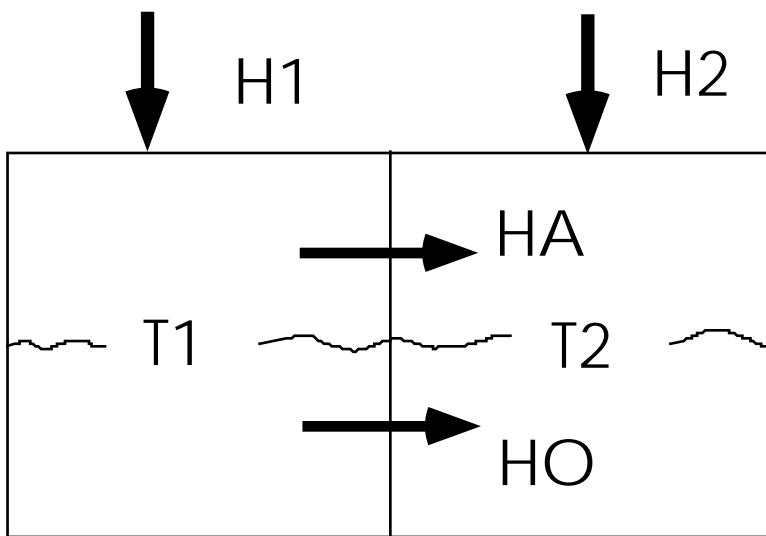


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Problem IV.1: Coupled Climate Model



Assume a simple coupled climate model (see figure) in which the climate state is characterised by two surface temperatures, T_1 at low latitudes and T_2 at high latitudes, both given in degrees Celsius. Radiation to and from space is

$$H_i = A_i - BT_i,$$

$i=1,2$; positive downward, where $A_1=90 \text{ Wm}^{-2}$, $A_2=-40 \text{ Wm}^{-2}$, and $B=2 \text{ Wm}^{-2}\text{K}^{-1}$. Energy is transported meridionally in both atmosphere and ocean, following the laws

$$\begin{aligned} H_A &= k_A(T_1 - T_2) \\ H_O &= k_O(T_1 - T_2) \end{aligned}$$

for atmosphere and ocean, respectively, with $k_A = k_O = 10^{14} \text{ WK}^{-1}$. Assume that low and high latitudes both cover an area of $1.25 \times 10^{14} \text{ m}^2$.

OVER

- a) Define the steady-state climate through energy balance for low and high latitudes. Calculate global mean temperature, the meridional temperature difference, and meridional energy transports in ocean, atmosphere, and the total climate system. [40%]
- b) Assume now that the climate system “loses” one meridional heat transport agent, for example, that the ocean transports no heat. What are the results now for global mean temperature, the meridional temperature difference, and meridional energy transport? Do the various quantities respond with differing sensitivities to the loss of ocean heat transport? If so, explain why the sensitivities differ. [20%]
- c) Given constant solar forcing (i.e., without changing A_1 and A_2), under what conditions does the climate system attain its maximum possible meridional energy transport? What would the consequences be now of losing one meridional transport agent? [20%]
- d) Based on the results from this simple climate model, explain why total meridional energy transports in complex climate models are similar under widely differing climates (i.e., temperature gradients). [20%]