Två perspektiv på CO2 & kolcykelns roll för klimatförändringarna

Internationell klimatpolitik efter Paris:
Mål för koldioxid och andra växthusgaser

Energimyndigheten 2017-12-06

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Fysisk Resursteori, SEE, Chalmers

Publikationer

- **Sterner, E.O. and Johansson, D.J.**, 2017. The effect of climate–carbon cycle feedbacks on emission metrics. *Environmental Research Letters*
- Bryngelsson, D., Hedenus, F., **Johansson, D.J., Azar, C.** and Wirsenius, S., 2017. How Do Dietary Choices Influence the Energy-System Cost of Stabilizing the Climate? *Energies*
- Levasseur, A., Cavalett, O., Fuglestvedt, J.S., Gasser, T., **Johansson, D.J.**, Jørgensen, S.V., Raugei, M., Reisinger, A., Schivley, G., Strømman, A. and Tanaka, K., 2016. Enhancing life cycle impact assessment from climate science: Review of recent findings and recommendations for application to LCA. *Ecological Indicators*

In progress:

- **Sterner, E.O., Persson, U.M.,** Adawi, T. and **Lundqvist, U.** All tasks are not created equal:A mixed methods study of public understanding of atmospheric CO2 accumulation
- **Jonson, E., Azar, C., Lindgren, K & Lundberg, L.,** 2017, Exploring the competition between variable electricity sources and baseload capacity in an agent-based model of the power system. Submitted for publication.

Publikationer

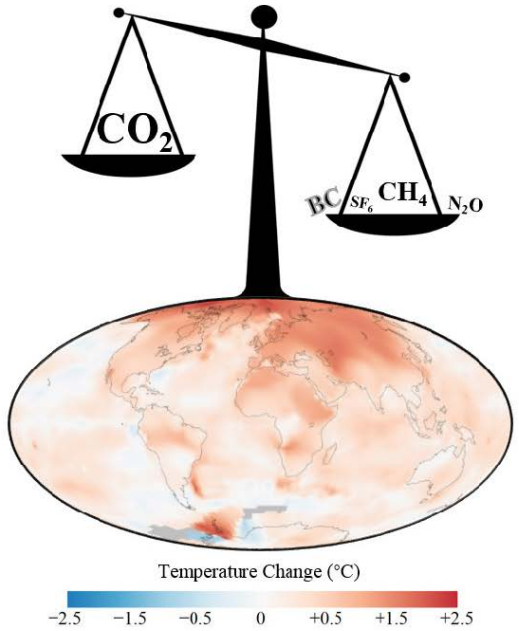
- Sterner, E.O. and Johansson, D.J., 2017. **The effect of climate-carbon cycle feedbacks on emission metrics.** *Environmental Research Letters*
- Bryngelsson, D., Hedenus, F., **Johansson, D.J., Azar, C.** and Wirsenius, S., 2017. How Do Dietary Choices Influence the Energy-System Cost of Stabilizing the Climate? *Energies*
- Levasseur, A., Cavalett, O., Fuglestvedt, J.S., Gasser, T., **Johansson, D.J.**, Jørgensen, S.V., Raugei, M., Reisinger, A., Schivley, G., Strømman, A. and Tanaka, K., 2016. Enhancing life cycle impact assessment from climate science: Review of recent findings and recommendations for application to LCA. *Ecological Indicators*

In progress:

- Sterner, E.O., Persson, U.M., Adawi, T. and Lundqvist, U. **Do people understand CO_2 accumulation?**
- **Jonson, E., Azar, C., Lindgren, K & Lundberg, L.,** 2017, Exploring the competition between variable electricity sources and baseload capacity in an agent-based model of the power system. Submitted for publication.

Metriker för klimatpåverkande ämnen

Tex. GWP:
Global Warming Potential



Jämföra klimatpåverkande ämnen
med en gemensam måttstock

Utsläppsmetriken GWP

NYTT: Temperaturåterkoppling för andra ämnen (IPCC AR5)

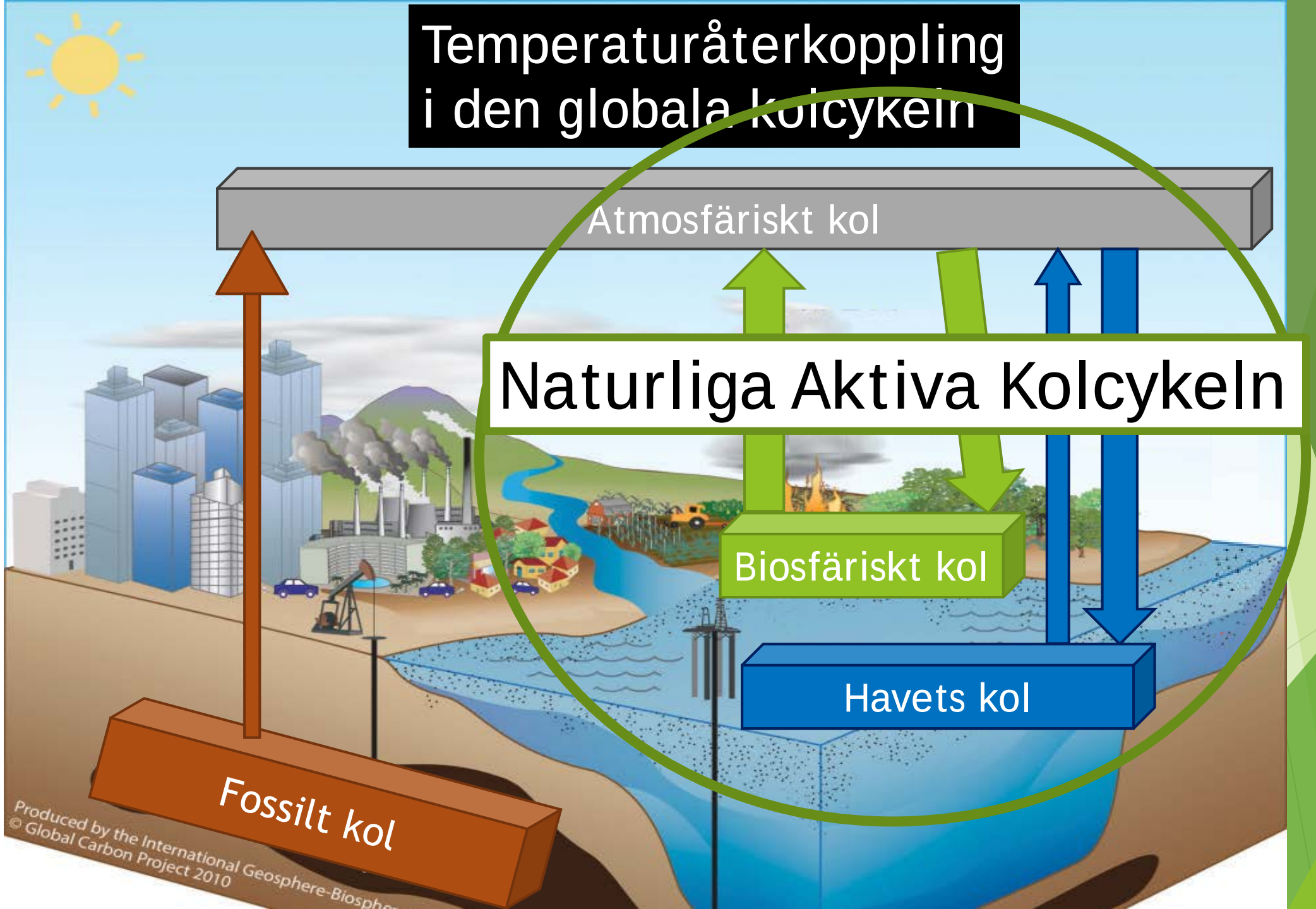
$$GWP_x(t) = \frac{\int_0^t \text{Uppvärmande effekt gas } \boldsymbol{x}}{\int_0^t \text{Uppvärmande effekt } \boldsymbol{CO_2}}$$

Temperaturåterkoppling för CO_2 (IPCC)

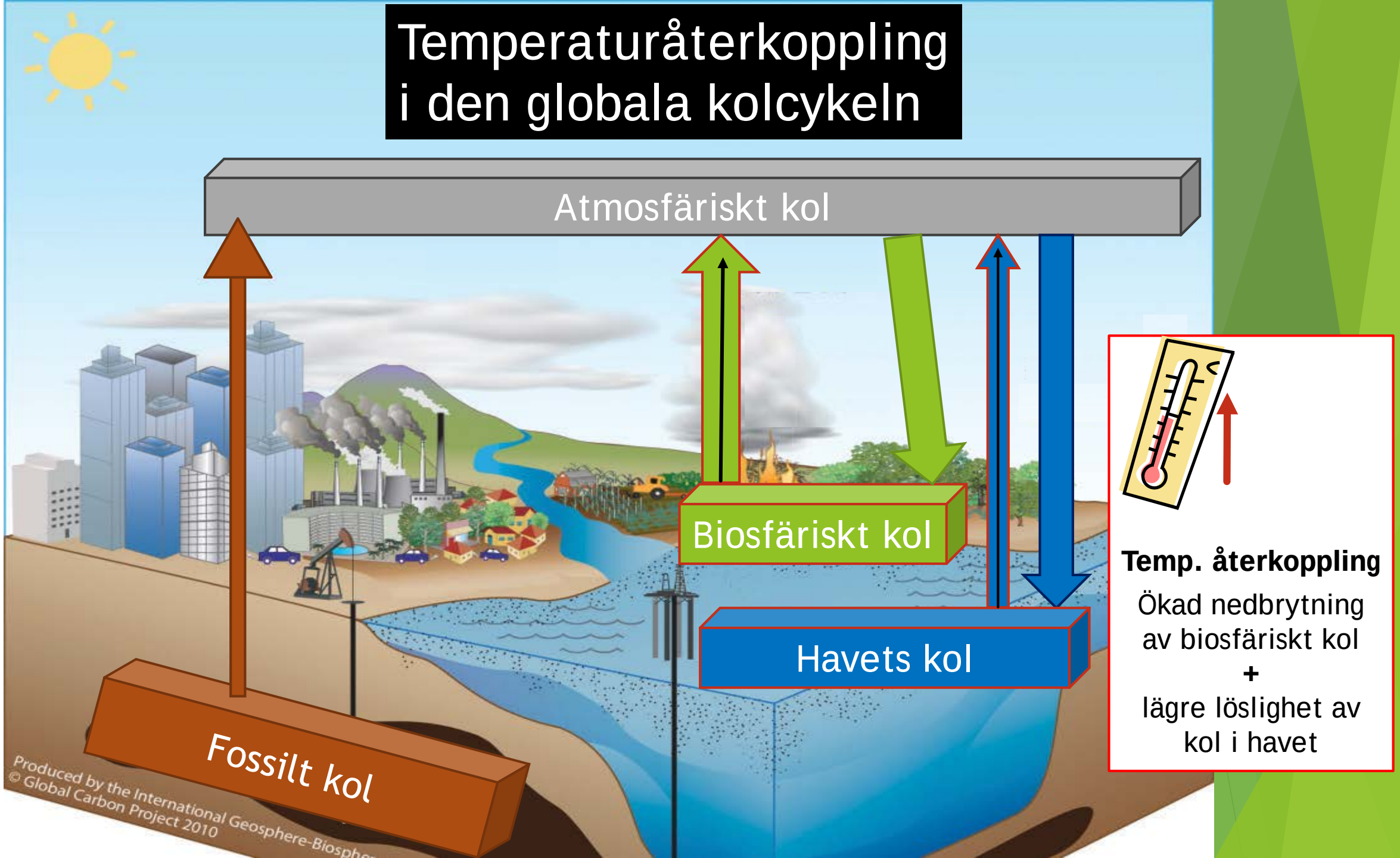
t=time horizon

Exempel: Metan GWP_{100} = 28 -> 34

Temperaturåterkoppling i den globala kolcykeln



Temperaturåterkoppling i den globala kolcykeln



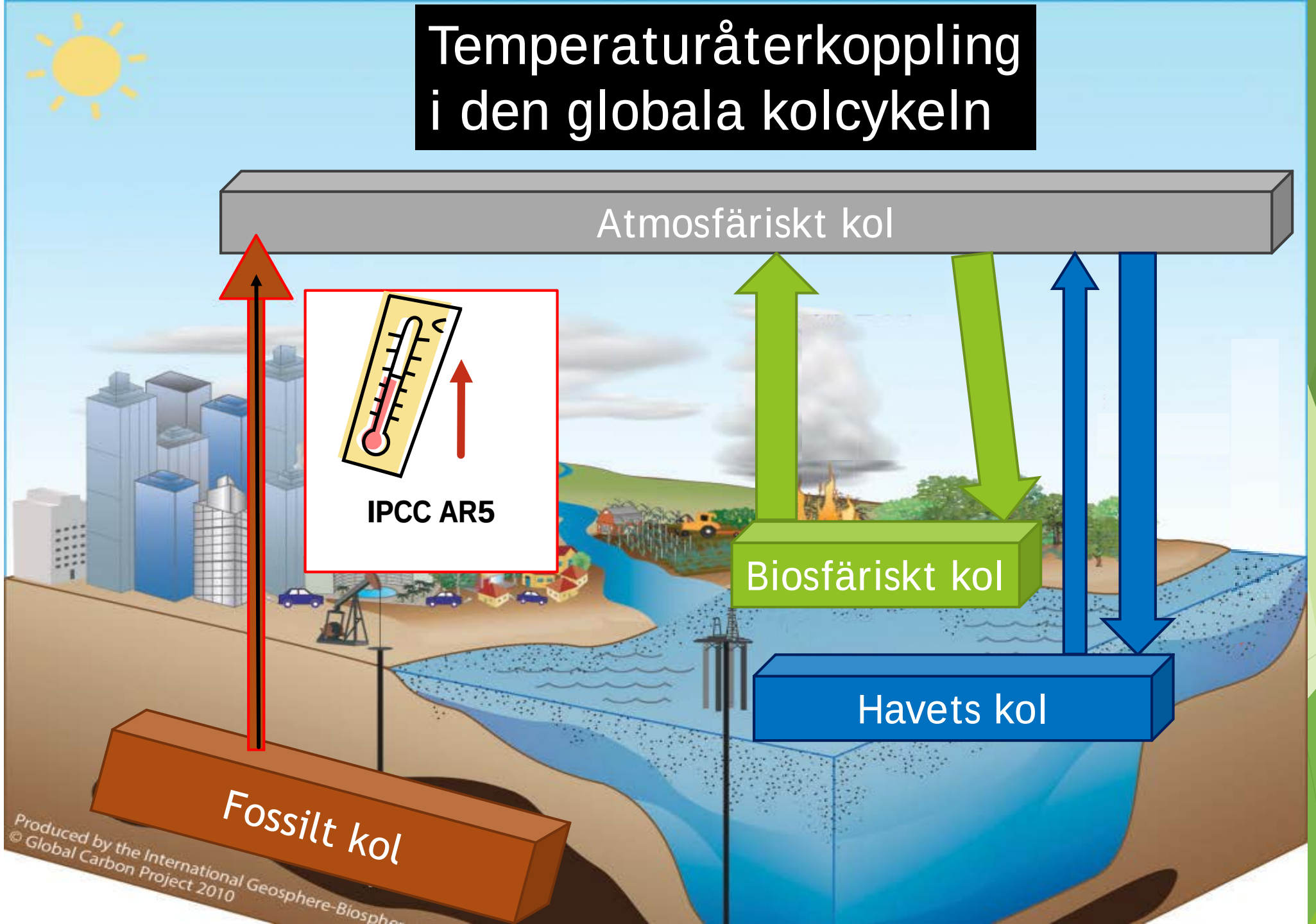
Temp. återkoppling

Ökad nedbrytning av biosfäriskt kol

+

lägre löslighet av kol i havet

Temperaturåterkoppling i den globala kolcykeln



Slutsatser studie 1

Exempel resultat: Metan GWP			
Metod	20 år	100 år	500 år
Vår	93	35	9.6
IPCC	88	33	13

Vår metod

- Starkare återkoppling på kort sikt
- Svagare på lång sikt

IPCC's metod

- En andel av den "temperatur-skapade" CO_2-tillskottet "stannar" i atmosfären praktiskt taget för evigt

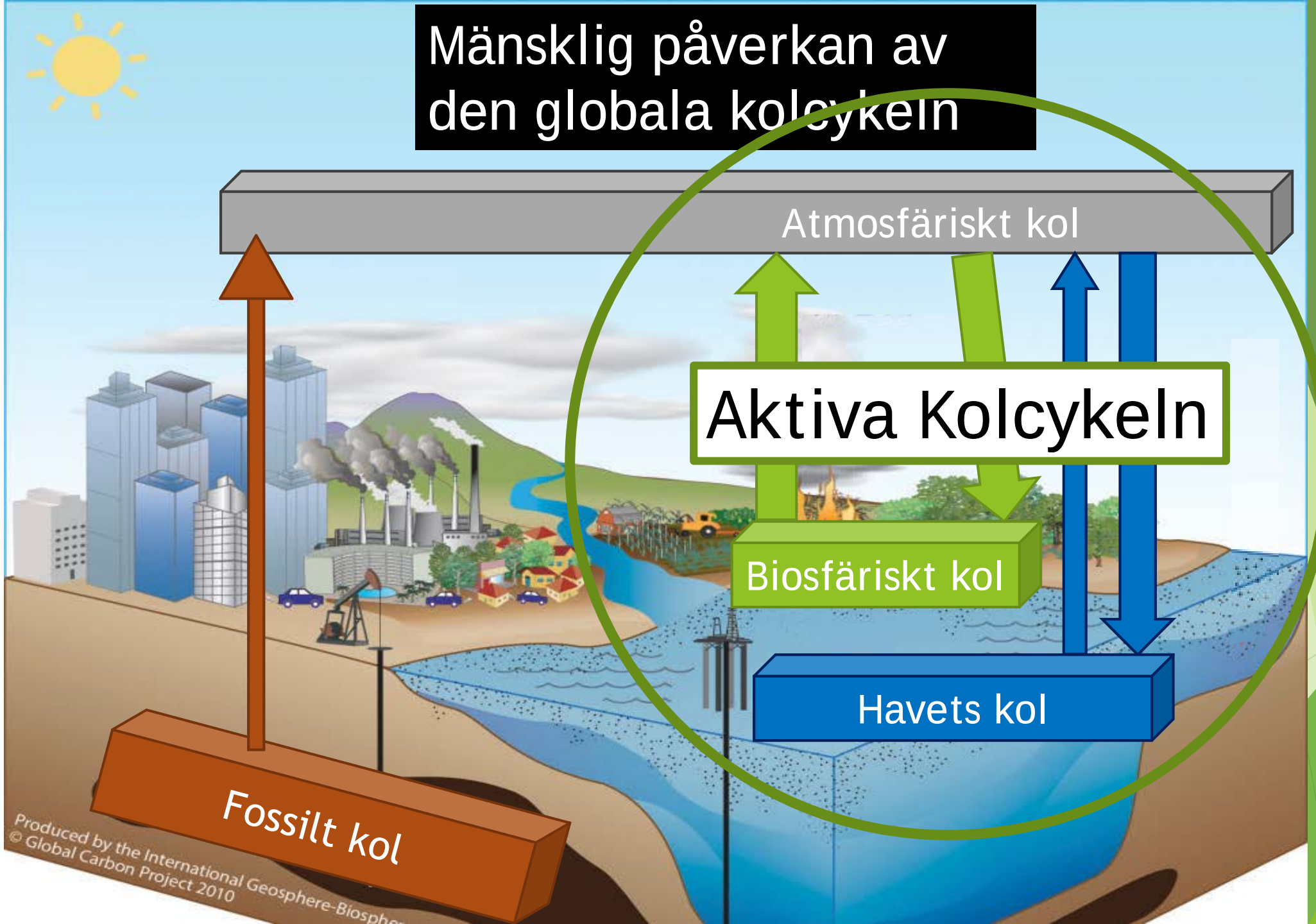
- Metrikvärden med långa tidshorisonter för kortlivade ämnen påverkas mest

(Black carbon osv)

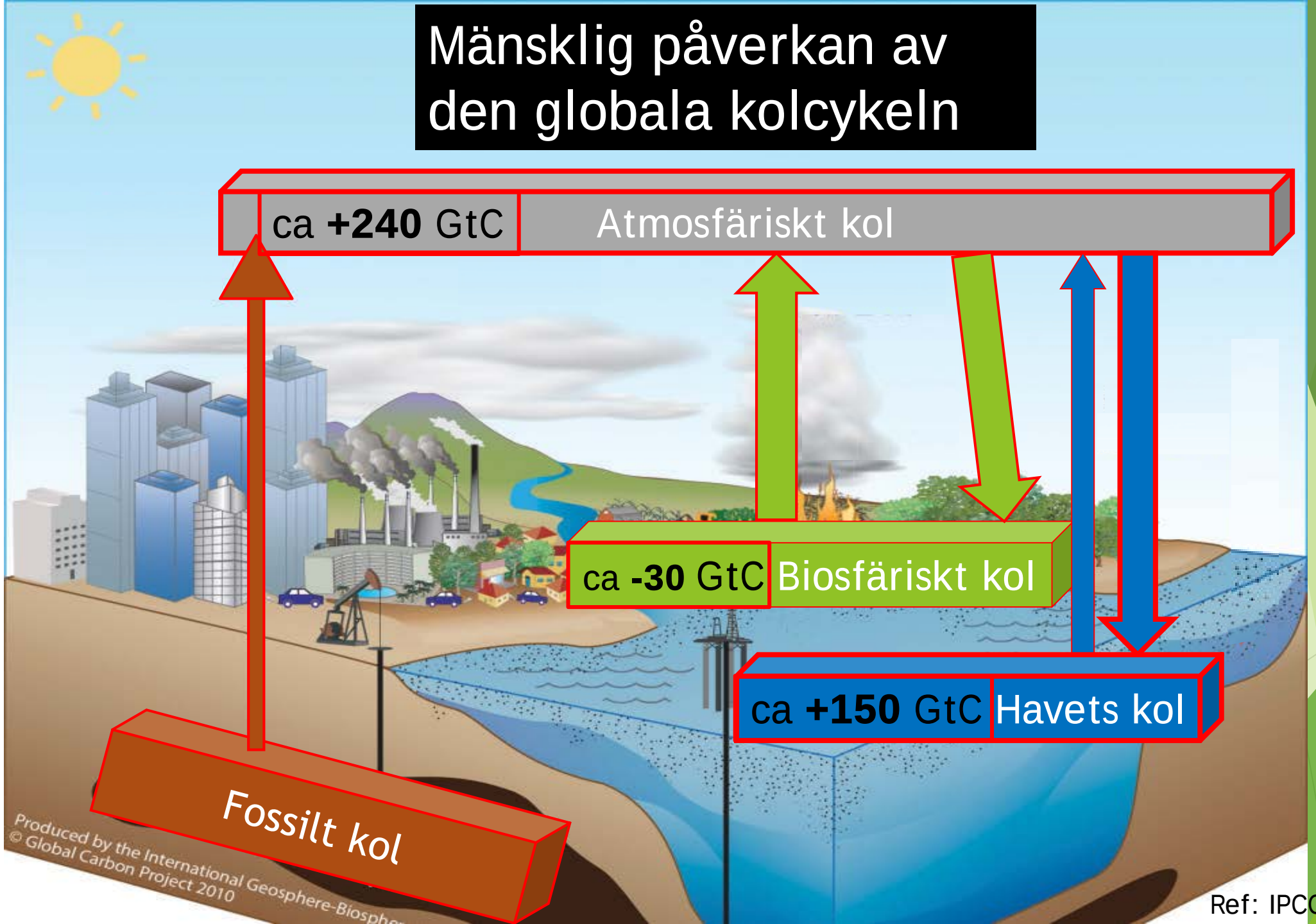
Studie 2

Förstår allmänheten ansamlingen av CO_2 i atmosfären?

Mänsklig påverkan av den globala kolcykeln



Mänsklig påverkan av den globala kolcykeln



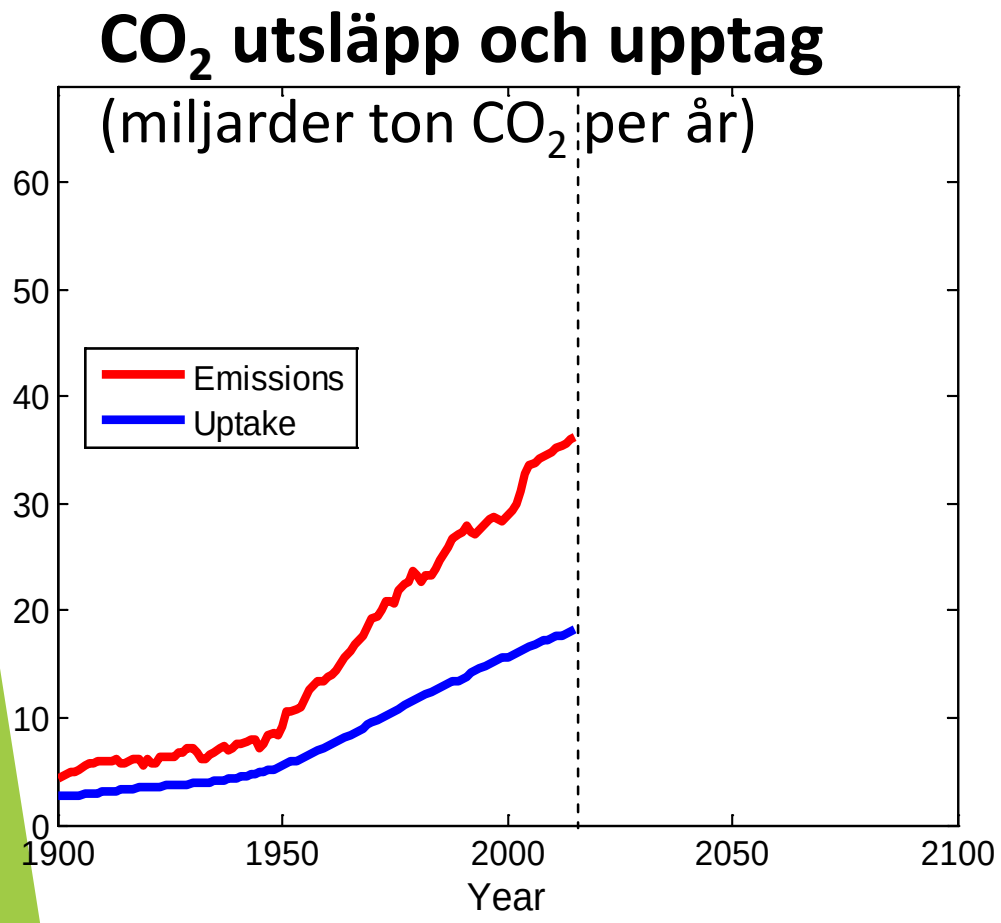
Ref: IPCC AR5 - Ciais 2013

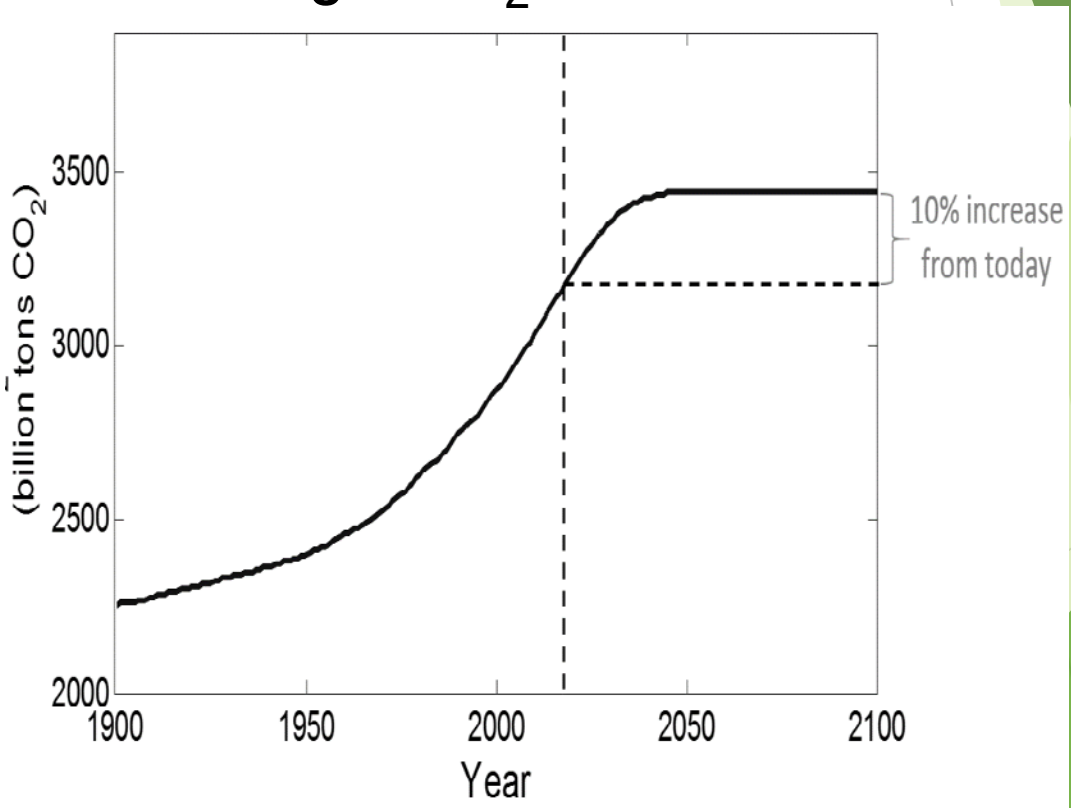
Förstår allmänheten ansamlingen av CO_2 i atmosfären?

- Tidigare forskning indikerar att även välutbildade personer inte förstår hur CO2 utsläpp påverkar mängden CO2 i atmosfären
- Vilket innebär att människor inte förstår varför CO2 utsläppen i princip måste upphöra för ett givet temperaturmål
- Frågor

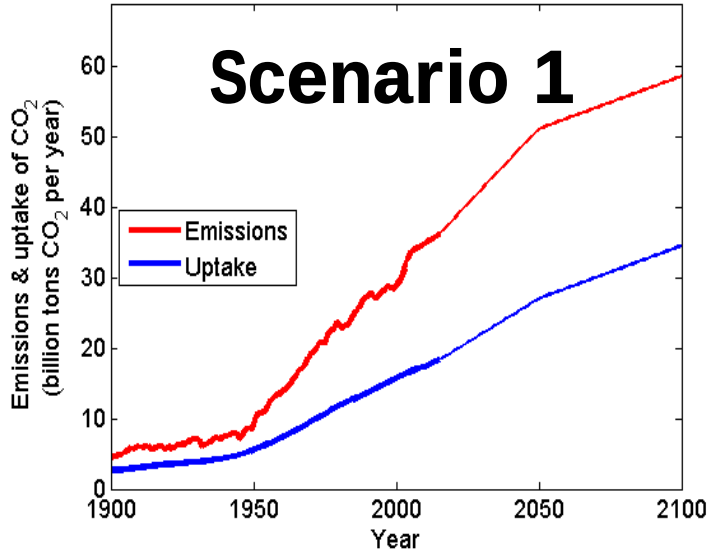
1. Stämmer detta?
2. Vad för typ av förståelse rör det sig om?
3. Är detta en anledning till begränsat stöd för kraftig klimatpolitik?
4. (Hur resonerar människor här?)

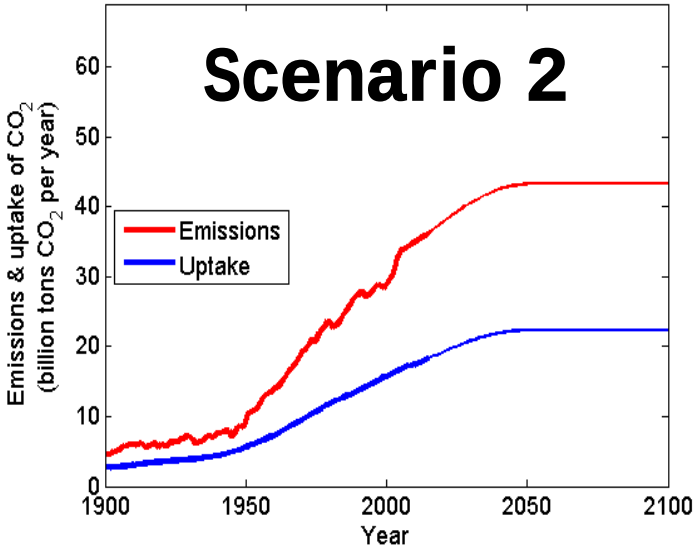
Uppgift - CO_2 stabiliseringsscenario

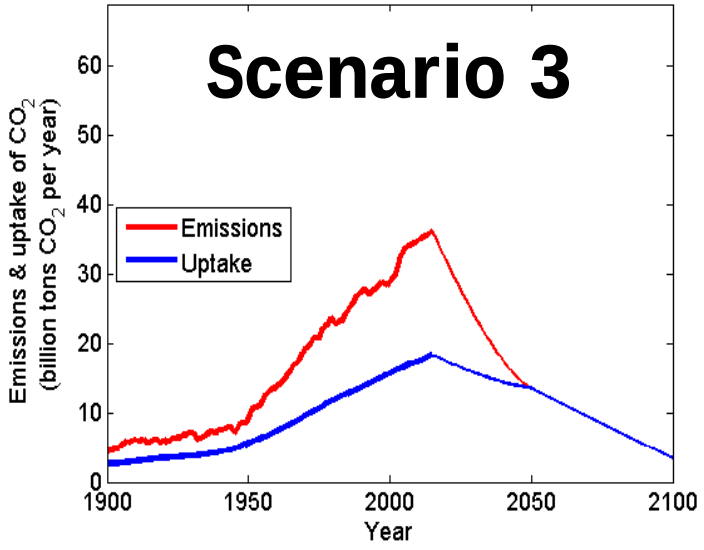


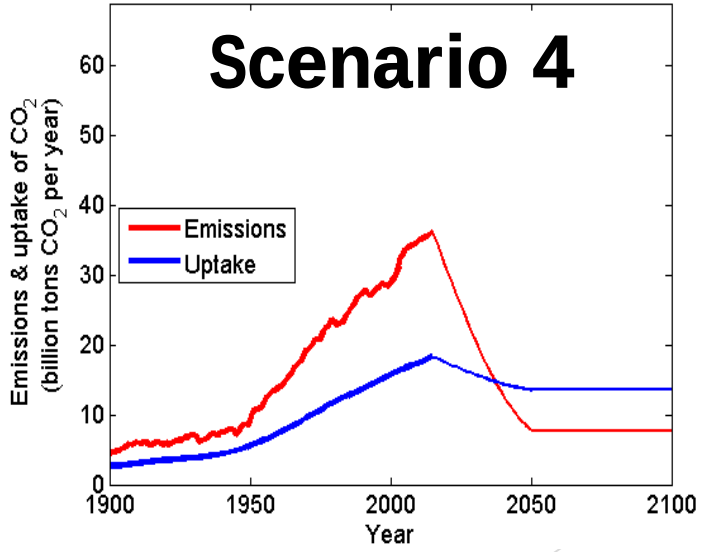


Vilket utsläpps & upptags-scenario uppnår CO_2 stabilisering?

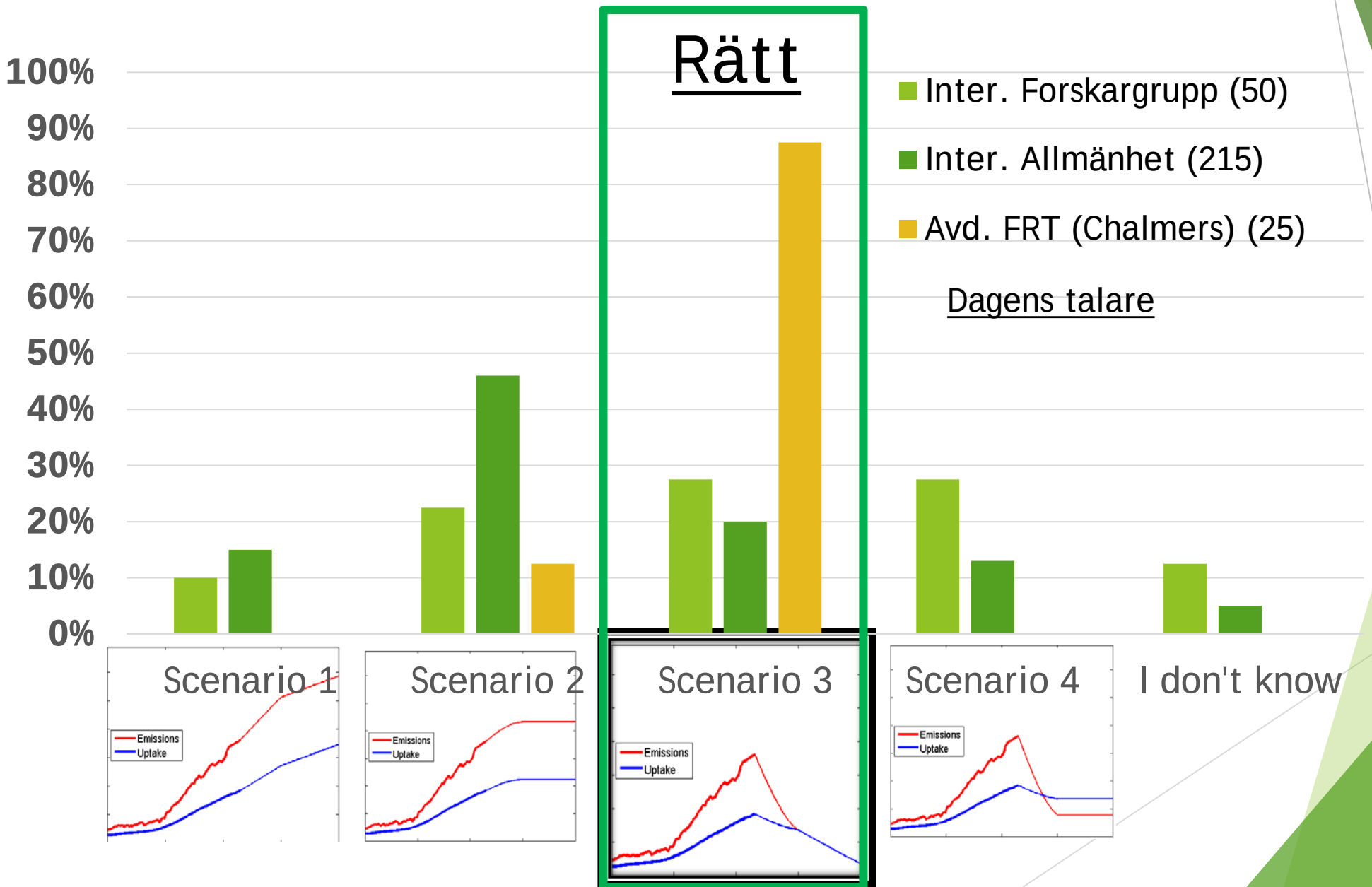






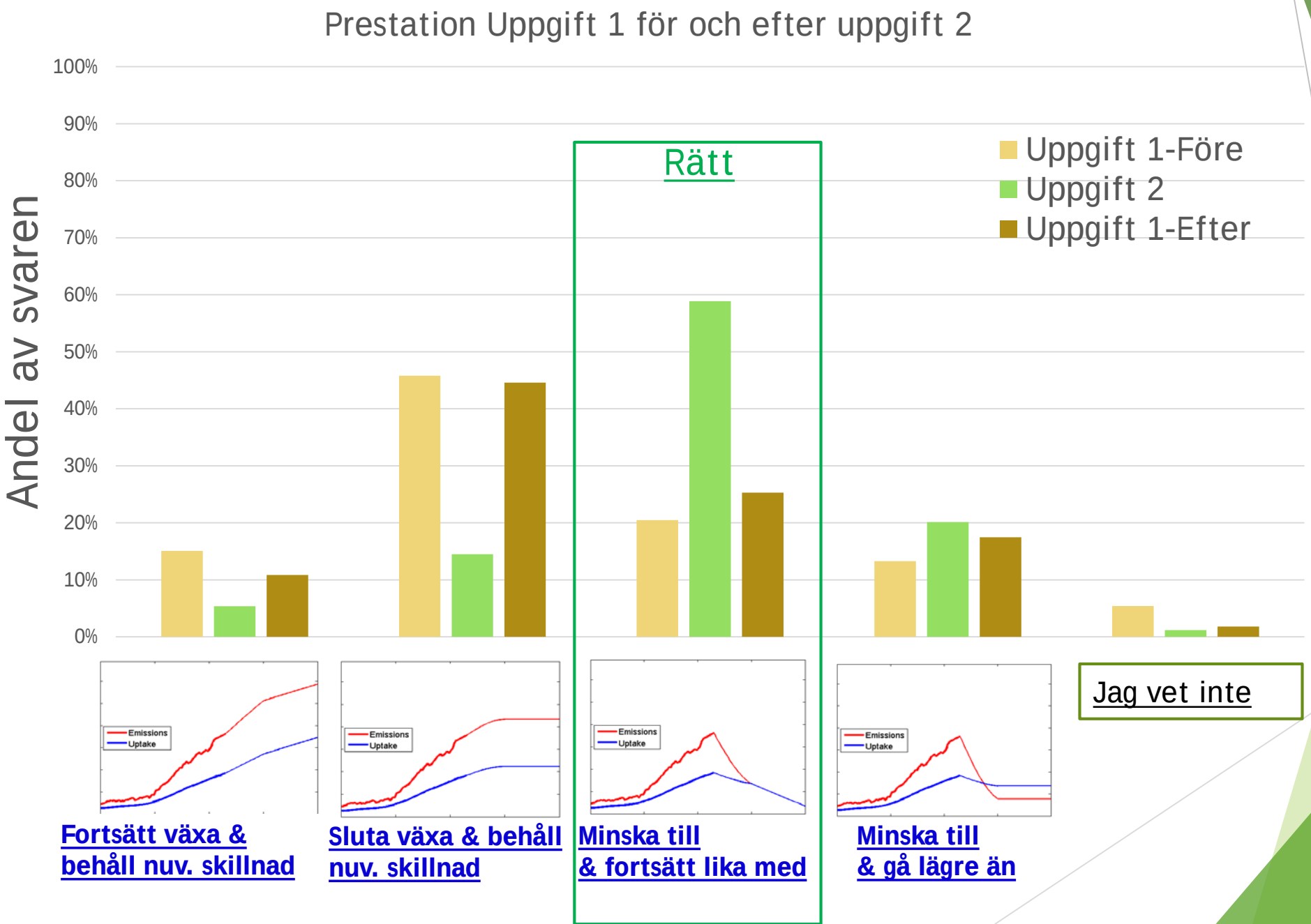


Svar på CO_2 uppgift



Uppgit 2 - Principfråga

Vad krävs av relationen mellan utsläpp och upptag för att mängden CO_2 ska stabiliseras i framtiden?


Prestation Uppgift 1 för och efter uppgift 2
Andel av svaren
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Uppgift 1-Före
Uppgift 2
Uppgift 1-Efter
Rätt
Emissions
Uptake
Fortsätt växa & behåll nuv. skillnad
Sluta växa & behåll nuv. skillnad
Minska till & fortsätt lika med
Minska till & gå lägre än
Jag vet inte

Klimatpolitisk fråga

Which of the following statements comes closest to your personal view?

94% -S**trong & immediate** action to reduce emissions of GHGs today, to reduce future climate impacts.

4% -**Moderate & immediate** action

2% -Action in the future, in response to climate impacts

0% -No action

0%- I don't know/I haven't formed an opinion

Tydlig koppling mellan prestation-stöd för politik saknas

Slutsatser studie 2

- Vissa CO2 uppgifter är utmanande…

  men majoriteten vet hur principen fungerar givet lite hjälp på traven

- Det är inte nödvändigt att prestera bra på uppgift 1 för att stödja en kraftfull klimatpolitik

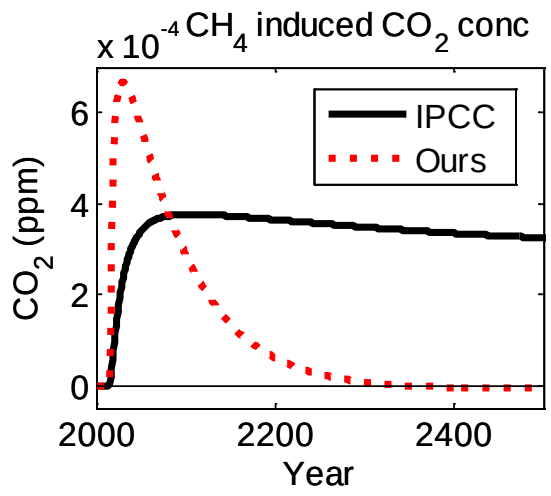
- (Sätten att resonera varierar kraftigt)…

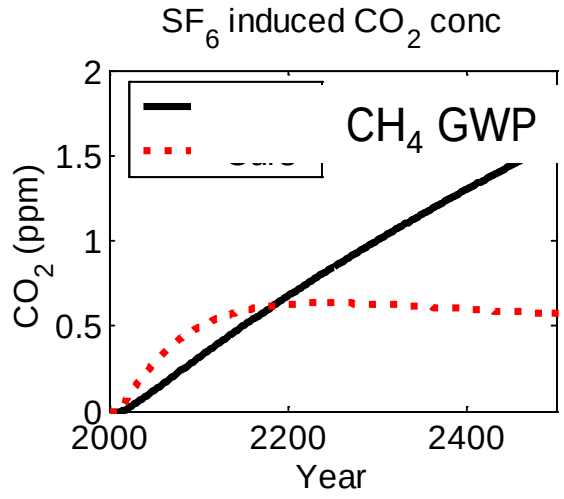
Tack för er uppmärksamhet och deltagande!

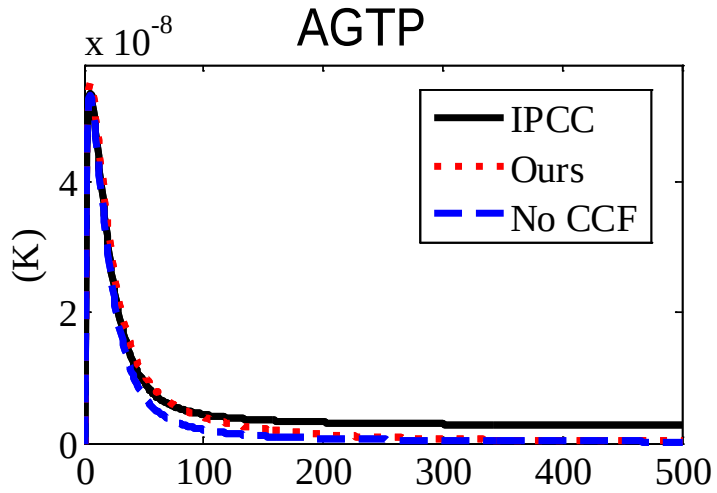
Extra slides

Results

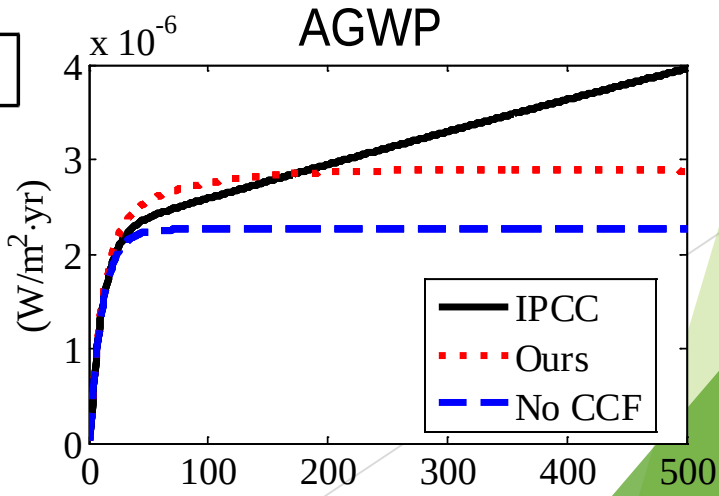
Approach	20 years	100 years	500 years
Ours	93	35	9.6
IPCC	88	33	13







CH4



Types and qualities of

- *Declarative* knowledge (knowing *what*)
- *Procedural* knowledge (knowing *how*)
- *Situational* knowledge (knowing *when*)

(de Jong and Ferguson-Hessler 1996)

Reasoning

Explain briefly how you reasoned when answering choosing to keep or change your answer?

In this category the students' answer focus on...

System thinking

- the system or a relationship between emissions and uptake for CO_2 stabilization.

Pattern thinking (Correlation heuristic)

- a direct pattern matching or connection between the amount of CO_2 in the atmosphere and the emissions and or the uptake.

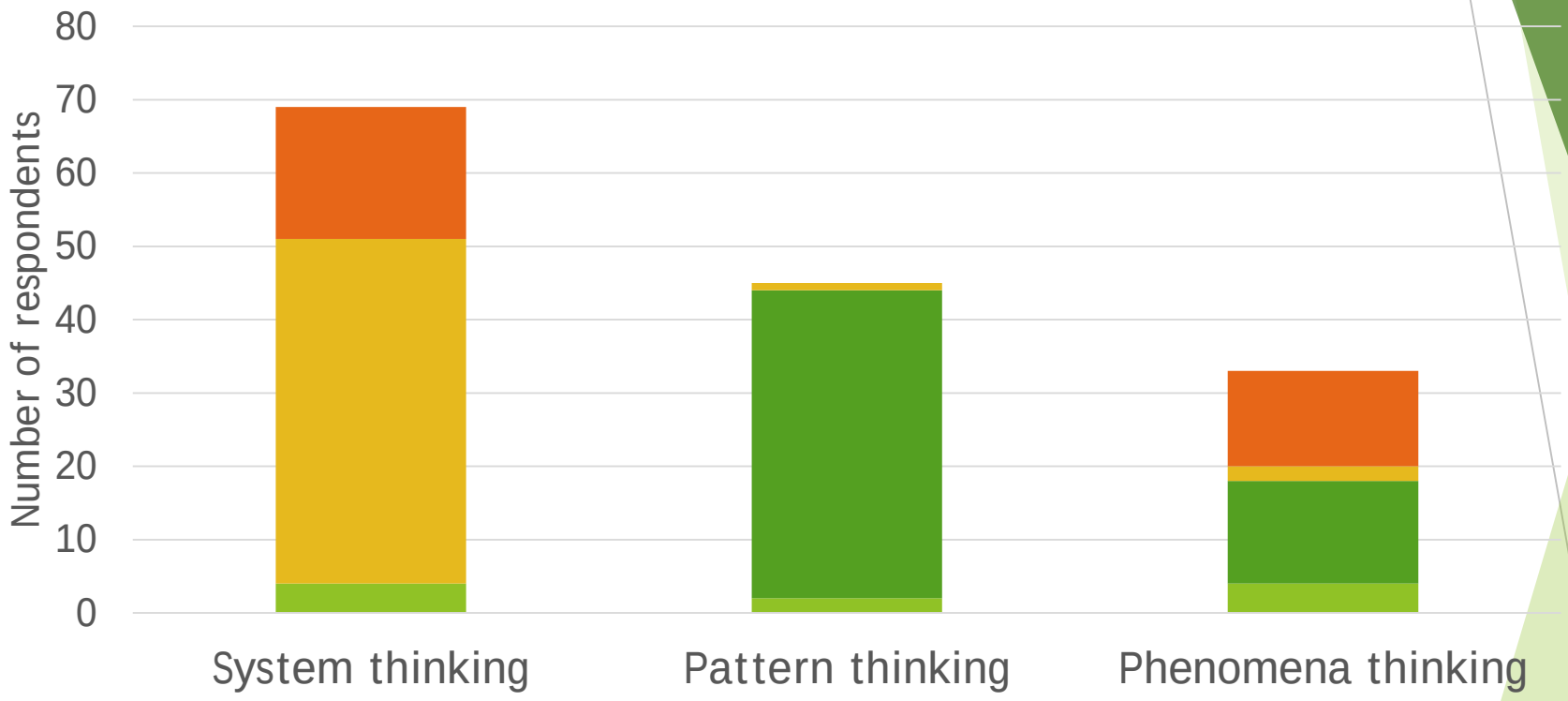
Phenomena thinking

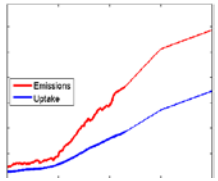
- information or thoughts related to the phenomena studied that are not required for solving the SF task.

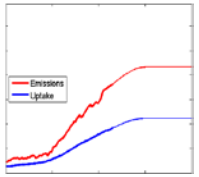
Examples of students' reasoning…

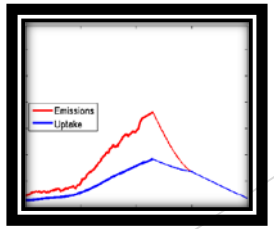
- **System thinking**
  - "The difference between both curves should equal a 10% increase an then remain constant" [*A=E-U]*
  - "For a stable level of CO2, the emission should be the same as the uptake. When someone leaves 3 apples in front of your door every day, but you can only eat 2 per day, the number of apples will grow. The one apple that you leave every day won't disappear magically! It's the same with flow charts."
- **Pattern thinking (correlation heuristic)**
  - "if CO2 stabilizes then everything stabilizes",
  - "Emissions rise about 10% and then level."
- **Phenomena thinking**
  - "Already there is a difference between uptake of emissions by 18 Billion tons per year. So if we want to reduceCO2 so it has to be reduce and we have to increase the uptake by increasing forest."

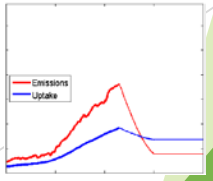
Answer alternative per reasoning category











Mitigation policy question

Which of the following statements comes closest to your personal view?

Incorrect on T1

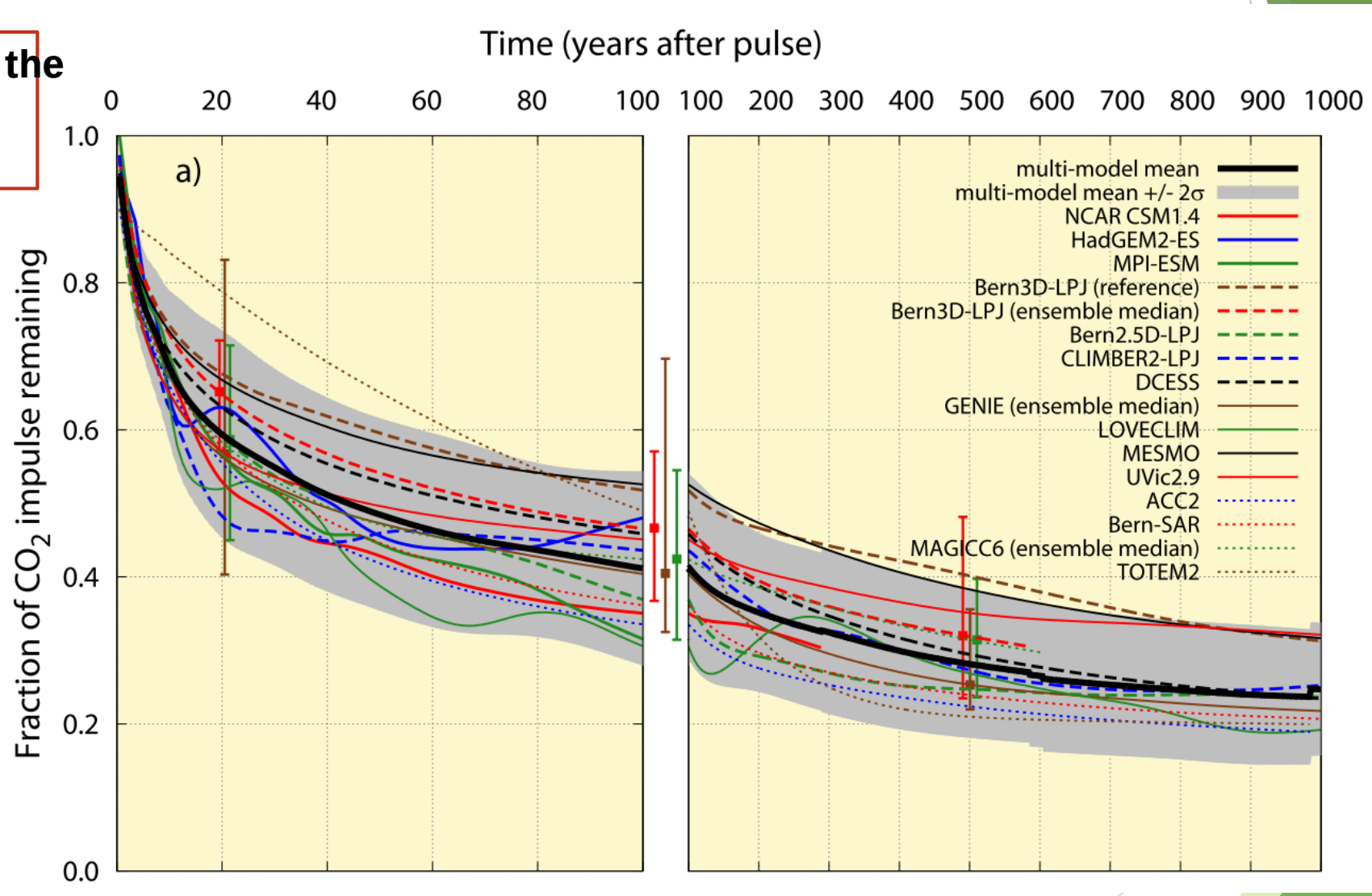
Correct on T1

94-Society should take **strong** action to reduce emissions of greenhouse gases today, to reduce future climate impacts.	**33**
5-Society should take **moderate** actions to reduce emissions of greenhouse gases today, to reduce future climate impacts.	**-0**
2-Society should reduce emissions of greenhouse gases in the future, in response to climate impacts as they actually occur.	**-1**
1-Society should note take **any** steps to reduce emissions of greenhouse gases (such as CO2).	**-0**
1-I don't know/I haven't formed an opinion	**-0**

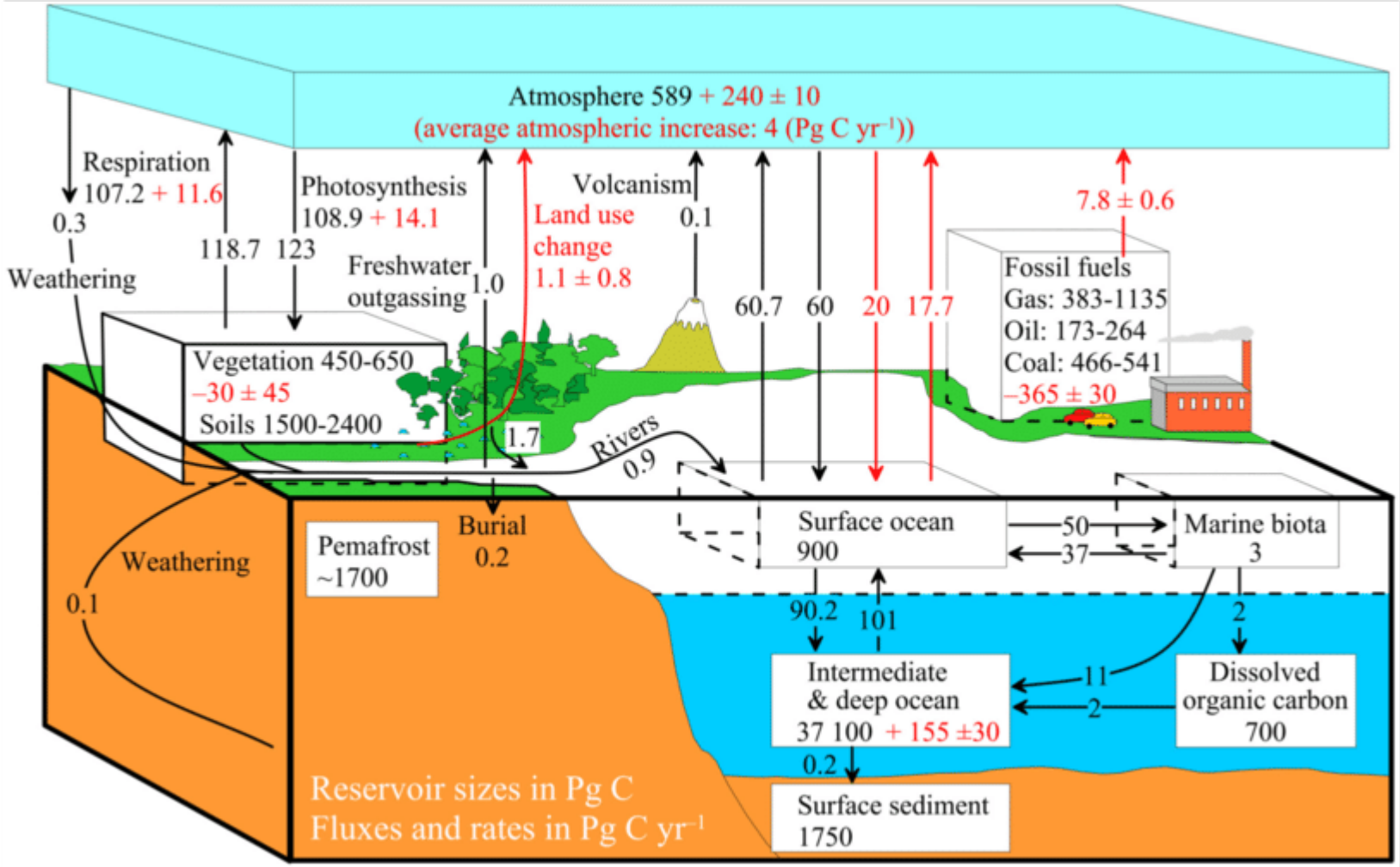
Connection to understanding/performance on T1 doubtful

IPCC uses this study for CO_2 impulse response function

20-25% remain in the atmosphere for a very long time



Joos F, Roth R, Fuglestvedt JS, et al (2013) Carbon dioxide and climate impulse response functions for the computation of greenhouse gas metrics: a multi-model analysis. Atmos Chem Phys 13:2793–2825. doi: 10.5194/acp-13-2793-2013


Atmosphere 589 + 240 ± 10
(average atmospheric increase: 4 (Pg C yr⁻¹))
Respiration
107.2 + 11.6
0.3
Weathering
118.7
123
Photosynthesis
108.9 + 14.1
Freshwater
outgassing
1.0
Land use
change
1.1 ± 0.8
Volcanism
0.1
60.7
60
20
17.7
7.8 ± 0.6
Fossil fuels
Gas: 383-1135
Oil: 173-264
Coal: 466-541
−365 ± 30
Vegetation 450-650
−30 ± 45
Soils 1500-2400
1.7
Rivers
0.9
Burial
0.2
Pemafrost
~1700
Weathering
0.1
Surface ocean
900
50
37
Marine biota
3
90.2
101
2
Intermediate
& deep ocean
37 100 + 155 ±30
11
2
Dissolved
organic carbon
700
0.2
Surface sediment
1750
Reservoir sizes in Pg C
Fluxes and rates in Pg C yr⁻¹