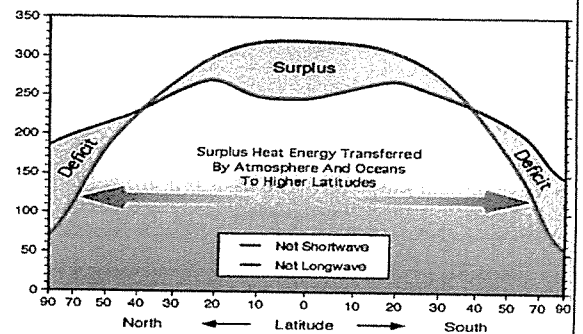


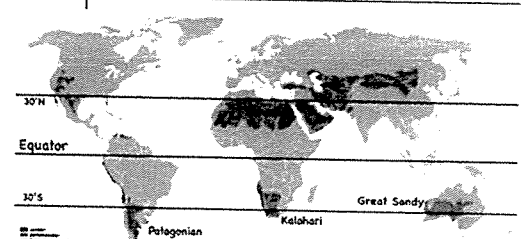
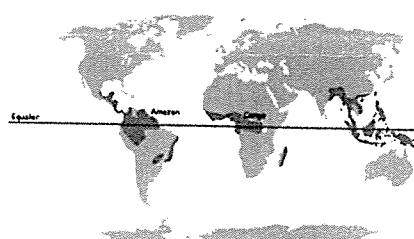
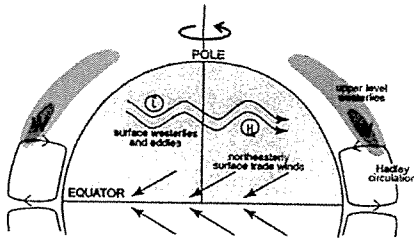
1. Jupiter's mean distance from the sun is  $7.8 \times 10^8$  km (or 5.2 Astronomical Units). Its (Bond) albedo is 0.34, and the solar luminosity is  $3.8 \times 10^{26}$  W, Stefan-Boltzmann constant is  $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ . [20 points] (a) What is the solar constant at Jupiter? (6%) (b) What would be the emission temperature of Jupiter if it were a perfect blackbody in equilibrium with the insolation? (7%) (c) The measured emission temperature of Jupiter is 125 K. How large is the additional energy flux that must be emanating from Jupiter's interior to lead to this emission temperature? [This energy flux is somewhat analogous to the (small) geothermal energy flux on Earth, but it is much larger and arises by different processes: It arises primarily because Jupiter is still contracting, and the gravitational energy that is released by the contraction emanates as an internal energy flux.] (7%)

2. The figure below illustrates the annual values of net shortwave (SW, in  $\text{W m}^{-2}$ ) and net longwave radiation (LW, in  $\text{W m}^{-2}$ ) from the South Pole to the North Pole. The corresponding global mean LW and SW are 234, 239, and the global mean cloud free LW and SW are 266 and 288. Solar constant is  $1367 \text{ W m}^{-2}$  [30 points]

- (a) Calculate the albedo values for the global mean and the global cloud free Earth. (10%)  
 (b) How do clouds affect net shortwave and net longwave radiation, respectively? (10%)  
 (c) Please list out three main atmospheric and oceanic processes that transport energy poleward and briefly describe how these processes transport energy poleward. (10%)



3. There are three figures in this question: [25 points]



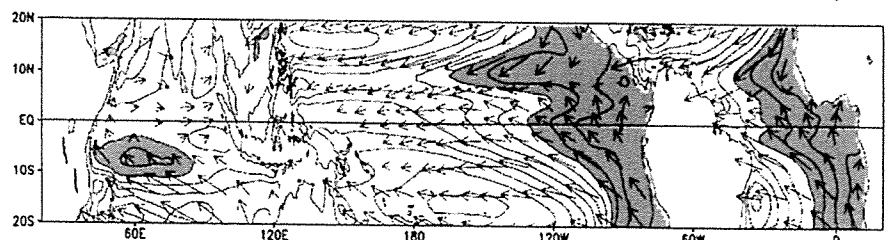
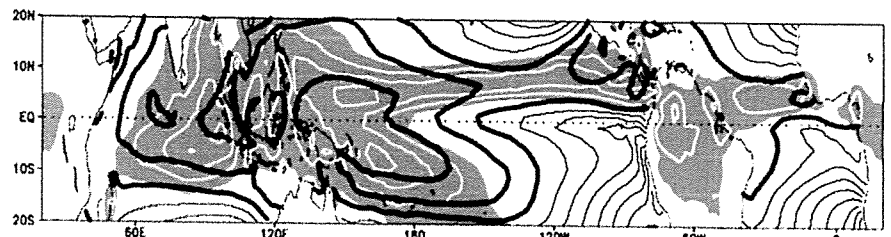
A schematic of general circulation of the atmos..

the locations of rainforests on earth.

the locations of deserts on earth.

- (a) Why are tropical trade winds easterly and midlatitude surface winds westerly? (8%)  
 (b) Why do most rainforests located in deep tropics and most deserts located in subtropics? (8%)  
 (c) Now suppose Earth's direction of rotation reversed, so that the Sun rises in the west and sets in the east, but the length of day is what it is today. Insolation and other factors, however, would be unchanged. Please describe how would the following rainforests and desert shift in this reversing rotating planet: 1. Congo Rainforest 2. Great Sandy Desert 3. Patagonian Desert (State your reasons briefly.) (9%)

4. The upper panel of the figure shows annual mean climatology of SST (black contours at  $1^\circ\text{C}$  intervals, contours of SST greater than  $27^\circ\text{C}$  thickened) and precipitation (white contours at  $2 \text{ mm day}^{-1}$ ; shaded  $> 4 \text{ mm day}^{-1}$ ). The lower panel shows annual mean climatology of surface wind stress vectors ( $\text{Nm}^{-2}$ ) and the  $20^\circ\text{C}$  isothermal depth (D20, contours at 20 m intervals, shaded  $< 100 \text{ m}$ ). [25 points].



- (a) write down the locations & values of warm SST in Western Pacific, cold SST in the north and south Pacific, (b) write down the values of D20 corresponding to the equatorial Pacific warm pool, cold tongue and cold SST near the eastern Pacific, and describe concisely

the causes of such distributions of SST and D20, (c) describe concisely the causes of the deep thermocline in north and south Pacific where  $\text{D20} > 200 \text{ m}$ .