ENV 320 – Radiation

Exercise session
28 March 2025

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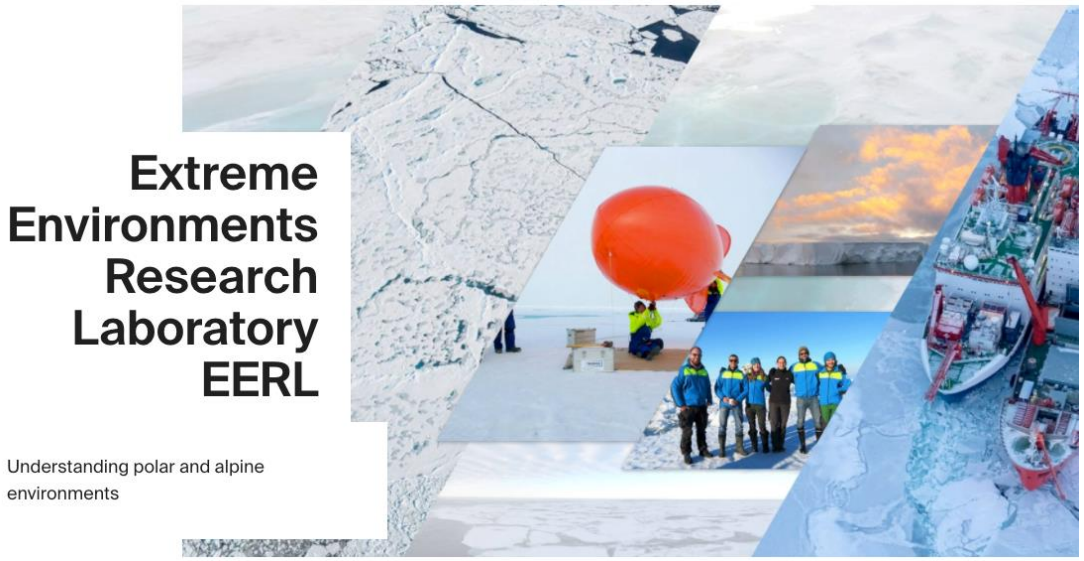
Teaching Assistant

- BSc in Meteorological Engineering
- MSc in Atmospheric Sciences
- PhD student at EERL and LAPI since October 2023
- Focus on modeling aerosol-cloud interaction in the Arctic



https://www.epfl.ch/labs/eerl/

Cloud Radiative Effect (CRE)

$$CRE_{LW} = F_{net,LW,cloudy} - F_{net,LW,cloudless}$$
$$CRE_{SW} = F_{net,SW,cloudy} - F_{net,SW,cloudless}$$
$$\longrightarrow \quad CRE_{TOT} = CRE_{LW} + CRE_{SW}$$

(Ramanathan et al. 1989)

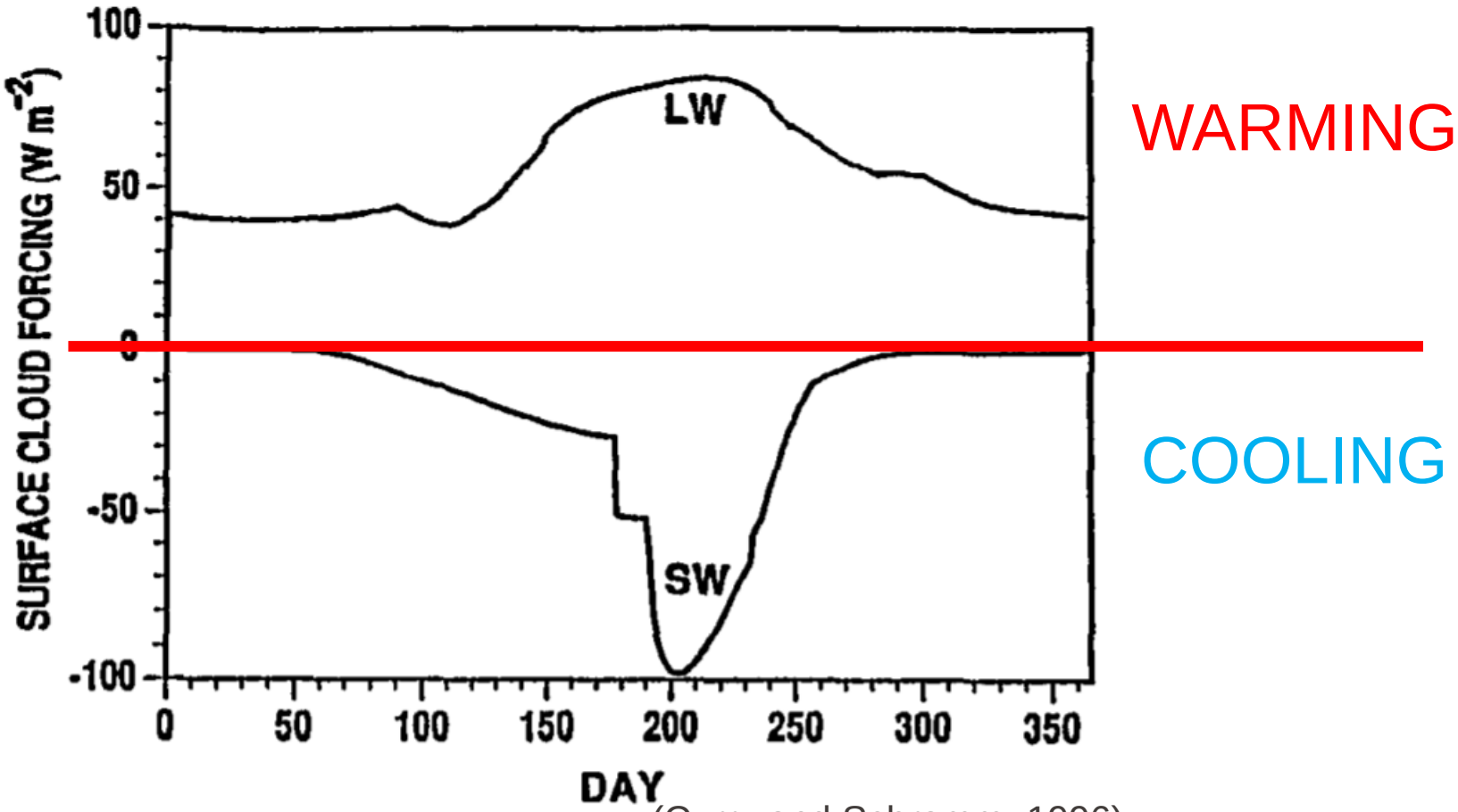
Also referred as cloud radiative forcing

Winter:
Polar night → no SW component to reduce/remove (in the Arctic)

Summer:
Warmer clouds → increased LW (Stephan-Boltzmann)

It is influenced by several factors:
- Season and time
- Latitude
- Cloud cover
- Cloud height
- Cloud microphysics
- Surface albedo
- Cloud and surface temperature

→ Not trivial to get it right



(Curry and Schramm, 1996)

Cloud Radiative Effect – Thermal infrared

Cloudless
- Surface (high emissivity, warm) strongly emits upwards
- Atmosphere (low emissivity, cold) weakly emits downwards

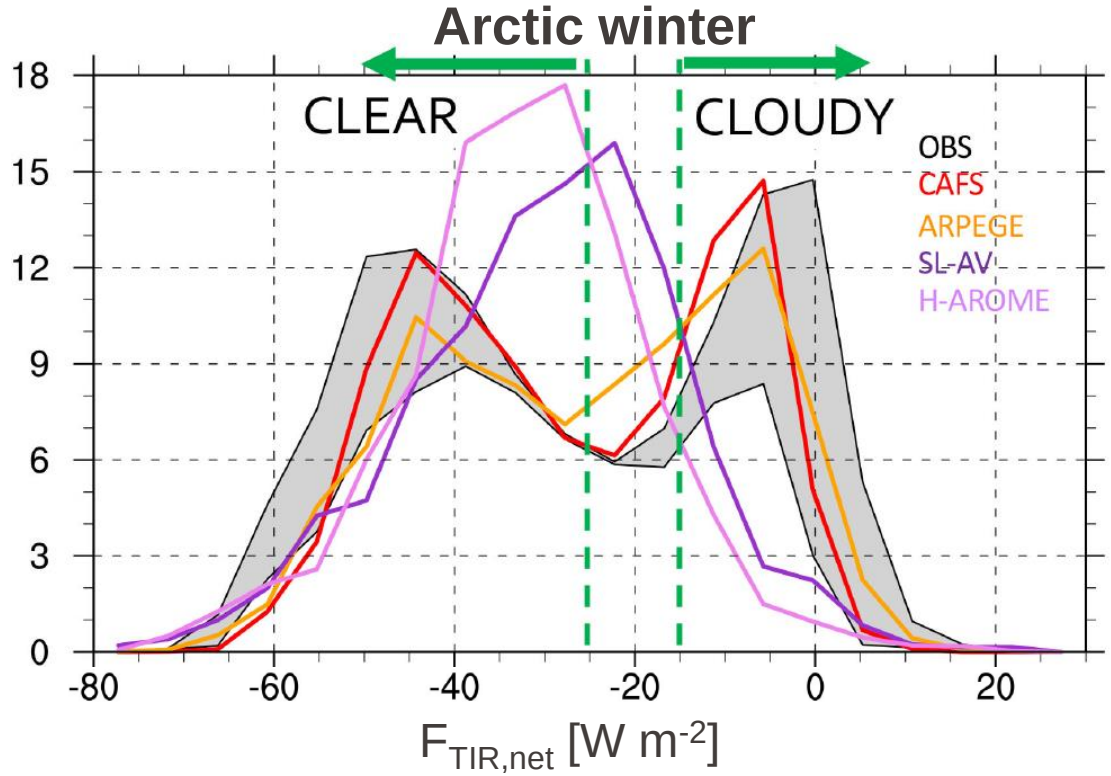
→ Negative net irradiance

Cloudy
- Surface (high emissivity, warm) strongly emits upwards
- Cloud (high emissivity, rel. warm) strongly emits downwards

→ Near zero net irradiance

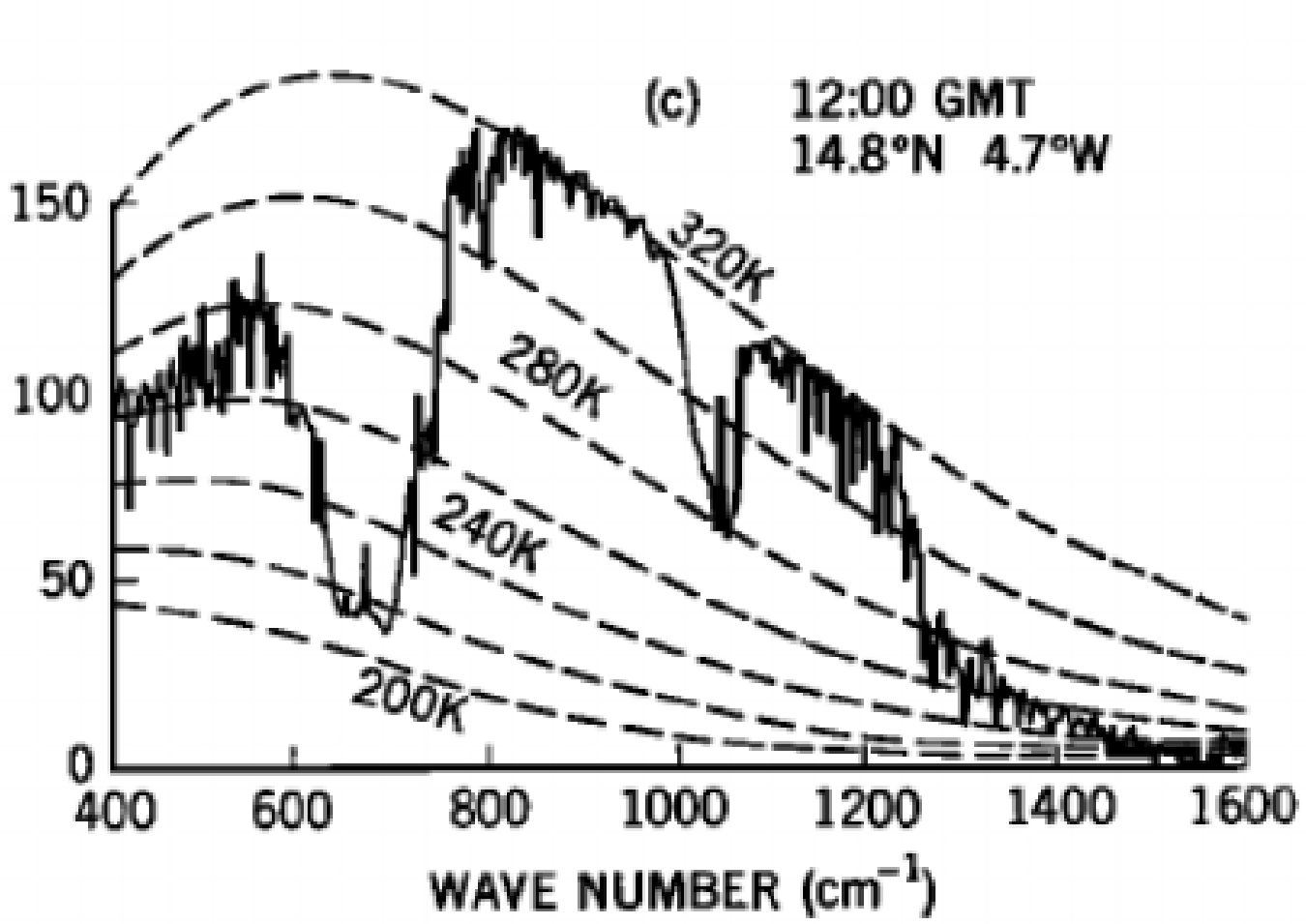
Q: What happens if the cloud is warmer than the surface? (think how)

→ Positive net irradiance



(adapted from Solomon et al., 2023)

Earth's emission in Sahara Desert



Saharan Desert

Hanely et al. 1972

On the figure

1. What do you think the dashed lines might be?
2. Locate absorption bands
3. Locate atmospheric windows and why?

Albedo change

- Due to urbanization, the city of Metropolia warmed by 2.5°C, rising from 290 K. Assume incoming solar radiation (solar constant = 1361 W/m²) is unchanged and the warming is caused solely by a decrease in surface albedo.
- Using the Stefan-Boltzmann Law ($\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}), estimate the percentage decrease in albedo:

(original – new) / original × 100%

Assume radiative equilibrium before and after.

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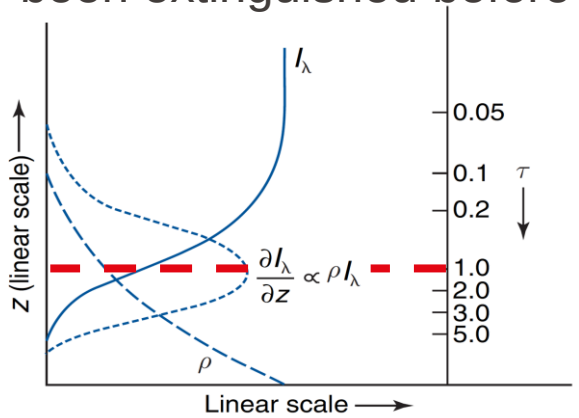
Mentimeter

Welcome to our radiation quiz! 🎉

Exercise/Quiz part 1

1. Greenhouse gases mainly absorb shortwave radiation (T/F)
2. Greenhouse gases result in only a small part of the terrestrial emission to escape to the space (T/F)
3. The IR window is the terrestrial emission that can escape to space (T/F)
4. Based on the figure; Extinction is most effective (maximum) at the level where τ ≈ 1 because:
   - Above that level: The air is thinner (lower density), so there's not enough gas or particles to significantly absorb or scatter radiation
   - Below that level: Although the air is denser, most of the radiation has already been extinguished before reaching this depth — the remaining radiation is weaker
   - Both



5. Why satellite sensors often "see" the atmosphere from the τ ≈ 1 level upward? (Open question)

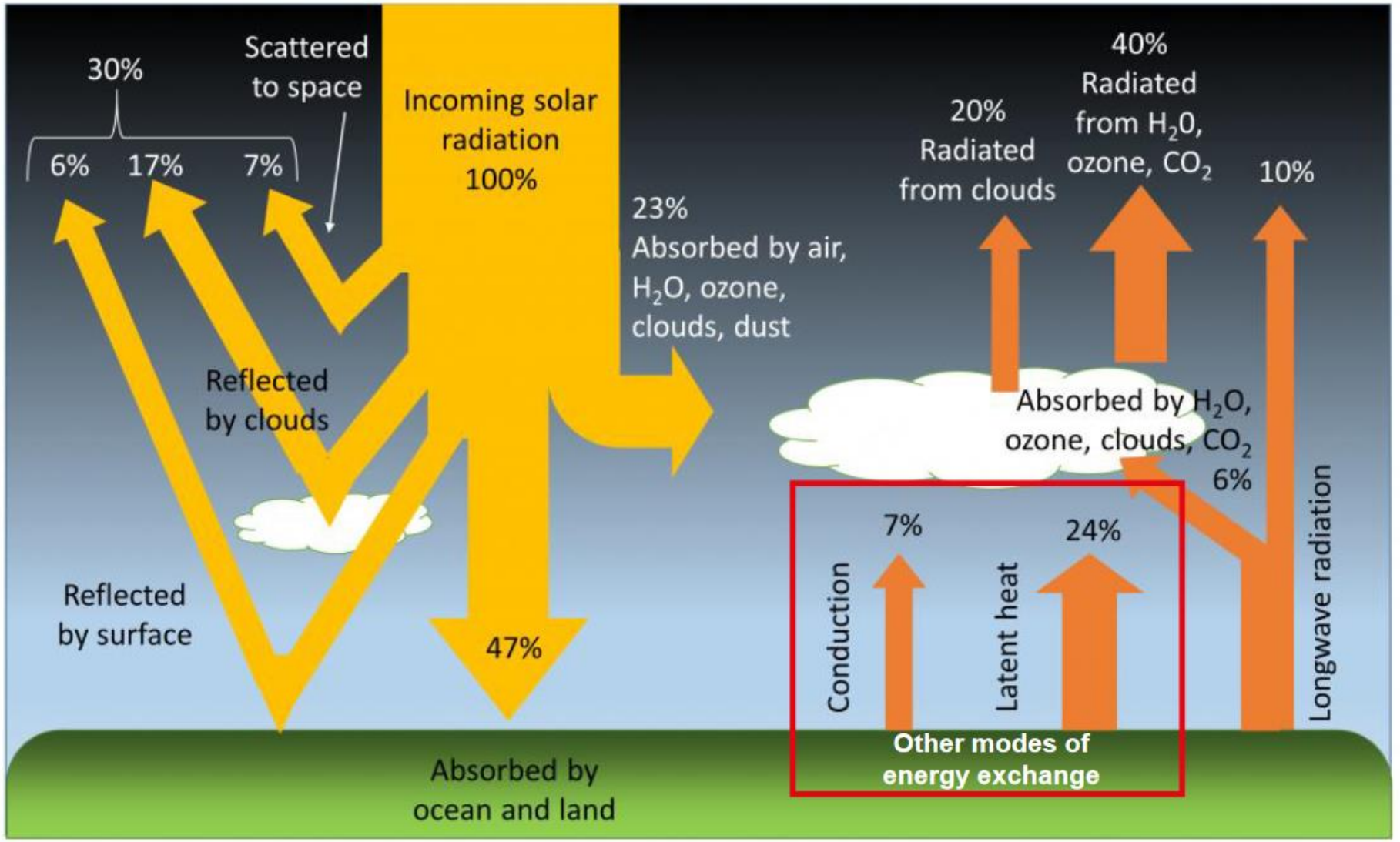
Exercise/Quiz part 2

6. Is terrestrial radiation scattered by particles? (T/F)
   - no scattering because wavelength is large compared to particles/molecules
7. Close to the surface, optical thickness increases, making removal of heat difficult (T/F)
   - Then what promotes cooling of the surface? (Convection/Sensible and latent heat)
8. Which statement is incorrect?
   - Clouds are important for the heating and cooling of atmospheric layers
   - Shortwave cooling of a cloud layer induces vertical instability and turbulence (T/F): Longwave cooling
   - Cloud tops heated via solar radiation results in more stable stratification of the atmospheric layer
9. What is the brightness temperature (open answer question)
10. What is radiative forcing?
    - A forcing that changes the radiation balance of earth
11. Greenhouse gases and aerosols can induce radiative forcing (T/F)
12. Negative effective radiative forcing forcing leads to temperature increase (T/F)

Assignment Launch

- Assignment due by 14 May
- TAs will be available for help with the assignments during the exercise sessions

Supporting content for the quiz



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