Sheet 1

1 Water in the compartments of the environment

a) The diagram below shows water stocks in the different compartments of the environment and annual water fluxes between them. Calculate the residence time of water in the oceans, in groundwater, and in the atmospheric compartment.

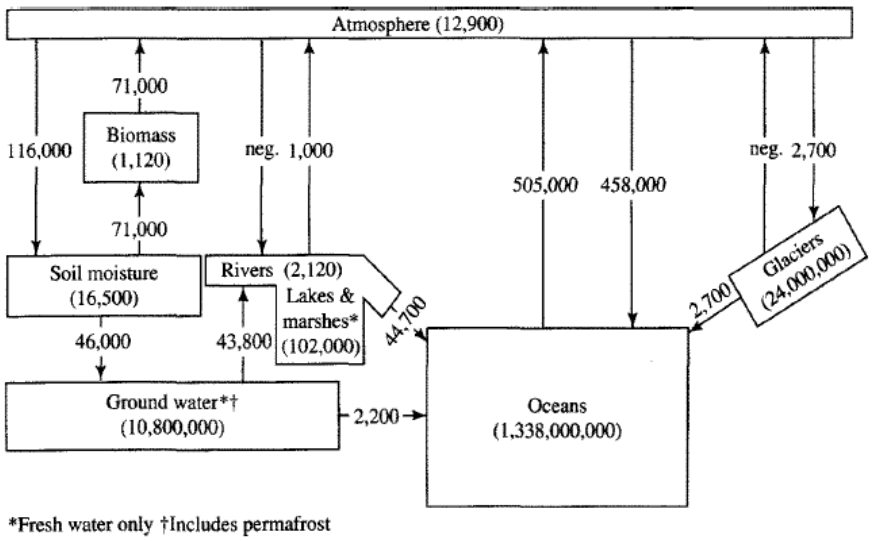

FIGURE 3-16
Schematic diagram of stocks (km^3) and annual fluxes ($km^3\ yr^{-1}$) in the global hydrologic cycle. Based on data of Shiklomanov and Sokolov (1983) (Table 3-1). Inflows and outflows may not balance for all compartments.

b) The ratio of evaporation to precipitation (E/P) is about 0.6 over land and 1.1 over the oceans. How do you explain this difference?

2 Water in the climate system

Water plays a major role in the climate system, due to its high heat capacity (c_p = 4182 J kg^{-1} K^{-1} at 20°C), heat of evaporation ($L_V = 2.45 \cdot 10^6$ J kg^{-1} at 20°C), and heat of fusion ($L_S = 3.34 \cdot 10^5$ J kg^{-1} at 0°C). The following examples shall demonstrate this.

a) Show that the global mean evaporation flux is about 1 m/a (use the numbers from the diagram in problem 1). What is the mean flux of latent heat from the Earth's surface into the atmosphere by evaporation?

b) According to Hansen et al., 2005, Science 308: 1431-35, Earth currently absorbs 0.85 W/m² more than it radiates back into space.

- Compare this energy absorption with the global annual energy consumption of mankind of about $4 \cdot 10^{20}$ J.
- Consider the uppermost 300 m of the oceans: What is the average warming of the water per year if it absorbs this power?

  Between 1955 and 1995, the uppermost 300 m of the oceans have been reported to warm by 0.3 °C (Gent et al., 2006, J. Clim. 19: 2366-81). Compare.

- Consider the glaciers: What percentage of glaciers would be lost per year if all the net power absorbed by Earth was transferred into melting, at zero degrees? Why is this number unreasonable?