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# Climate

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PHYS 246 class 11

<https://lkwagner.github.io/IntroductionToComputationalPhysics/intro.html>

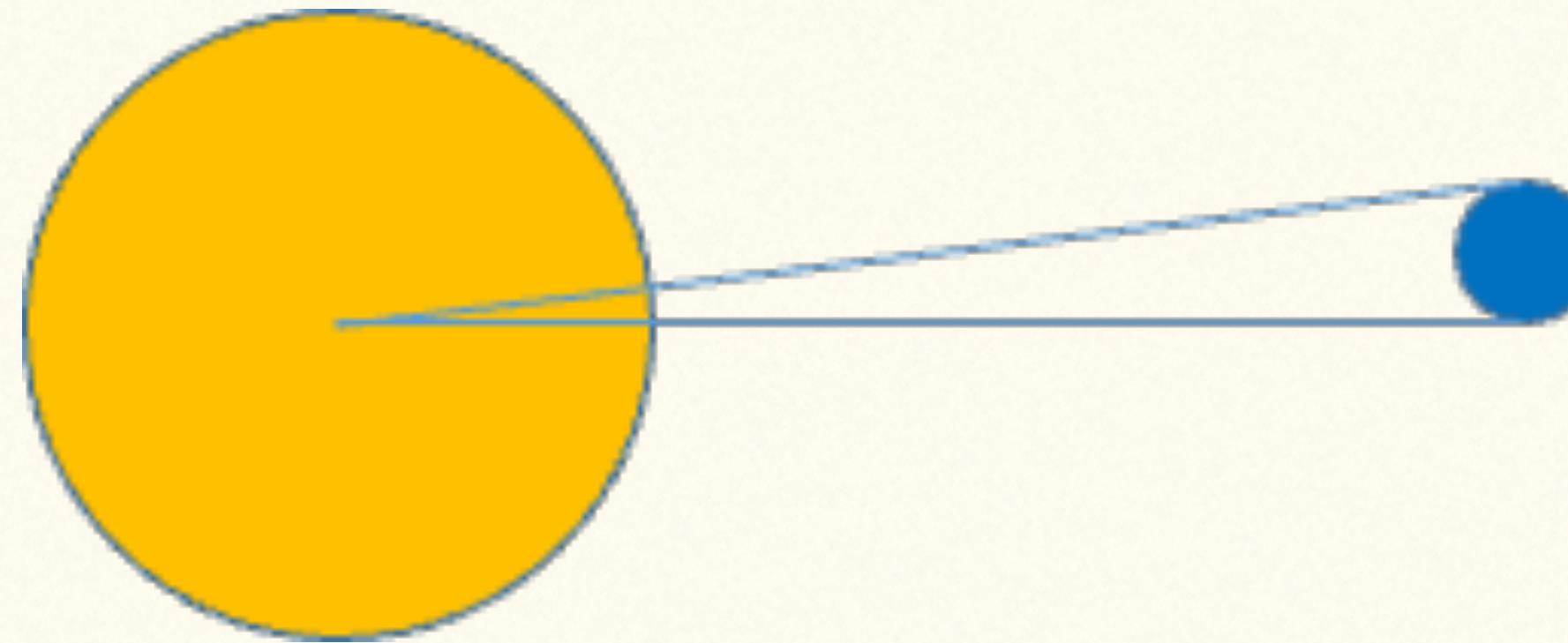
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# Announcements/notes

- 'Predator-prey' is due tonight
- There are updates as of 1 PM today. Make sure you get the current version.
- April 17th -- project proposals due
- May 13th NOON -- slides and ipynb file due
- Note that the final exam is REQUIRED to obtain a grade in this course

```
from google.colab import drive  
drive.mount('/content/drive')  
!cp /content/drive/MyDrive/Colab\ Notebooks/Dynamics.ipynb ./  
!jupyter nbconvert --to HTML "Dynamics.ipynb"
```

# Earth-Sun thermodynamic system



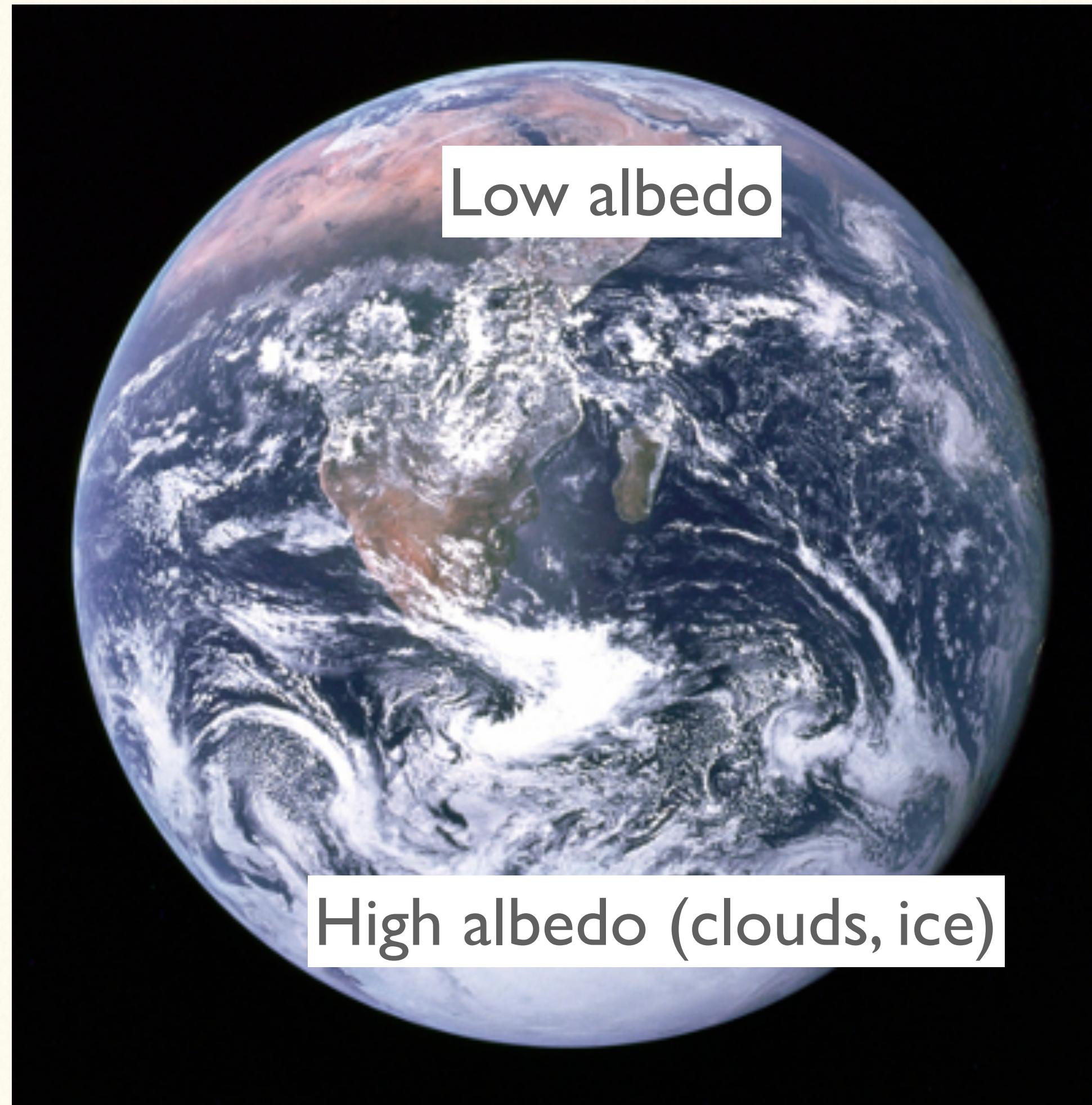
$$P_{\text{sun}} = \sigma_{SB} T_s^4 A_{\text{sun}} = 3.6 \times 10^{26} \text{W}$$

$$\frac{P_{\text{incident}}}{A_{\text{earth}}} = P_{\text{sun}} \frac{\pi R_e^2}{4\pi d_e^2} = 1.6 \times 10^{17} \text{W}$$

$$P_{\text{earth}} = \sigma_{SB} T_e^4 4\pi R_e^2 = 2 \times 10^{17} \text{W}$$

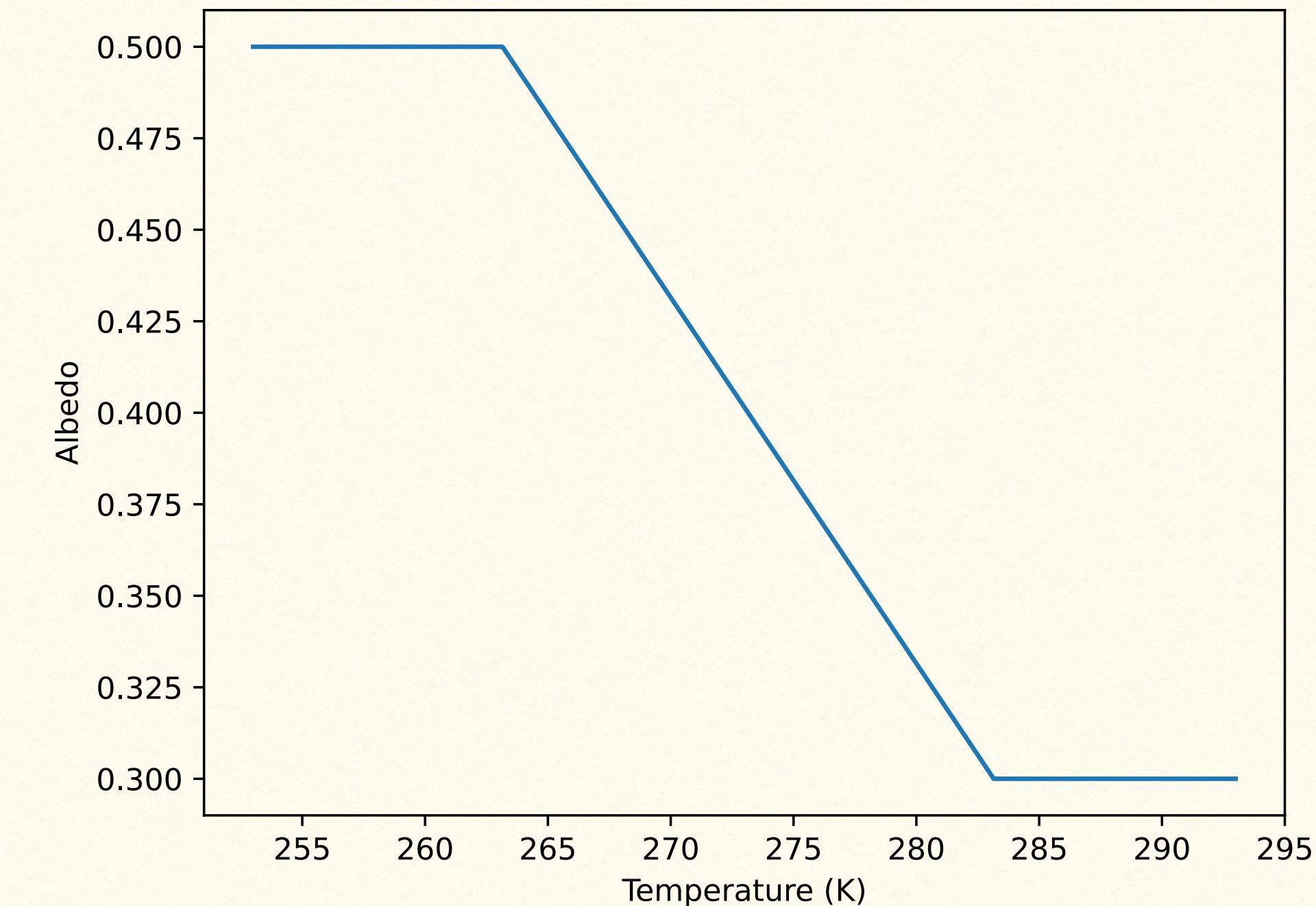
Current power usage of humanity:  $1.7 \times 10^{13} \text{W}$

# Albedo



Models:

- a) On average around 0.3 (30%) of the visible light incident on the Earth is reflected back out. (ex 1)
- b) Slow freezing of ice (ex 2)
- c) Abrupt freezing of ice (ex 3)



# Greenhouse effect

The Earth is emitting a huge amount of infrared radiation!

Some of that is blocked by the atmosphere and the heat is kept instead of radiating out to space.

Models:

a)  $P_{emit}/A = \epsilon\sigma_{SB}T_e^4$  (ex 1a,b)

b)  $\frac{P_{emit}}{A} = A + BT_e$  (ex 1c, 2, 3)

c)  $\frac{P_{emit}}{A} = A + BT_e + r \log\left(\frac{\rho}{\rho_0}\right)$  (ex 1d)

# Models

## Exercise 1:

- a) What if the Sun and Earth were complete blackbodies (it would be cold)
- b) Add in albedo and effect of greenhouse gases
- c) Modify greenhouse gases a bit
- d) Incorporate changing CO<sub>2</sub> through 'forcing'

## Exercise 2: Feedback loops

- a) Time dependence of the climate
- b) Effect of ice on albedo
- c) Hysteresis

## Exercise 3: Latitude dependence

- a) Latitude dependent insolation and albedo
- b) Latitude dependent temperature
- c) Heat diffusion through the latitudes

# Time dependence/equilibrium

$$C \frac{dT}{dt} = P_{in} - P_{out}$$

Discussion: what is equilibrium?

# Snowball earth

