ESCI 344 – Tropical Meteorology
Lesson 7 – Temperature, Clouds, and Rain

References: *Forecaster's Guide to Tropical Meteorology* (updated), Ramage
Tropical Climatology, McGregor and Nieuwolt
Climate and Weather in the Tropics, Riehl
General Circulation of the Tropical Atmosphere, Vol. II, Newell et al.

Reading: *Introduction to the Meteorology and Climate of the Tropics*, Chapter 3

TEMPERATURE

- **Horizontal temperature gradients are small in tropics, except near cold ocean currents and upwelling areas, or land-sea contrast regions.**
- **Cold fronts sometimes penetrate the tropics, but even then, the temperature contrast is usually negligible by the time they are at latitudes lower than 20.**
  - **The remnants of these cold fronts are referred to as *shear lines*.**
- **Mean surface air temperature over tropical oceans is near 82°F.**
- **Mean surface air temperature over tropical continents can be over 90°F.**
- **Over the ocean, mean air temperature is controlled mainly by the sea-surface temperature (SST).**
- **Air temperature and SST are usually within a few degrees of each other, except off of east coasts of continents during winter.**
- **Seasonal variation is small (usually less than 10°F) over open ocean, and practically disappears as Equator is approached.**
  - **Continental areas have larger seasonal range of temperature.**
- **Shape of seasonal temperature curve varies**
  - **More sinusoidal in higher latitude tropics with extremes in January and July.**
  - **Lower latitudes less sine shaped.**
    - **Lower latitudes can have a double maximum, due to clouds associated with rainy season which suppress surface heating.**
    - **Highest temps in low latitudes often occur right before rainy season**
- **Diurnal variation influenced by proximity to ocean, prevailing flow, and humidity.**
- **Typical diurnal temperature variations are**
  - **< 10°F – Small islands and coastal stations with onshore flow**

- **10 to 20°F – Coastal stations affected by land-sea breeze, or inland stations during rainy season.**
- **> 20°F – Inland stations during dry season**

TEMPERATURE PROFILE

- **The tropopause is much higher, and has a much colder temperature, than in the mid-latitudes.**
- **The table below gives values for the tropopause from the Standard Atmosphere for 15 and 30 N latitudes, as well as for the mid-latitudes.**

	30N – Jan.	30N – July	15N - Annual	Mid-latitude
Pressure	**200 mb**	**130 mb**	**100 mb**	**225 mb**
Temperature	**–57°C**	**–70°C**	**–80°C**	**–57°C**

VERTICAL MOTION

- **Averaged vertical motion at 500 mb is well correlated with averaged precipitation, and with averaged precipitation minus averaged evaporation.**
- **Vertical motion not as well correlated with clouds, since many low-level clouds can be formed without significant vertical motion.**

CLOUDS

- **Clouds and precipitation are highly correlated over most of tropics, except in eastern parts of oceanic anticyclones where stratus and stratocumulus prevail.**
- **Clouds are enhanced to windward of large islands and land masses, and depleted to leeward.**
- **Tropical cumulus are often subdivided into**
  - ***Doldrum* cumulus – Form in regions of light wind with little vertical shear**
    - **Stand straight up.**
    - **Bases are slightly wider than tops.**
    - **Cloud base is around 1,500 ft (a few hundred feet or more lower in showers), with tops from 6,000 to 12,000.**

- ***Trade-wind*** **cumulus – Form in trades, with bases near wind speed max.**
  - **Clouds tilt upstream**
  - **Bases around 2,000 ft.**
  - **Mean cloud top height is near 7,400 ft., but distribution is skewed left, so the modal cloud-top height is closer to 4,000 ft.**

- **Cumulonimbus**
  - **Over open ocean, cumulonimbus are almost always associated with synoptic or mesoscale disturbances.**
  - **Much more common over land.**
  - **Over ocean, tops are usually 30-40,000ft., but in tropical cyclones can be 50-60,000 ft.**
  - **Tops higher over land.**
  - **Anvil blow off can extend hundreds of miles.**
- **Stratus and stratocumulus**
  - **Stratus and stratocumulus are common in the eastern portions of ocean basins, and east of the subtropical highs.**
  - **Stratus is more common in coastal regions, with stratocumulus more common over open ocean areas.**
  - **Stratus and stratocumulus often transition back and forth between types.**
  - **A common diurnal cycle in mountain valleys is radiation fog in the morning, transitioning to stratus and then breaking into stratocumulus before dissipating.**
- **Altostratus and altocumulus**
  - **In tropics, these are usually associated with disturbances such as upper-level cyclones or tropical cyclones.**
- **Cirriform clouds**
  - **Form independently, or from Cb anvil blow off.**
  - **Thin cirrus common in tropics**
  - **Cirrostratus is often associated with upper-level disturbances.**
  - **Cirrostratus also common on south side of subtropical jet.**
  - **Cirrocumulus forms much less frequently than cirrus or cirrostratus.**
  - **Cirriform clouds form at much greater height in tropics than in midlatitudes.**

DIURNAL CYCLES OF CLOUDINESS AND PRECIPITATION

- **Open ocean**
  - **Maximum in rainfall and cloudiness occurs during late night and early morning hours.**
  - **Possible causes are:**
    - **At night time, the longwave cooling at the cloud tops destabilizes the air column and results in more buoyancy within the clouds.**
    - **At night time, the longwave cooling of air outside of convective clouds is greater than inside the clouds, resulting in more buoyancy within the clouds.**
    - **Increased difference in sea-surface temperature and air temperature (water usually slightly warmer than air at night), resulting in enhanced evaporation at night and early morning).**
    - **Convergence/divergence pattern associated with atmospheric tides (this effect is extremely small, and probably of secondary importance).**
  - **Numerical simulations[1] point to the first of these as being the most likely explanation.**
- **Over land**
  - **In coastal areas and in island regions, cloudiness and rainfall variations dominated by land-sea breezes.**
  - **Mountain-valley breezes important if mountains are present.**
  - **Regions near large lakes are influenced by land-lake breezes.**
  - **In general**
    - **Small islands have a late-night and early-morning rainfall maximum, similar to that over the open ocean, and for the same reasons.**
    - **Large islands have an afternoon maximum due to daytime heating, land-sea breezes, and mountain-valley breezes.**
  - **In some areas, tropical glaciers are more extensive on the western slope of tall mountains than on the eastern slope. This is because the eastern slope**

[1] Kubota, Numaguti, and Emori, 2004: 'Numerical Experiments Examining the Mechanism of Diurnal Variation of Tropical Convection,' *J. Met. Soc. of Japan*, **82**, 1245-1260

receives abundant, relatively cloud-free morning sunshine. In afternoon, when sun would be shining on the western slope, the valley breeze and elevated heating have caused cloud build ups which shield the slope from the sun.