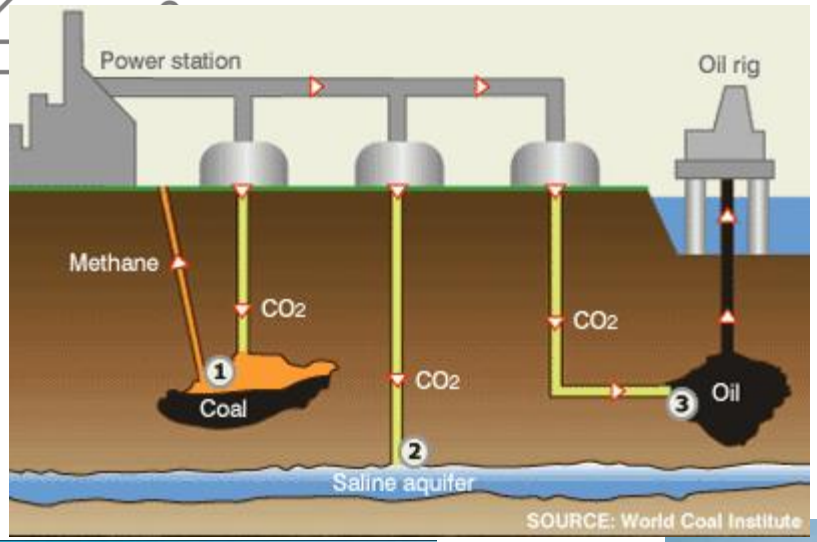
photo: Discovery Channel

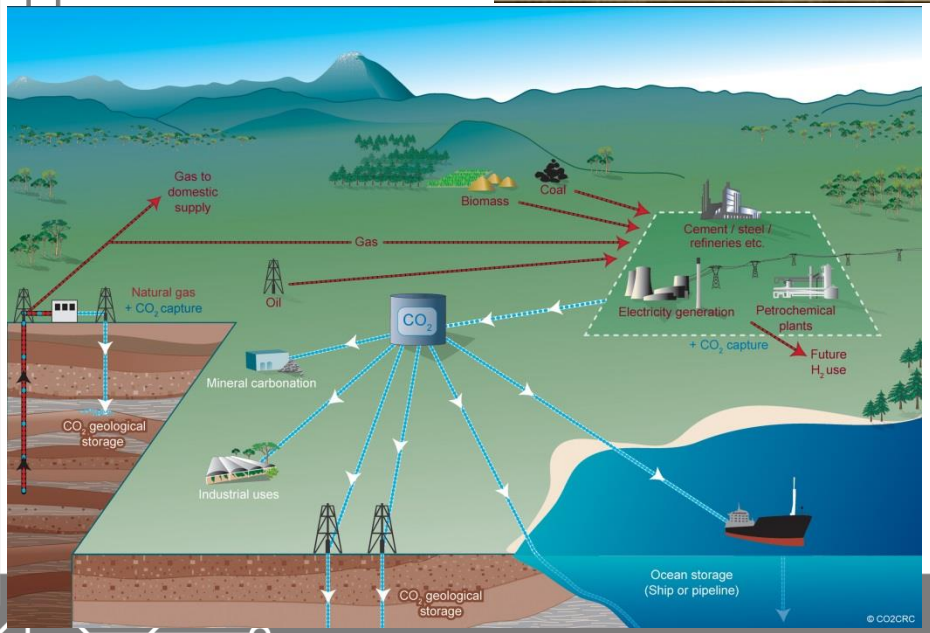
Biochar

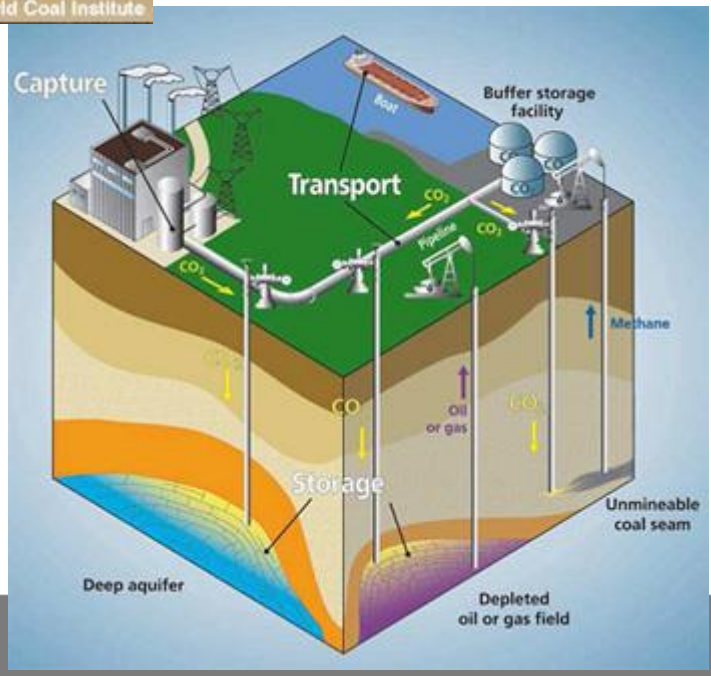
- Pyrolýza biomasy
- Dřevěné uhlí
- Mělký depozit do půdy
- Možná obohacuje půdu
- Ukládání pryč CO2

Wikimedia commons

„Klasické“ CCS







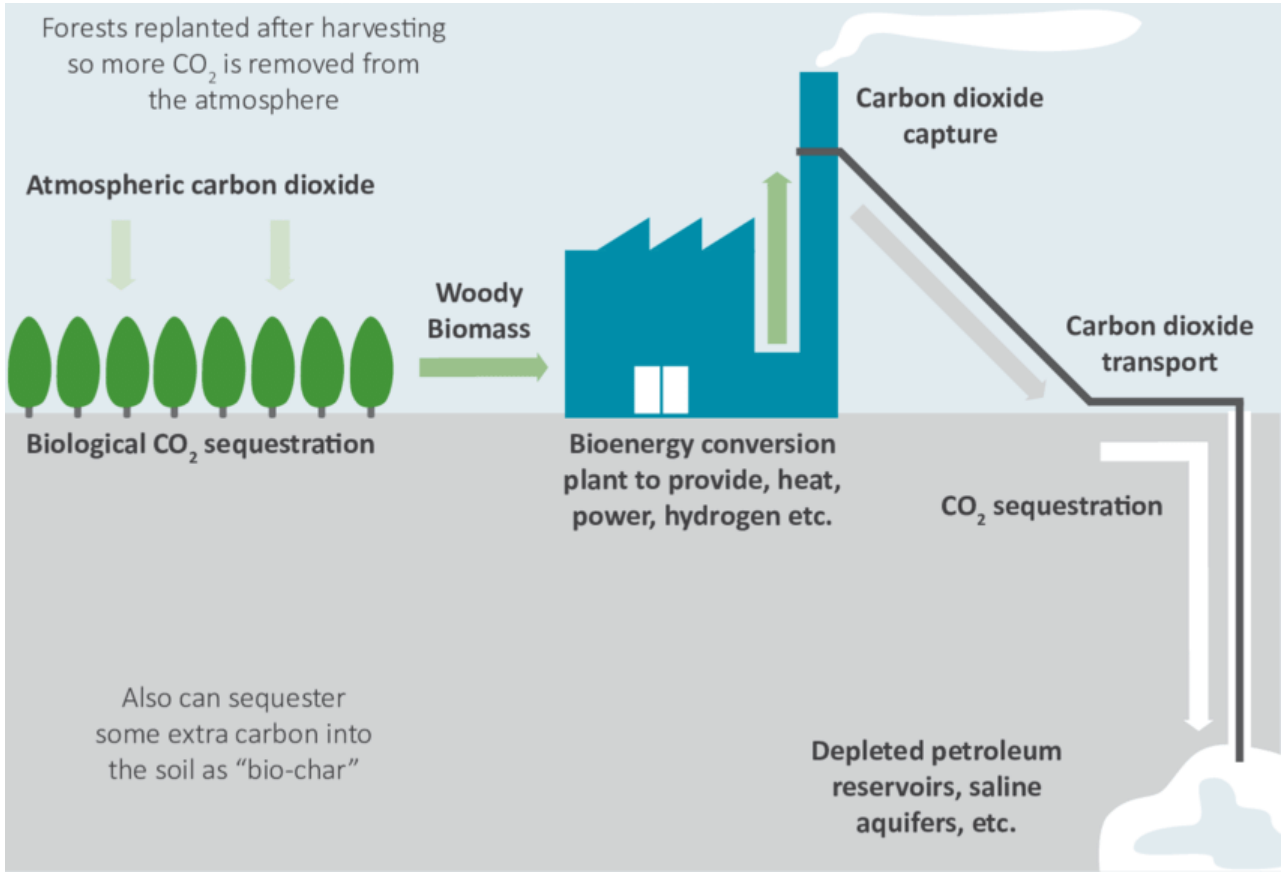
Zachytávání CO_2 z atmosféry (DACS)

SMITHSONIAN.COM

Geoffrey Holmes et al. / Energy Procedia 37 (2013) 6079– 6095

Geoffrey Holmes et al. / Energy Procedia 37 (2013) 6079– 6095

Biologická CO_2 sekvestrace (BECCS)



CCS vs SRM

Carbon Dioxide Removal proposals…	Albedo Modification proposals…
… address the cause of human-induced climate change (high atmospheric GHG concentrations).	…do not address cause of human-induced climate change (high atmospheric GHG concentrations).
…do not introduce novel global risks.	… introduce novel global risks.
…are currently expensive (or comparable to the cost of emission reduction).	…are inexpensive to deploy (relative to cost of emissions reduction).
…may produce only modest climate effects within decades.	…can produce substantial climate effects within years.
…raise fewer and less difficult issues with respect to global governance.	…raise difficult issues with respect to global governance.
…will be judged largely on questions related to cost.	…will be judged largely on questions related to risk.
…may be implemented incrementally with limited effects as society becomes more serious about reducing GHG concentrations or slowing their growth.	…could be implemented suddenly, with large-scale impacts before enough research is available to understand their risks relative to inaction.
…require cooperation by major carbon emitters to have a significant effect.	…could be done unilaterally.
…for likely future emissions scenarios, abrupt termination would have limited consequences.	…for likely future emissions scenarios, abrupt termination would produce significant consequences.

Pokud se rozhodneme že (ne)potřebujeme GE …

Máme platformu, abychom to mohli vyjednat?

- OSN / OECD / WTO?

Máme nástroj?

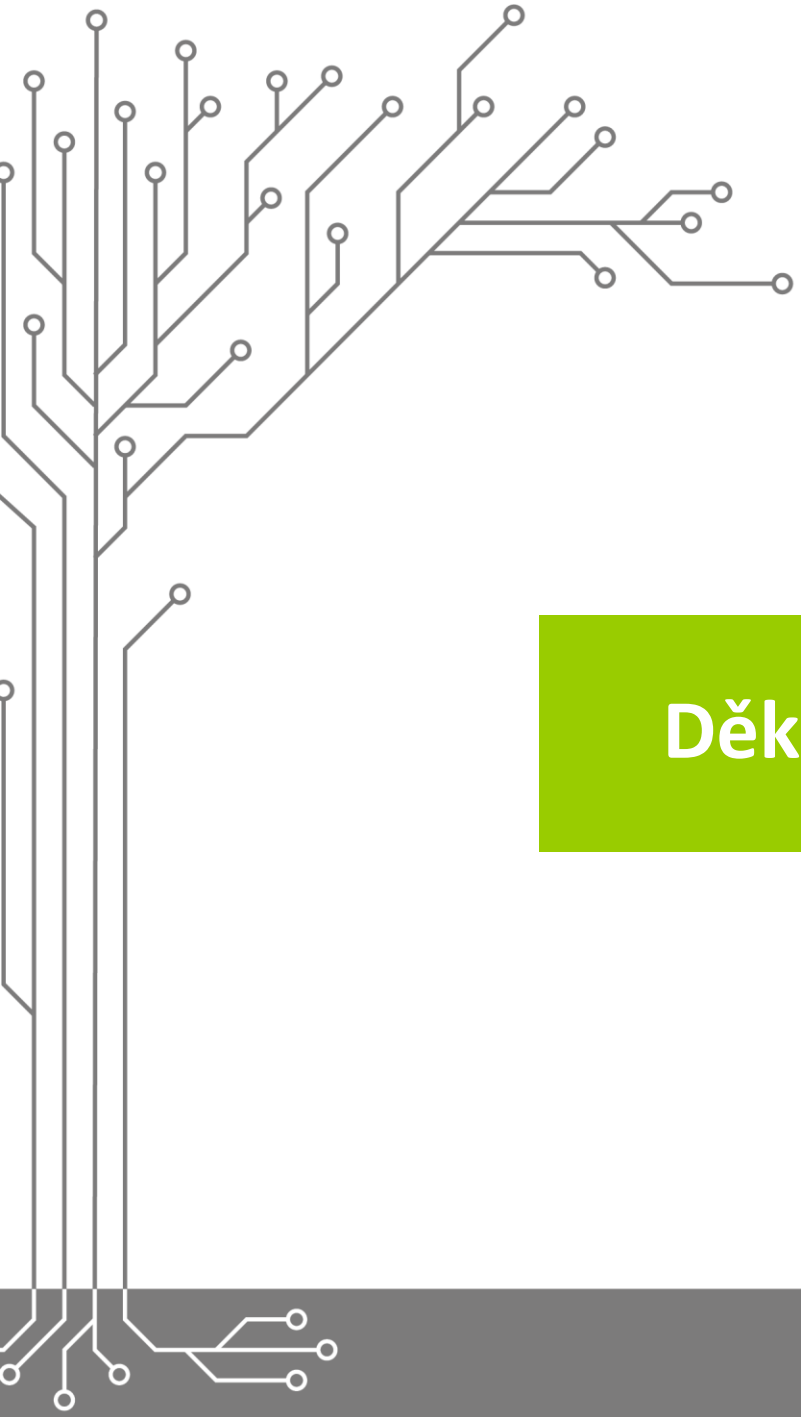
- UNFCCC
- ENMOD

Máme organizaci/mechanismy vymáhat?

- UNSC

Problém akce/neakce

- Stejně jako u zk budou vítězi i poražení
- Některé GE jsou atraktivně levné ve srovnání se zmírněním / přizpůsobením
- GE jako strašidlo proti neakci
- GE jako odůvodnění pro neakci
- Klimatická setrvačnost (tj. Klima nemá brzdy a některé možnosti GE je nemají také)



Děkuji za pozornost

Spatium naturalis per humana vita

Indikátory životního prostředí a indikátory zranitelnosti ve vztahu ke změně klimatu

Mgr. Tereza Kochová, PhD.

Příští seminář 17.9.2019 – 14:00 – 15:30

Sources:

- Page 1: The Guardian (deleted)
- Page 4: original sources for graphical mix are at http://www.pearltrees.com/t/mesenfor-sledovani-horizontu/geoingeneering/id12784665
- Page 6: IPCC, LOTR: Fellowship of the ring (movie quote)
- Page 7: Autor dle Earth's Annual Global Mean Energy Budget; Kiehl, J. T. and Trenberth, K. E., 1997 Bull. Amer. Meteor. Soc., 78, 197-208
- Page 8: Lynn M. Russel , 2012 US Frontiers of Engineering Symposium (FOE), presentation
- Page 9: Author
- Page 10: Mitigation - Robert Rapier, BP data, Adaptation - unknown source, GE/CI Royal Society + National Academy of Sciences, US
- Page 11: The radiative forcing potential of different climate geoengineering options; T. M. Lenton and N. E. Vaughan, Atmos. Chem. Phys., 9, 5539–5561, 2009
- Page 13: Ecocem.ie + White roof project
- Page 14: Hindman, E. E., W. M. Porch, J. G. Hudson and P. A. Durkee, 1994: Ship-produced cloud lines of 13 July 1991. Atmos. Environ., 28, 3393-3403.
- Page 15: Lynn M. Russel , 2012 US Frontiers of Engineering Symposium (FOE), presentation
- Page 16: Lynn M. Russel , 2012 US Frontiers of Engineering Symposium (FOE), presentation
- Page 17: Eli Kintisch, US Frontiers of Engineering Symposium (FOE), presentation
- Page 18: U.S. Geological Survey Photograph taken by Richard P. Hoblitt + NASA space shuttle images+ Thompson higher educations
- Page 19: Eli Kintisch, US Frontiers of Engineering Symposium (FOE), presentation + An overview of geoengineering of climate using stratospheric sulphate aerosols; Philip J Rasch, Simone Tilmes, Richard Turco, Alan Robock, Luke Oman, Chih-Chieh (Jack) Chen, Georgiy L Stenchikov, Rolando R Garcia Phil. Trans. R. Soc. A 2008 366 4007-4037; DOI: 10.1098/rsta.2008.0131. Published 13 November 2008
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- Page 22: NASA, ISS images + Discovery channel
- Page 23: Wikimedia commons
- Page 24: CO2CR + World Coal Institute +www.CO2remove.eu
- Page 25: Geofrey Holmes et al, 2013, Energy Procedia 37, 6079-6095
- Page 26: © 2015 The National Academy of Sciences
- Page 27: How the whales change climate (https://youtu.be/M18HxXve3CM) + unknown source
- Page 28:© 2015 The National Academy of Sciences
- Page 29: Relative outcomes of climate change mitigation related to global temperature versus sea-level rise, Gerald A. Meehl, Aixue Hu, Claudia Tebaldi, Julie M. Arblaster, Warren M. Washington, Haiyan Teng, Benjamin M. Sanderson, Toby Ault, Warren G. Strand & James B. White III, Nature Climate Change 2, 576–580 (2012) doi:10.1038/nclimate1529
- Page 30: Author
- Page 35: Author