

# Climate Change Education for Physics Teachers

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How does topic of climate change  
relate to physics teachers?

Climate Science  
is based on  
**CLIMATE PHYSICS**

Physics teachers must become climate literate!

# Why should pupils learn about greenhouse effect?

- Importance of greenhouse gases for Earth's climate
- Global climate disruption
- Adaptation and mitigation



# Why should pupils learn about ozone depletion?

- In the Czech republic 1300 cases of skin cancer annually.
- Within last 30 years number of cases rose by 420%!
- Is it due to ozone depletion?



# Common misconceptions

- One of the most popular persistent misconceptions is that **the ozone hole plays a major role in global warming** (e.g., Rye et al., 1997)
- Dove (1996) showed that even undergraduate (baccalaureate) students believed that **motor vehicle emissions are one reason for the destruction of the ozone layer.**
- More than half of the students in a Swedish study believed that **the greenhouse effect is only a human-induced phenomenon.** They did not distinguish between the natural greenhouse effect necessary for life on Earth and its human enhancement (Andersson and Wallin, 2000)

Quoted from Uherek 2008

# Research question

"What misconceptions about greenhouse effect do pre-service physics teachers have?"

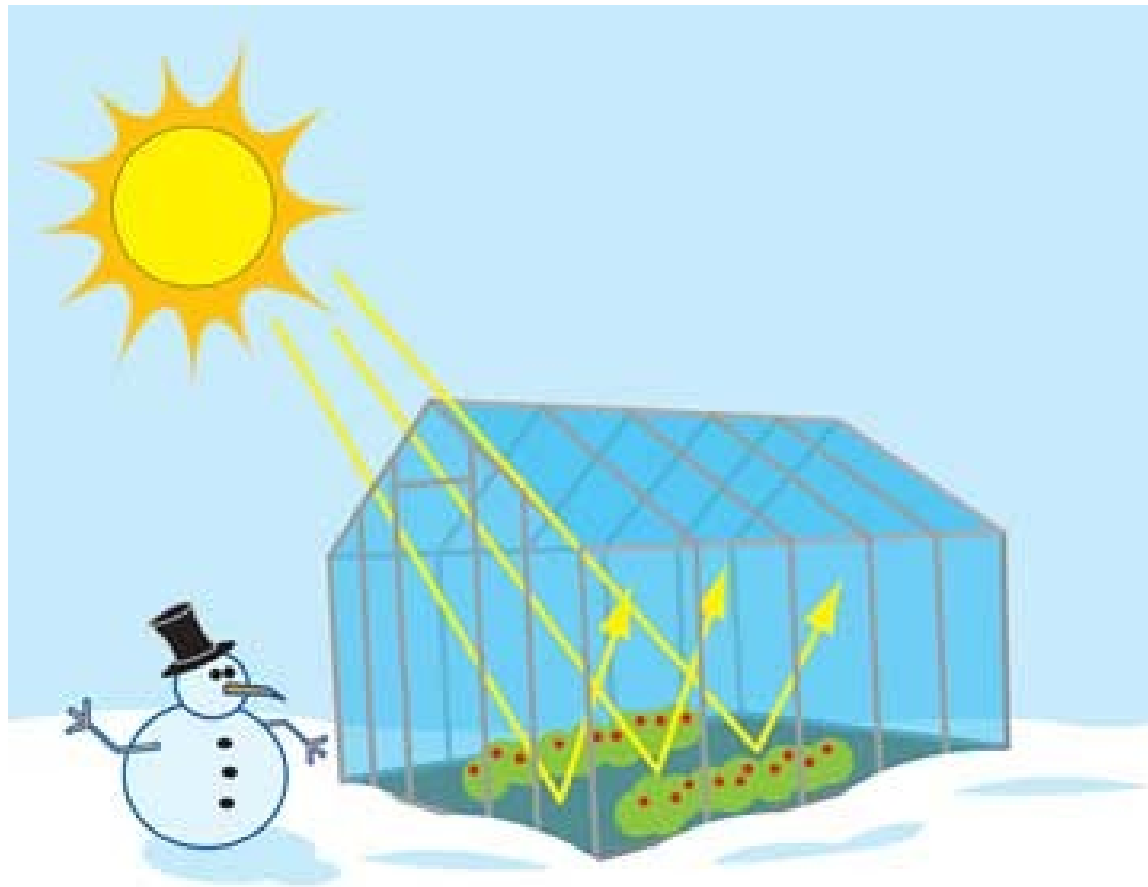
# Case Study

We've interviewed six PhD students of didactics of physics (on average, 20 min).

- Students were informed in advance just about the topic of interview – Greenhouse Effect. (They were not trained or prepared for it.)
- Interviews were conducted following a structured set of 17 questions.
- Interviews were recorded and analyzed.

# Questions asked during interview:

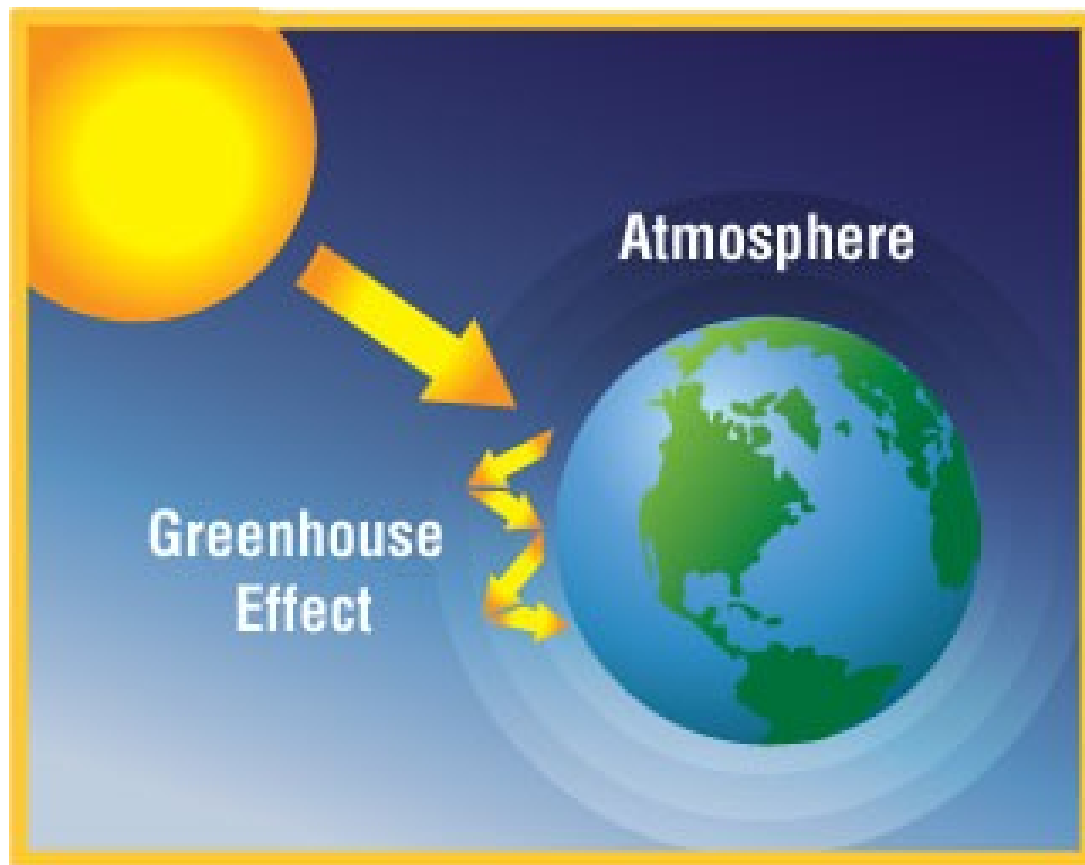
*1. Use the following picture to explain the greenhouse effect.*





# Questions asked during interview:

2. *Use the following picture to explain the greenhouse effect in the Earth's atmosphere.*



# Questions asked during interview:

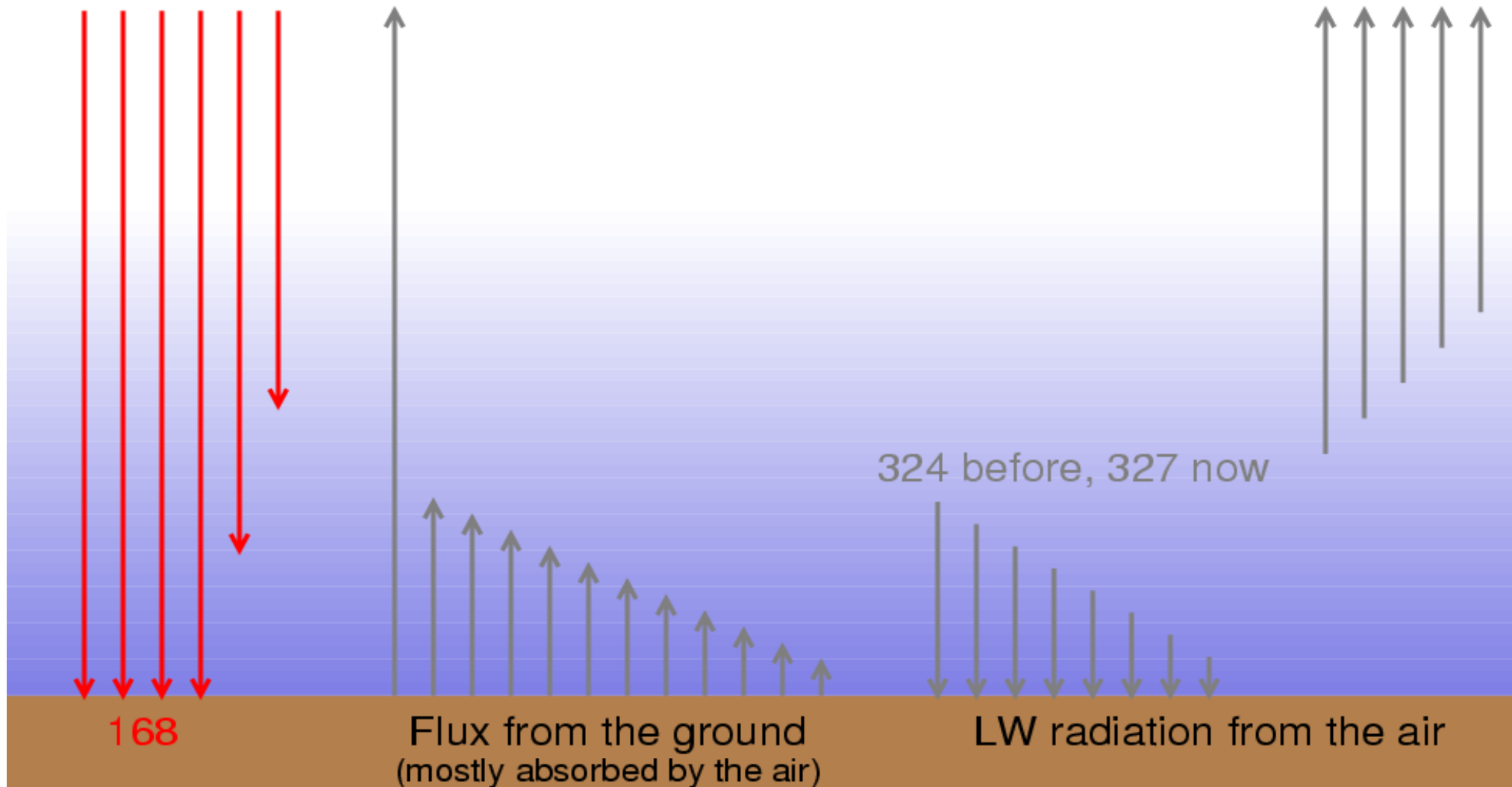
- 3. What differences can you see for those two cases?*
- 4. How does a foil greenhouse work?*
- 5. Estimate average surface temperature of the Earth.*
- 6. Estimate average surface temperature of the Earth without atmosphere.*

# RF with no cooling aerosols added

Greenhouse effect: heat flux /  $W/m^2$ , 1 arrow = 40

Solar radiation  
235

Longwave radiation back to the Universe  
235 before 1900, but only 232 now: over 1 % inbalance!



No GH: temperature would drop not by 33 K, but by a good 100 K from our ~288 K

; sqrt(sqrt((0.7 \* 1367 / 4) / 5.67e-8))

~255 - provided the albedo remains

; sqrt(sqrt((0.1 \* 1367 / 4) / 5.67e-8))

~157 - with albedo 0.9

; sqrt(sqrt((0.2 \* 1367 / 4) / 5.67e-8))

~186 - with albedo 0.8 (wouldn't be less...)

# Questions asked during interview:

7. *What are the most significant greenhouse gases in the Earth's atmosphere?*
8. *Where are the greenhouse gases in the Earth's atmosphere located?*
9. *When concentration of atmospheric greenhouse gases increases, what happens to the temperature of (a) Earth's surface, (b) stratosphere?*

# Above troposphere, GHGs cool the air

This is difficult... the pressure broadening of molecular spectral lines is no more present, so the gasses absorb little of the upwelling LWIR, but do emit at full Planck strenght...

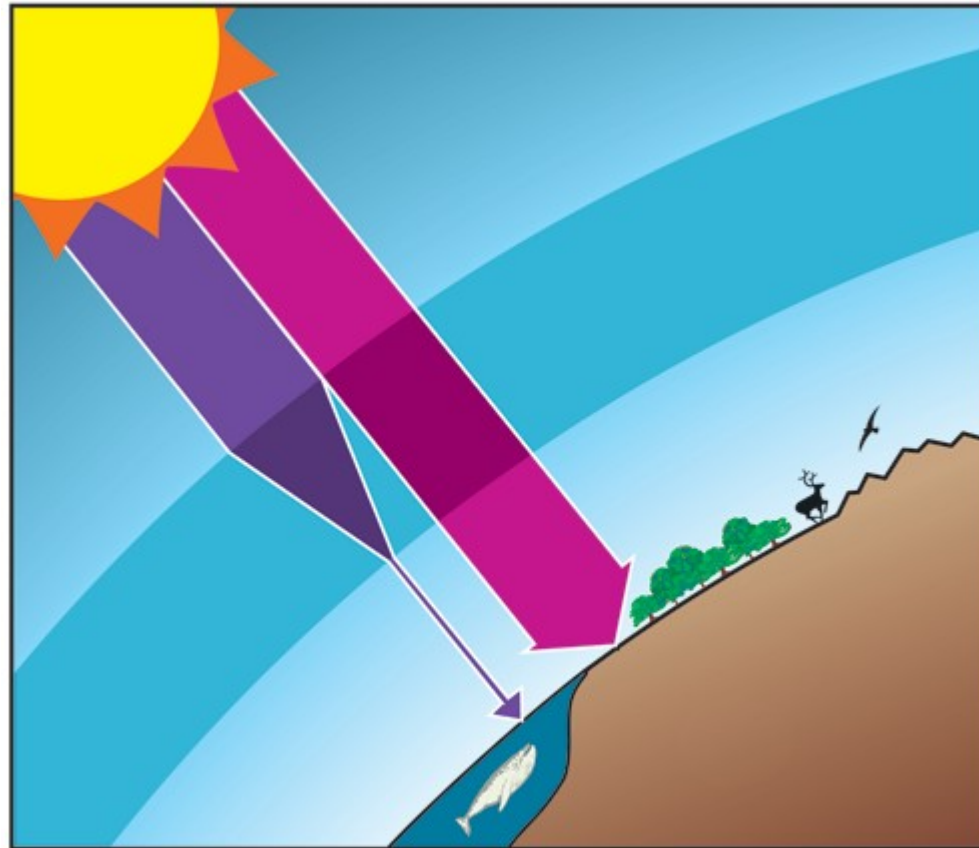
# Questions asked during interview:

*10. What you think this picture represents?*



# Research questions

*11. Use the following picture to explain the function of ozone layer.*





G. Thomas Farmer • John Cook  
Climate Change Science:  
A Modern Synthesis  
Volume 1 - The Physical Climate

>As we've seen before, the incoming radiation is **mainly ultraviolet (UV) radiation. This UV radiation heats the Earth** which causes it to re-radiate heat in the form of infrared (IR) radiation. Much of this IR radiation is trapped near Earth's surface by the greenhouse gases that in turn re-radiate some of this back to the surface.<

# Questions asked during interview:

12. *Where in the atmosphere is ozon located?*
13. *What is the cause of ozone layer depletion?*
14. *Where in the atmosphere are ozone holes located?*
15. *Why do ozone holes form above poles?*
  
16. *Can global warming somehow contribute to depletion of ozone layer? (How?)*
17. *Can depletion of ozone layer somehow contribute to global warming? (How?)*

# Findings

- *Unable to explain why under foil-greenhouse surface is warmer compare to surroundings.*
- *Hesitation whether Earth without atmosphere would be warmer or cooler.*
- *Missing information about location of ozone holes.*

# Findings

- *Confirmed conception that ozone hole allows more solar radiation to penetrate the atmosphere and heat Earth's surface.*

Although in principle this idea is right, the heating effect is negligible.

In fact interviewees have probably never investigated the problem before – they fabricated this (mis)conception during the interview.

# Findings

- *Not confirmed common conclusion of similar studies: people believe that greenhouse gases are located in a single layer.*

Although interviewees had been offered a single layer model to explain greenhouse effect, they do not really believe it is so (we explicitly asked them). It is just a misleading simplification...

# Recomendations

- Pre-service physics teachers should be provided with comprehensive course about physical background of climate change and related issues.
- We developed a study material (textbook) for pre-service physics and chemistry teachers available at <http://amper.ped.muni.cz/gw/activities/klima.pdf>  
English version coming soon!