Lecture Notes, Ocean Circulation, Part 1 (T.F. Pedersen)

Relevant text pages: 72-78 (Global hydrology)

Review: Important terms and observations

Latent heat of vapourization:

It takes 2260 kJ/kg to convert liquid H_2O to H_2O vapour at 100û C at sea level. It follows that condensation of vapour to liquid releases 2260 kJ/kg to the surrounding environment as **latent heat of condensation**. This is a major source of heat to the atmosphere.

Latent heat of fusion:

Converting ice to liquid H_2O requires 335 kJ/kg. Freezing water to form ice ***releases*** 335 kJ/kg.

Heat capacity of water:

It takes 419 kJ/kg to raise water at sea level from 0û to 100û C.

Conclusion: moving water about the planet in its various phases, and converting from one phase to another, has important consequences for the transfer of energy, for the patterns of surface temperatures and precipitation, and for the distribution of both heat and salinity in the oceans.

Saturation vapour pressure:

Where the rate of condensation equals the rate of evaporation, water vapour is in equilibrium with liquid H_2O. The vapour pressure of H_2O at this point (ie. the pressure that water vapour gas exerts, as a fraction of the total pressure of all gases in the atmosphere) is the saturation vapour pressure (SVP). At constant temperature, adding more water vapour (via evaporation) normally leads to increased condensation (clouds, rain). If the host air cools, condensation occurs and lowers the SVP, while if the air warms, the SVP rises and clouds may diminish or disappear (in a non-linear fashion -- see Figure 4-23 in the text).

Condensation is facilitated by microscopic particles in the air (**Cloud Condensation Nuclei**, or CCNs), which include tiny specks of dust, soot (black carbon), sulphate aerosols etc. Thus adding CCNs locally or regionally (from natural or human-made sources) can increase precipitation.

Most rainfall occurs as a result of **uplift**, either:

(a) via convecting air masses which rise because (i) air becomes positively buoyant (**self-**

assessing question: describe two ways in which air can become buoyant) and subsequently cools (**what is the average rate of cooling per km of altitude?**), lowering the SVP and rendering the air supersaturated; (ii) a less-dense air mass rides up over a denser one in a frontal zone (e.g. at the polar front -- see page 64, Fig. 4.9 in the text).; or

(b) via the **orographic effect** where increasing topographic elevation forces a moving air mass upward.

Distribution of Precipitation:

Heavy precipitation is seen over the oceans in the convective belt of the ITCZ and along the polar front zone in the mid-latitudes. On continents, precipitation is particularly pronounced on the windward sides of mountain ranges (e.g. the eastern slopes of the Andes are wetter than the western slopes; the southern slopes of the Himalaya are very wet during the summer monsoon, while the northern slopes are relatively dry).

Deserts occur generally under the descending (subsiding) arms of the Hadley Cells, in continental interiors far from sources of moisture, and occasionally along coastlines where cold water at the surface inhibits evaporation (eg, off Namibia, Peru and Baja California). Why does cold water exist at the surface in such low-latitude regions? This is an expression of both upwelling and the gyre circulation, both of which are described in the next section (Chapter 5 in the text).