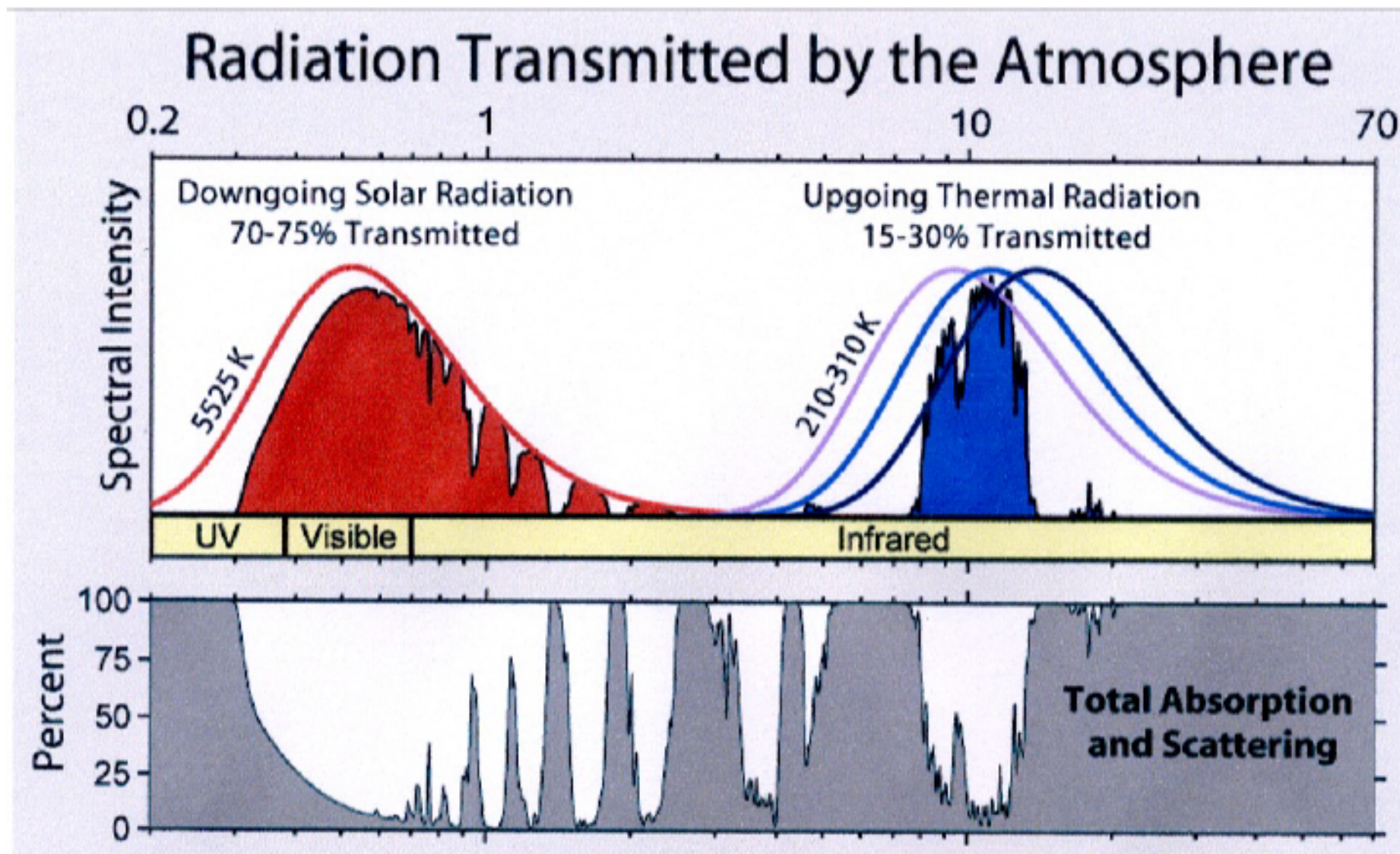
A bright sun with prominent rays is positioned in the upper center of the frame against a clear blue sky. Below the sun, a vast expanse of water is covered with numerous ice floes of various sizes. The scene is brightly lit, and a lens flare is visible in the lower center. The text is overlaid in the middle of the image.

# Global Warming

## Lecture 4.1

### One-Layer Model: Deviation

- 1. Sun's shortwave radiation and Earth's longwave radiation can be treated separately;**
- 2. The atmosphere is more transparent for the sun's shortwave radiation and is more opaque for the Earth's long wave radiation.**

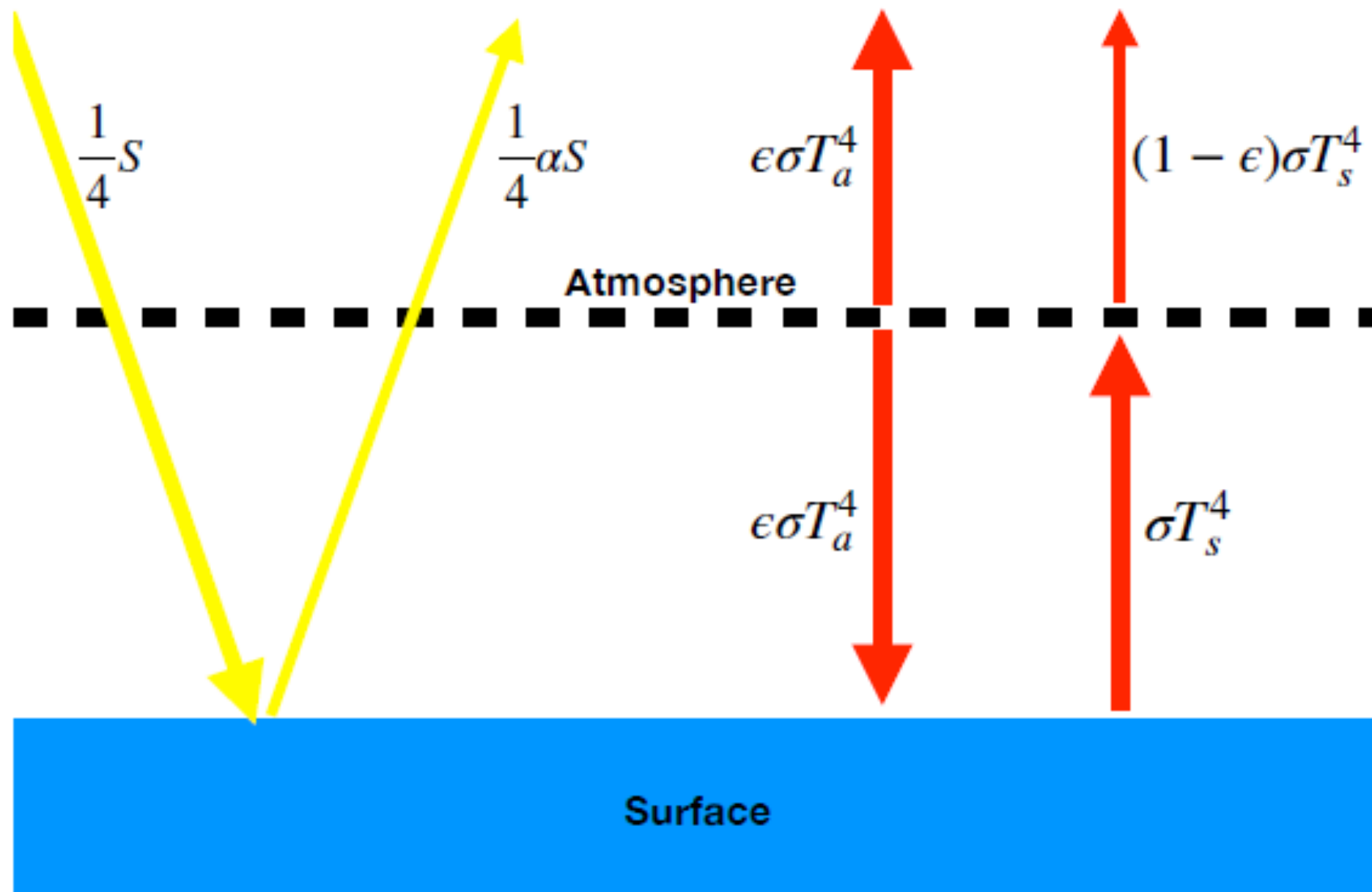


- 1. Sun's shortwave radiation and Earth's longwave radiation can be treated separately;**
- 2. The atmosphere is more transparent for the sun's shortwave radiation and is more opaque for the Earth's long wave radiation.**
- 3. Kirchhoff's law: absorptivity=emissivity**  
 $(a = \epsilon)$
- 4. 3 + Stefan-Boltzman's law: if emissivity is  $\epsilon$  and temperature is  $T$ , the radiative flux is**  
$$F = \epsilon \sigma T^4 \text{ (W/m}^2\text{)}$$



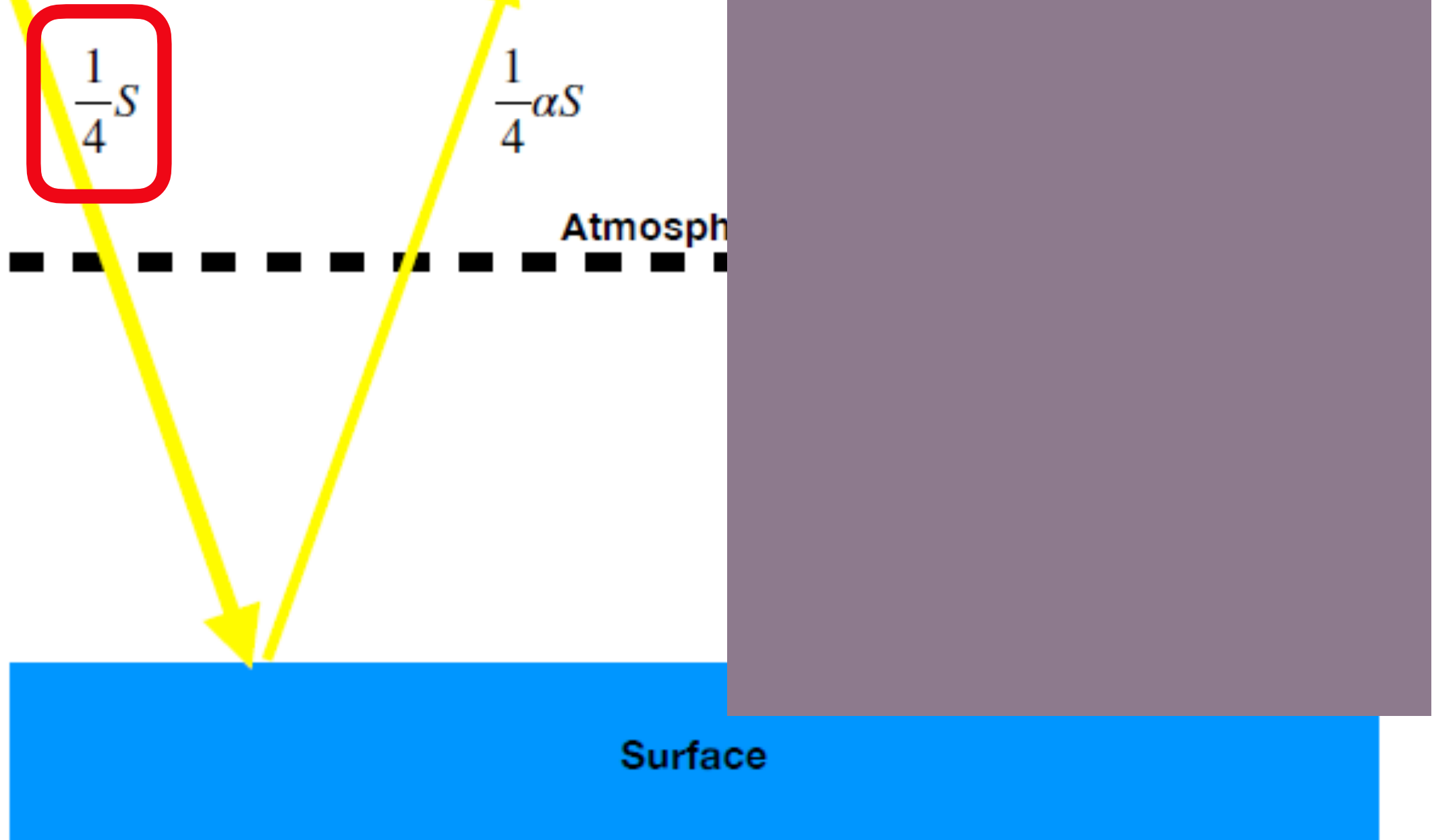
## Assumptions:

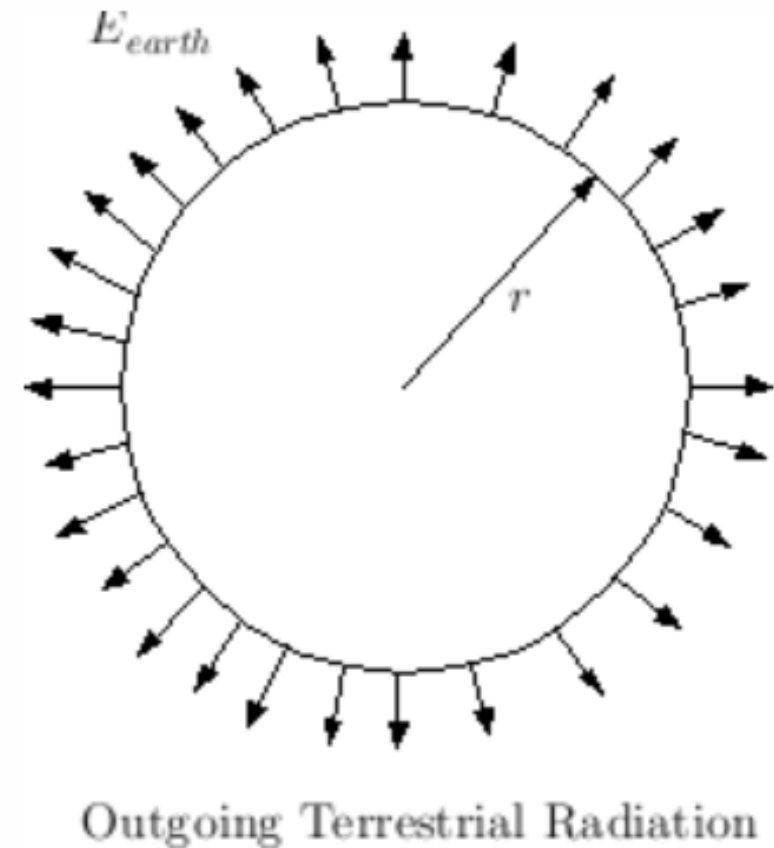
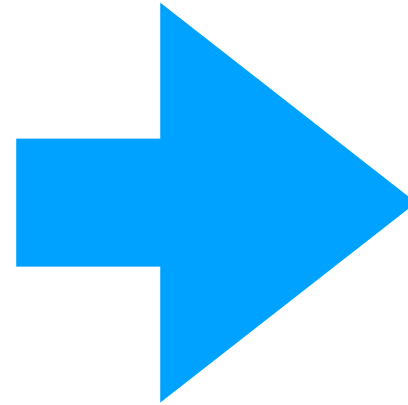
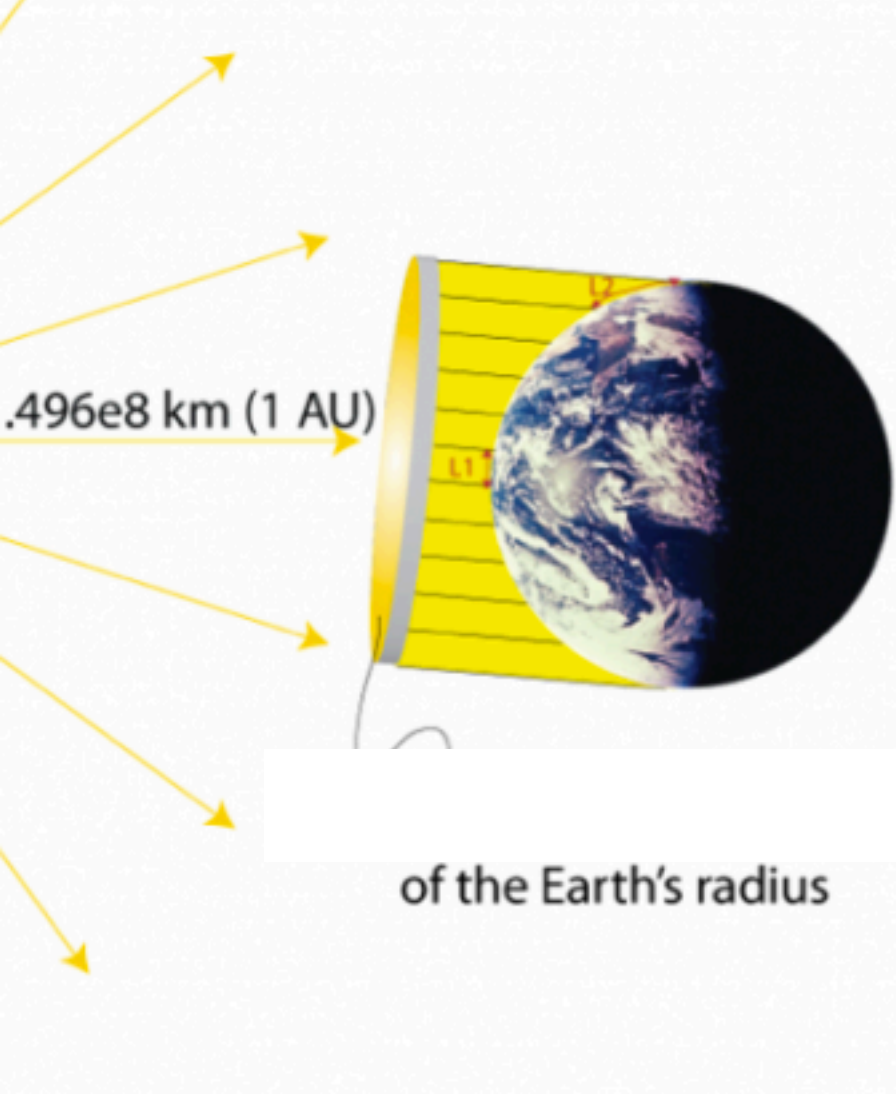
1. Atmosphere is transparent to solar radiation, and the emissivity (=absorptivity) for the Earth's radiation is  $\epsilon$
2. The surface is emitting longwave radiation as blackbody, and has an albedo of  $\alpha$  for the shortwave radiation.



## One-Layer Model

Why factor  $\frac{1}{4}$  ?





$$\frac{S \pi R^2}{\text{W/m}^2 \text{ m}^2} = [\text{W}]$$

energy hitting Earth's surface per unit time per unit area (averaged over globe):

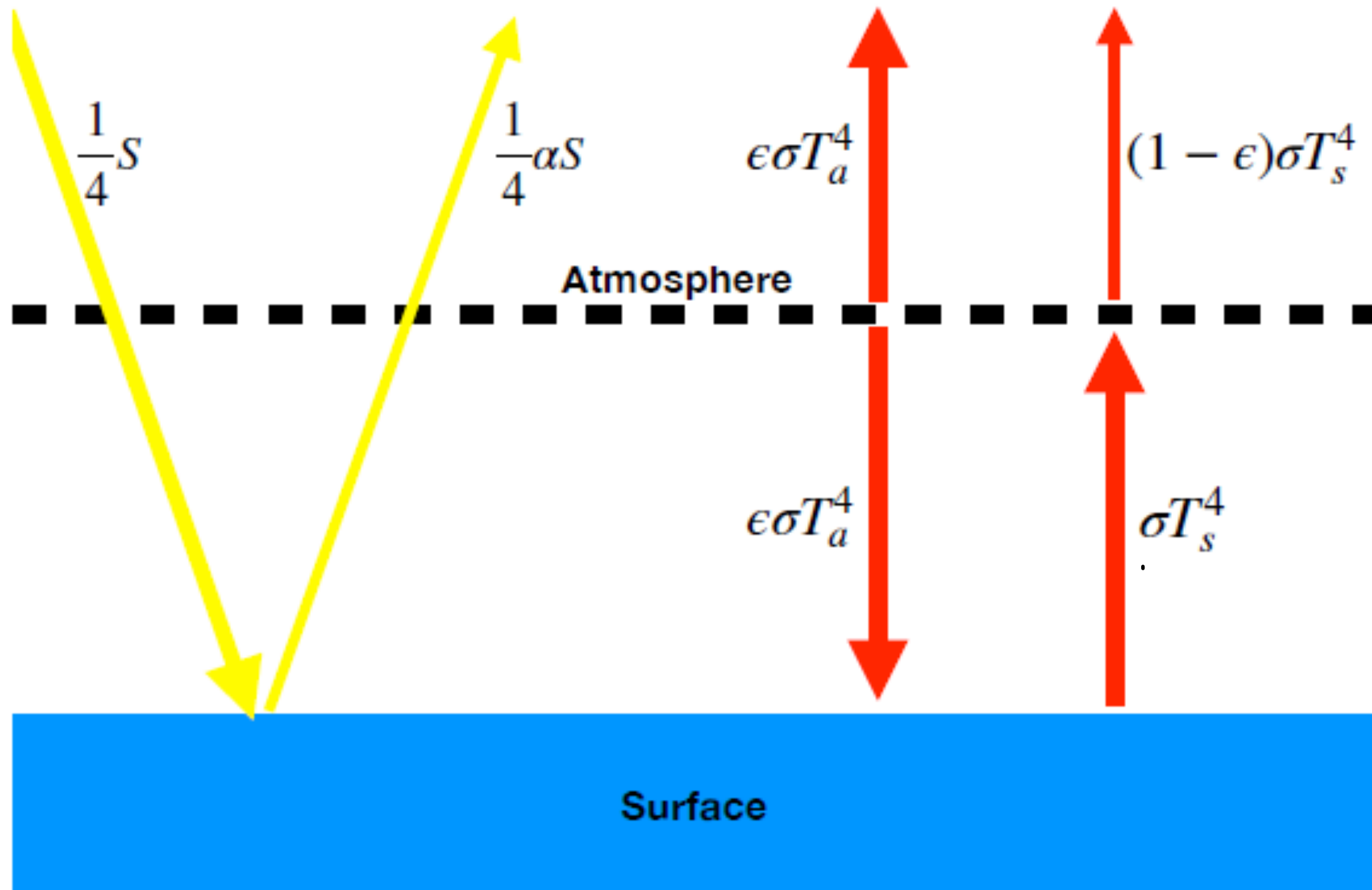
$$\text{Area : } 4\pi R^2$$

$$\frac{S \pi R^2}{4\pi R^2} = \frac{1}{4} S.$$

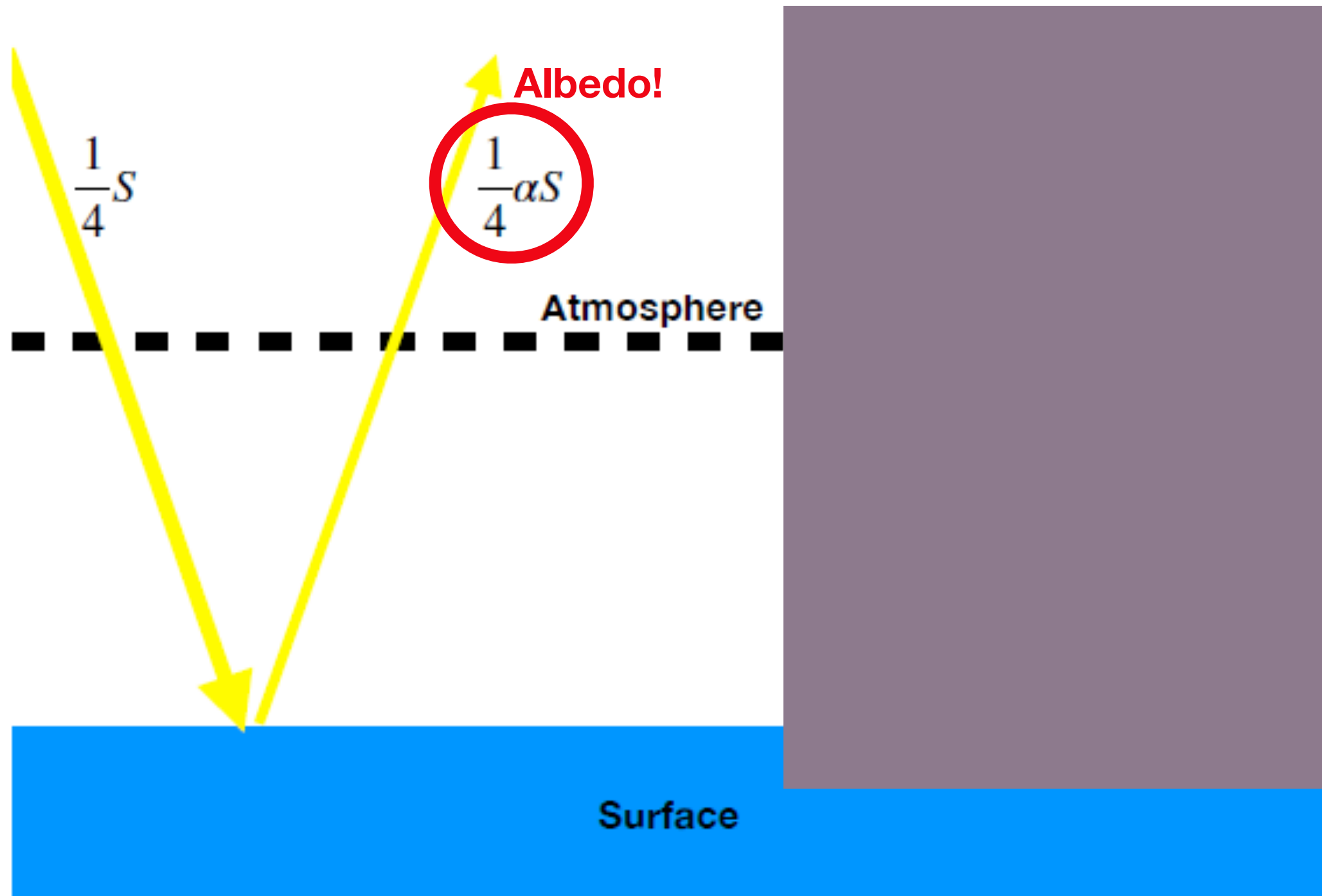
W

m<sup>2</sup>

# ONE-LAYER MODEL

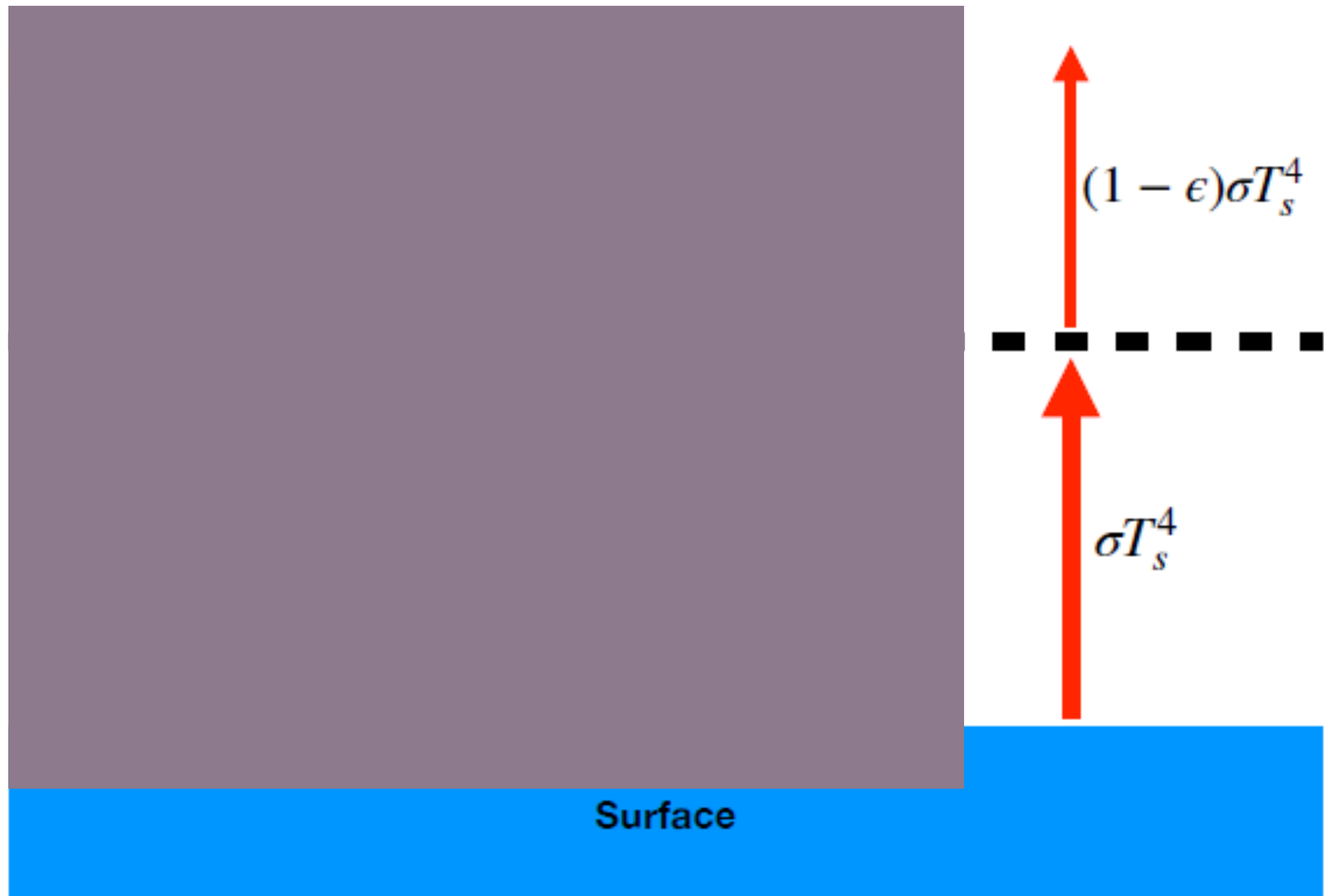


# 1. Shortwave Radiation

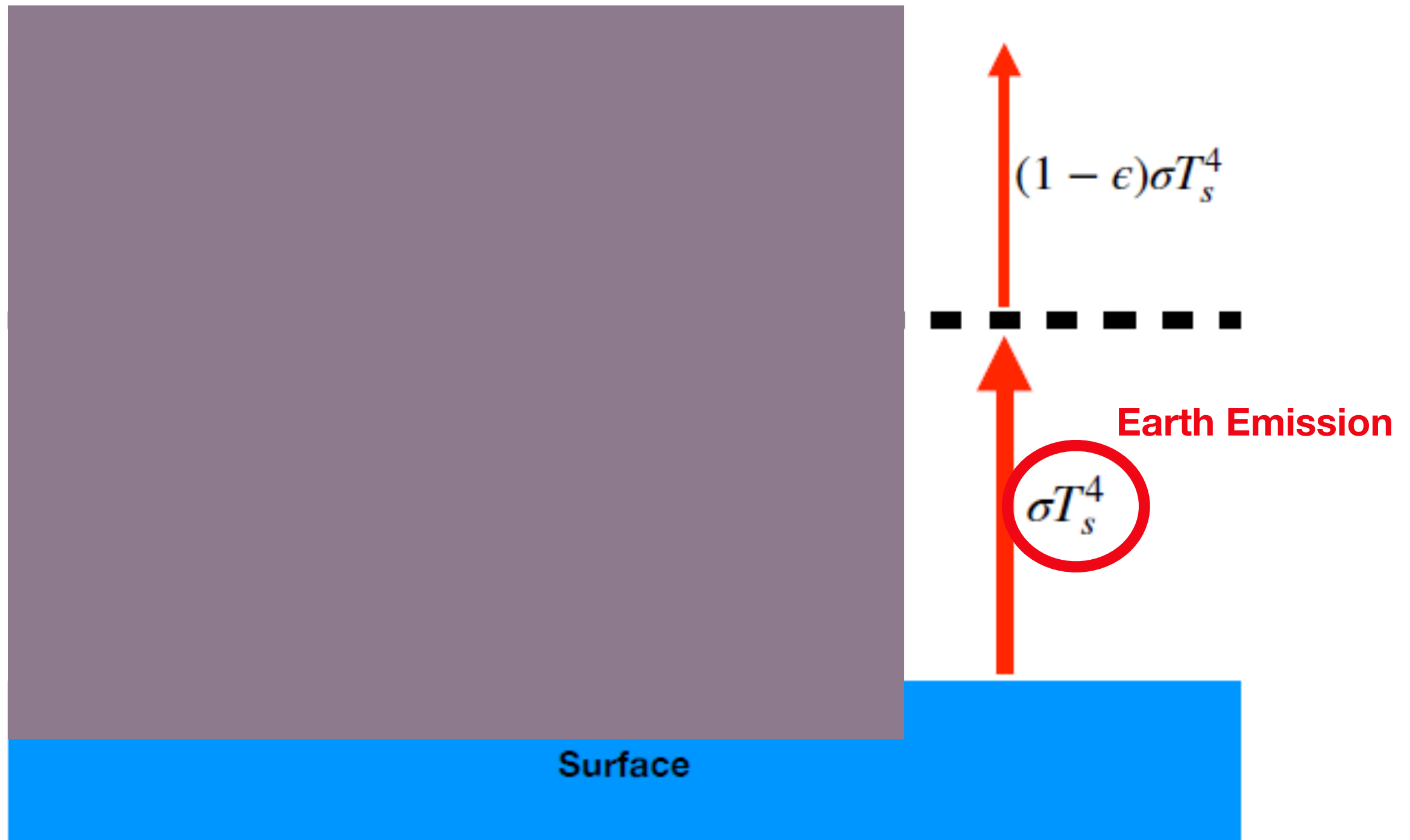




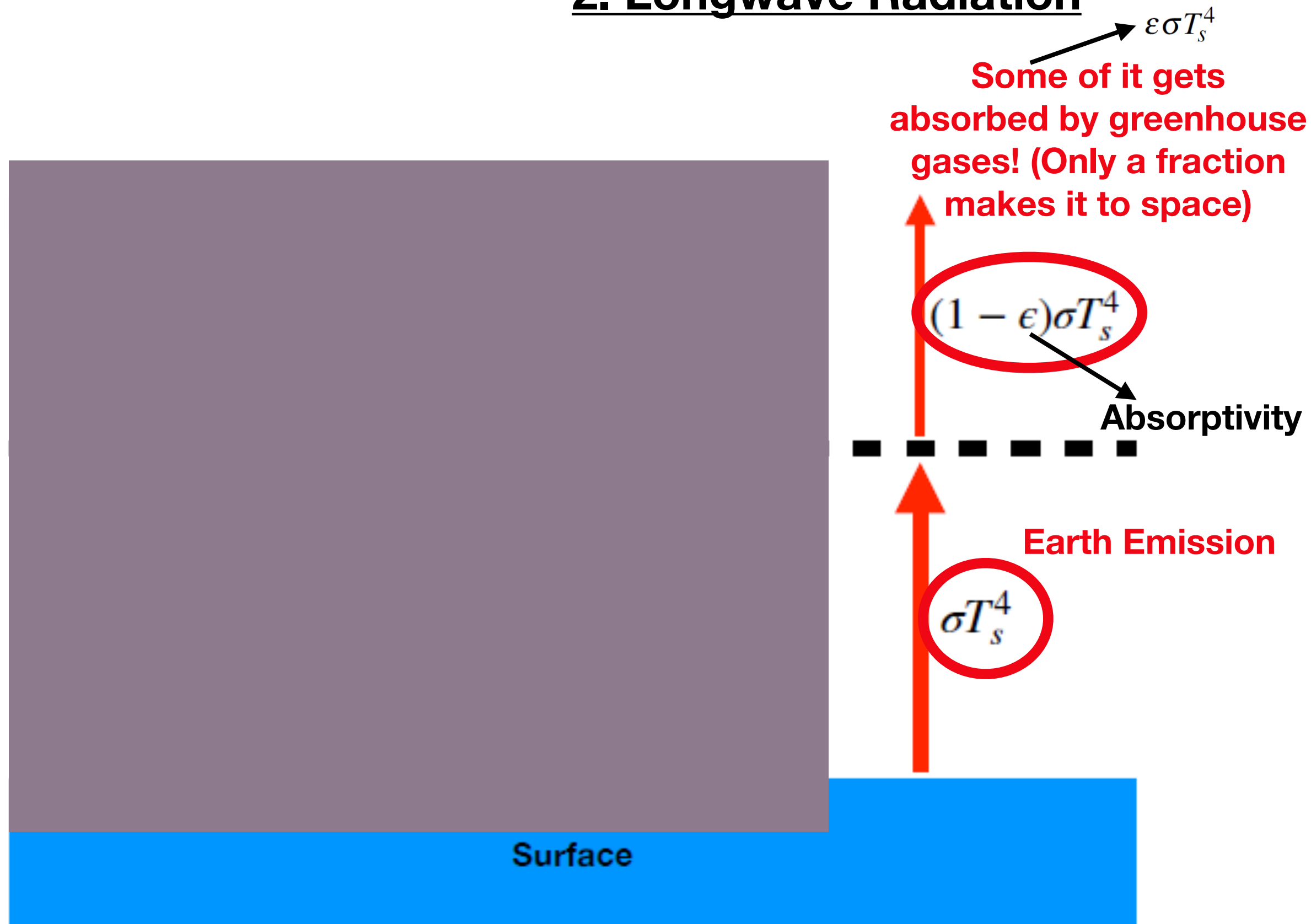
## 2. Longwave Radiation



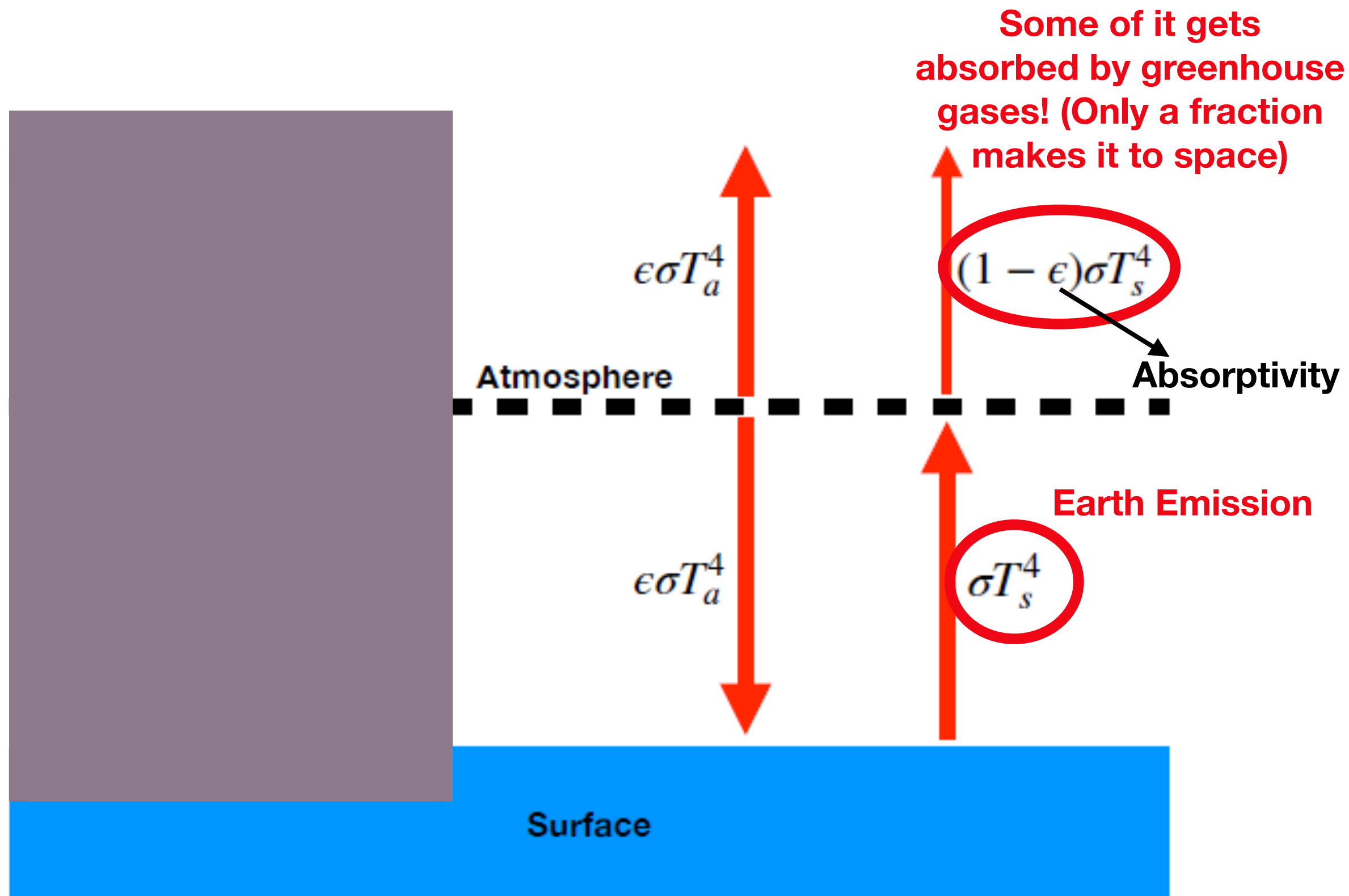
## 2. Longwave Radiation



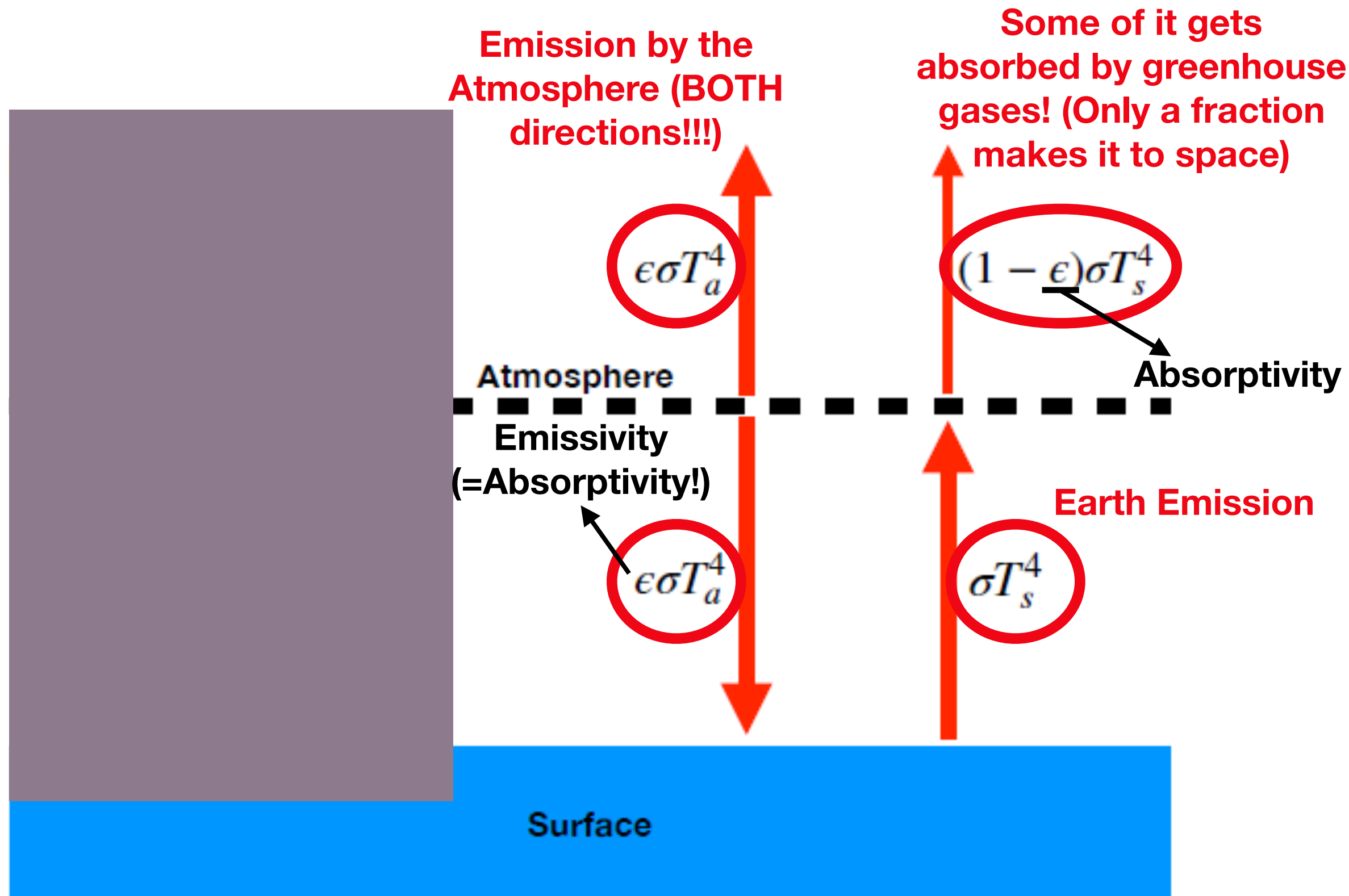
## 2. Longwave Radiation



## 2. Longwave Radiation



## 2. Longwave Radiation





# ONE-LAYER MODEL

