

## Other large-scale circulation patterns

We shall close with a discussion of the surface pressure distribution and a word on monsoon, desert, and global cloud distribution.

At midlatitude in winter, surface pressure tends to be lower over the ocean, higher over land, while in summer, the subtropical highs are strongest over the ocean. This is because of the different thermal capacity for storing heat over land versus over the ocean. This causes the ocean to be warmer in the winter and cooler in the summer. From the relation between thickness and temperature and the fact that 500mb heights are more zonally symmetric, we can explain the surface pressure differences.

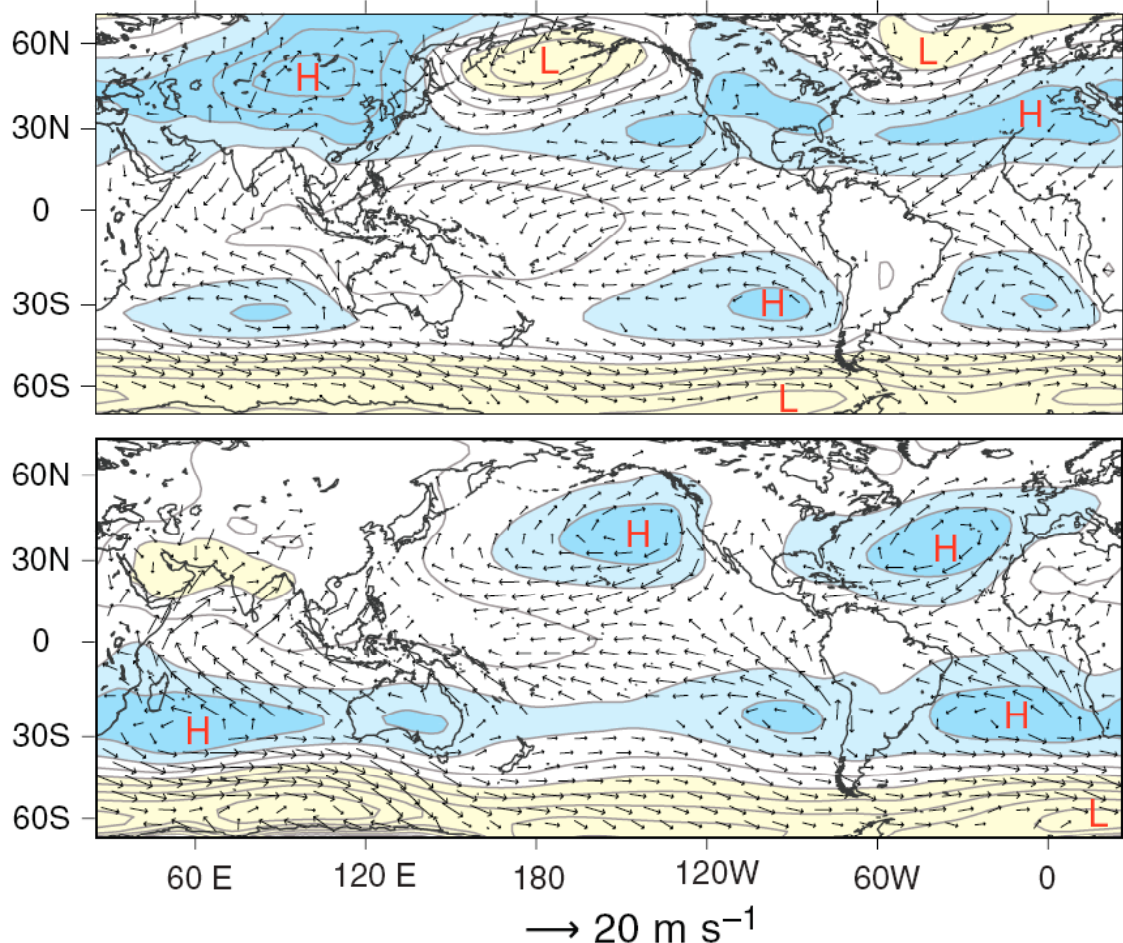
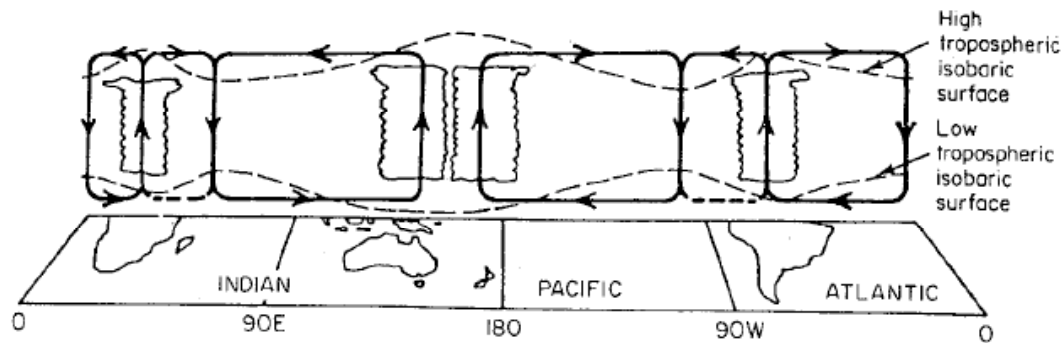


Fig. Surface pressure and winds in January (top) and July (bottom)

In the tropics, things are not zonally symmetric either. The circulation in the Pacific is known as the Walker circulation. The circulation gets weakened every 3-7 years due to some coupled processes of the tropical atmosphere/ocean system and is known as El Nino.



**Fig. 6.22** Schematic view of the east-west Walker circulation along the equator indicating low-level convergence in regions of convection where mean upward motion occurs. [From Webster (1983).]

In some regions of the tropics the winds below consistently in one direction during part of the year and then may weaken or blow from a very different direction for the rest of the year. These are called monsoons. The most important example is the Asian monsoon. During the summer the Tibetan plateau is heated by insolation. Because of the low heat capacity of land and its high elevation, the air above it becomes warmer than the surroundings at the same pressure. This drives a circulation that draws warm, moist air from the ocean to the land, which supports intense precipitation over India and the slopes of the Himalayas during summer. (Note that the surface winds flow northwestward in the southern hemisphere and northeastward in the northern hemisphere. Why?) During the winter, things are reversed, and the region experiences a wintertime drought. These are of great importance to the population there.

Below is the distribution of the world's deserts. Deserts can occur for a number of reasons. They can occur on the downwind side of mountain ranges. Examples are the North American Desert, the Monte and Patagonian Deserts. The coastal deserts of Peru and Chile are related to this as well, although they are also in the region of broad subtropical subsidence and affected by the cold ocean nearby. Deserts also form in regions blocked from moisture, such as the Gobi desert. The Sahara and Arabian Deserts are located in the subtropics and are also affected by its large landmass. So is the Australian Desert.

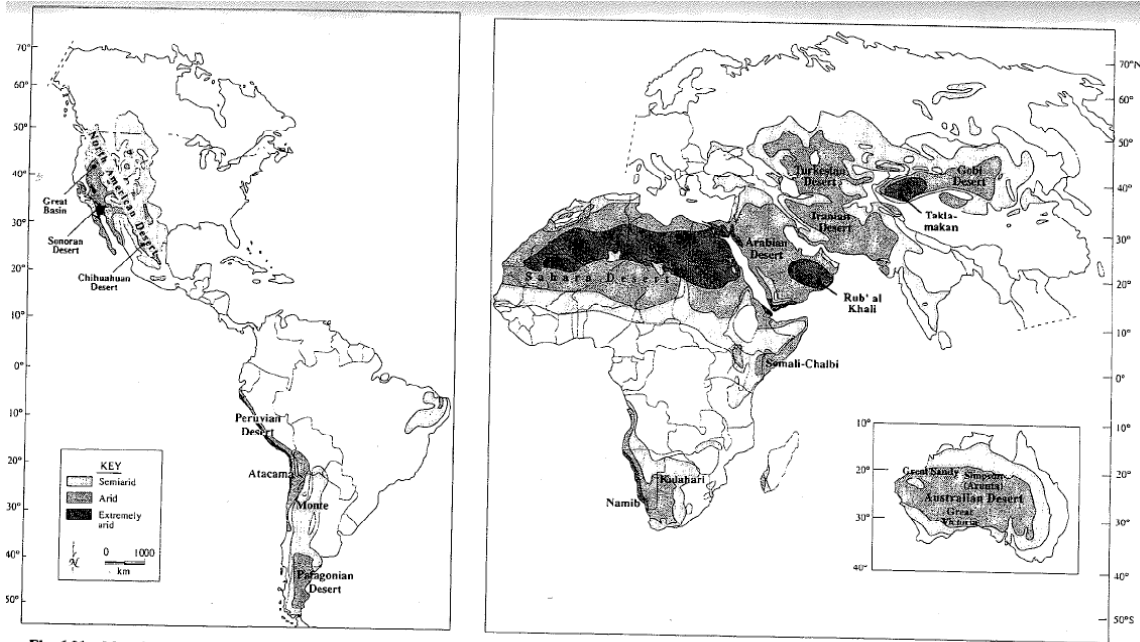
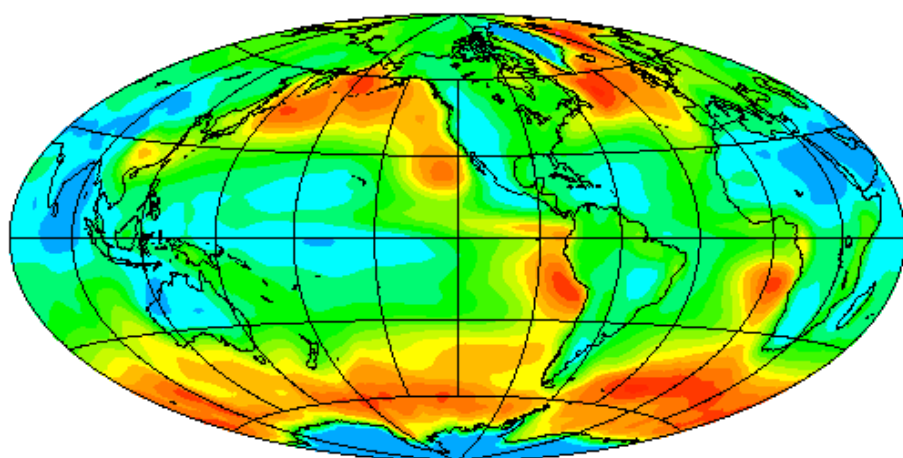


Fig. 6.21 Map showing arid lands around the world. Meigs classification taken from *Mosaic* magazine (Vol. 8, Jan/Feb 1977). [See McGinnies *et al.*, eds., (1968). Permission granted by the Office of Arid Lands Studies.]

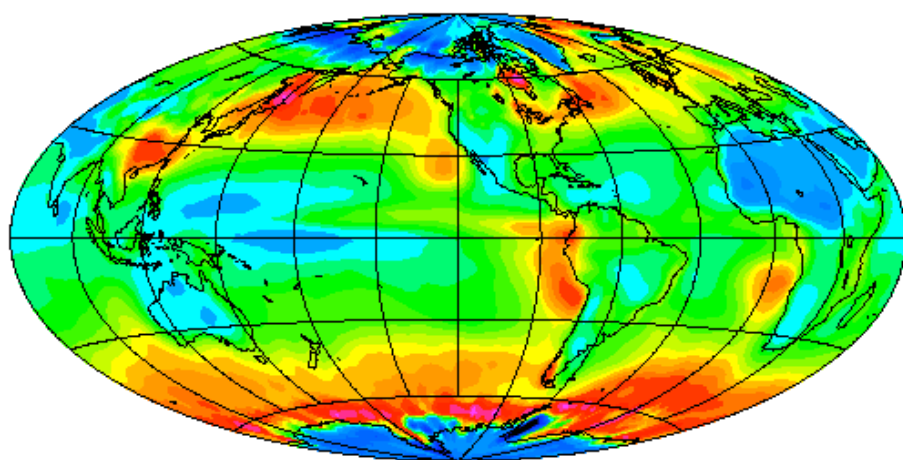
Now we talk briefly about the global cloud distribution. Over the warm tropics, we have deep convective clouds, e.g in the ITCZ. This is not entirely surprising because conditions there are most favorable to deep convection. The shallow boundary clouds seen below need a little more discussion, particularly because of their important radiative impact. On the east side of the subtropical ocean, there are abundant stratocumulus clouds. These are associated with the cooler ocean surface and the subsidence in the bulk of the troposphere. These factors keep the clouds low (less than 2km above the surface). As air flows towards the tropics from the subtropics, convection deepens and the clouds transition into trade cumulus (or fair weather cumulus).

Annual ISCCP C2 Inferred Stratus Cloud Amount



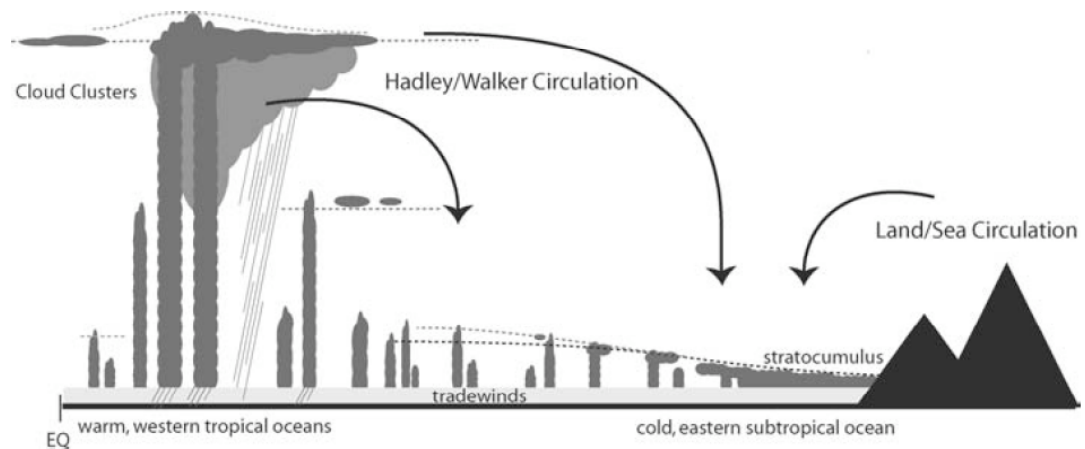
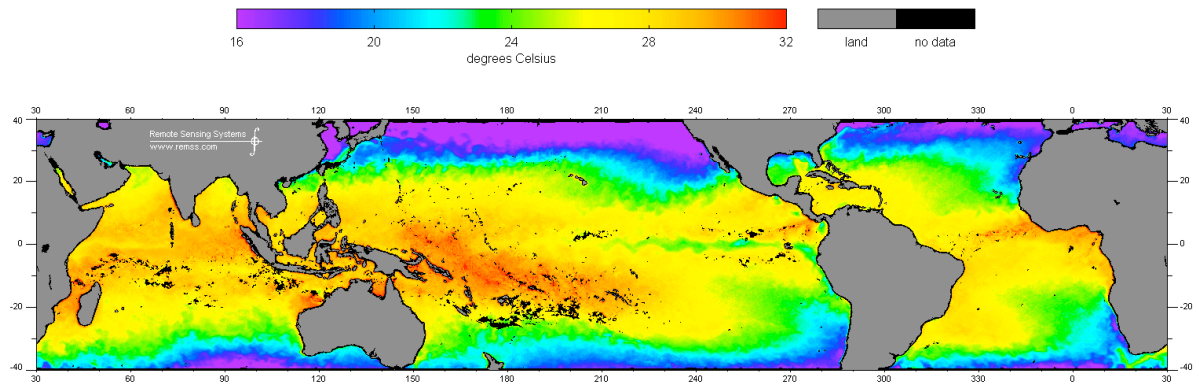
Percent

Annual ERBE Net Radiative Cloud Forcing



$W/m^2$

TMI Sea Surface Temperature, 3-days ending: March 08, 2007



**Figure 1** Cloud regimes in thermally direct circulations. Adapted from Arakawa (1975).



Low Clouds (bases <2 km above ground)

## STRATOCUMULUS ( $S_c$ )





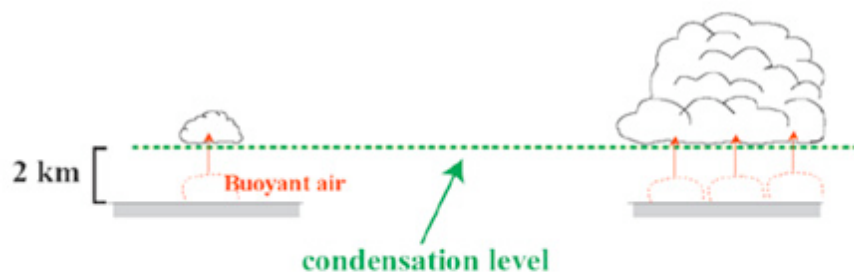


Low Clouds (bases <2 km above ground)

### CUMULUS (Cu)

"Fair weather  
cumulus"

"Towering Cu or  
cumulus congestus"



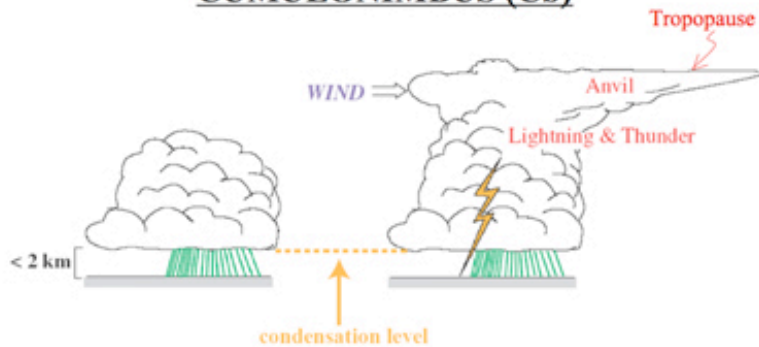
Buoyant parcels of air rise above condensation level





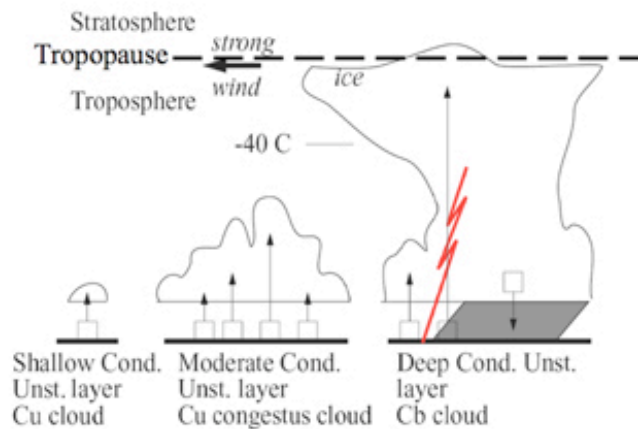
Low Clouds (bases <2 km above ground)

### CUMULONIMBUS (Cb)



*Nimbus* means precipitating--particles have grown large enough to fall below cloud base

### **Cu & Cb clouds in relation to conditional instability**



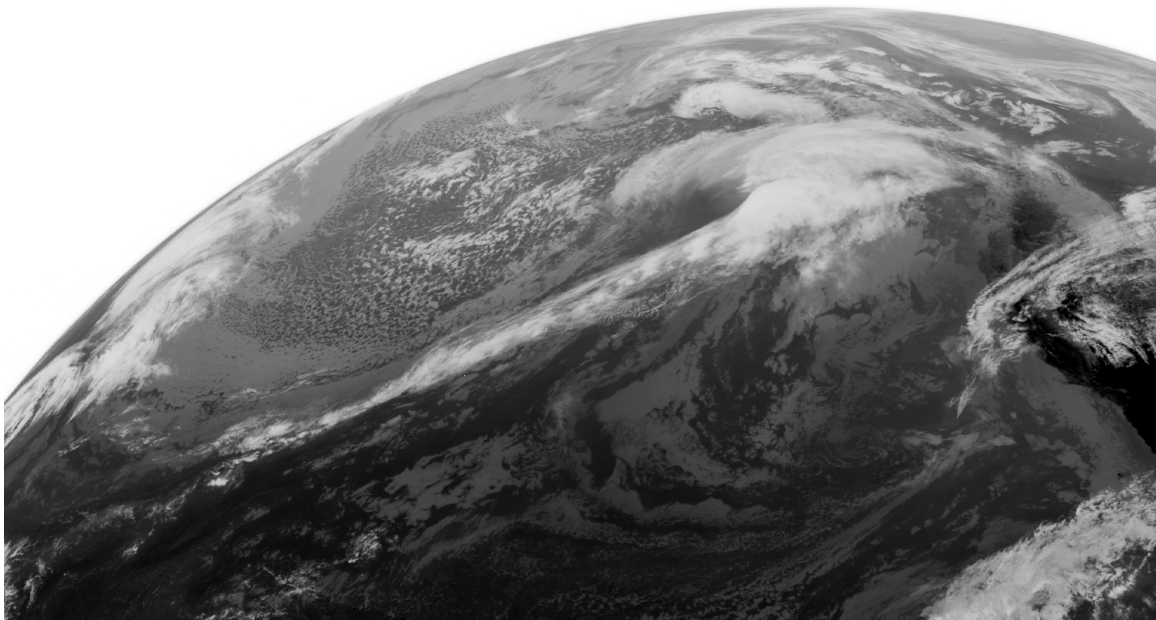
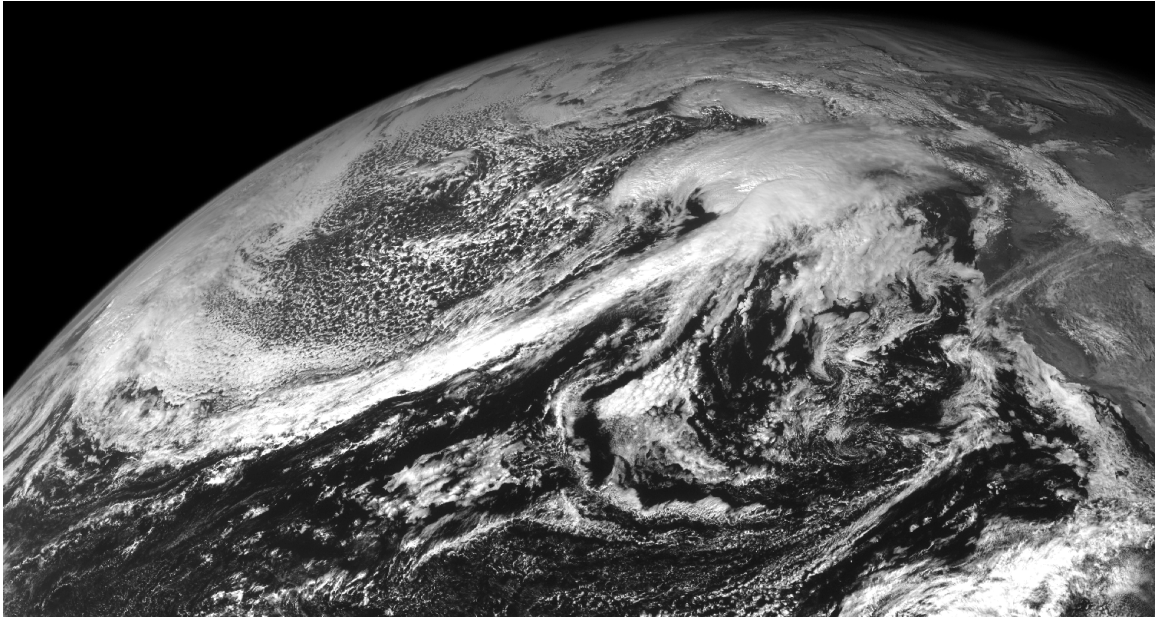
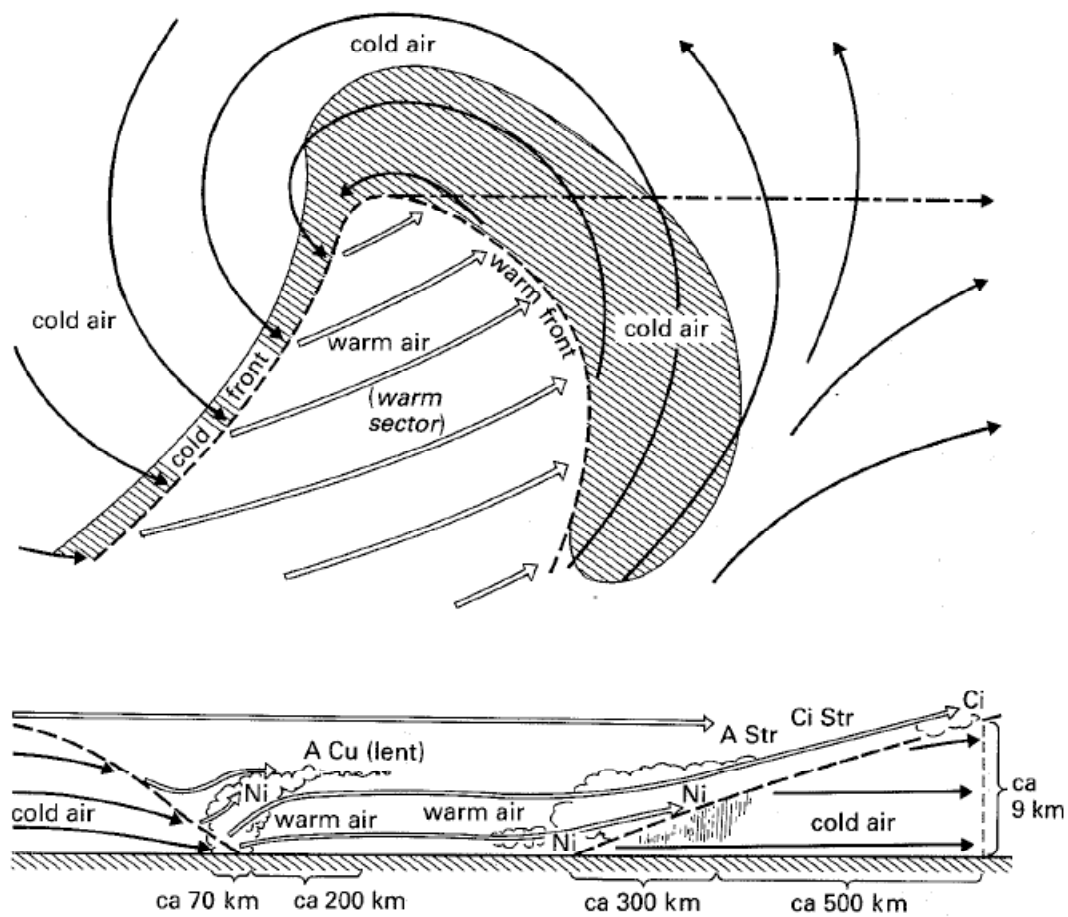
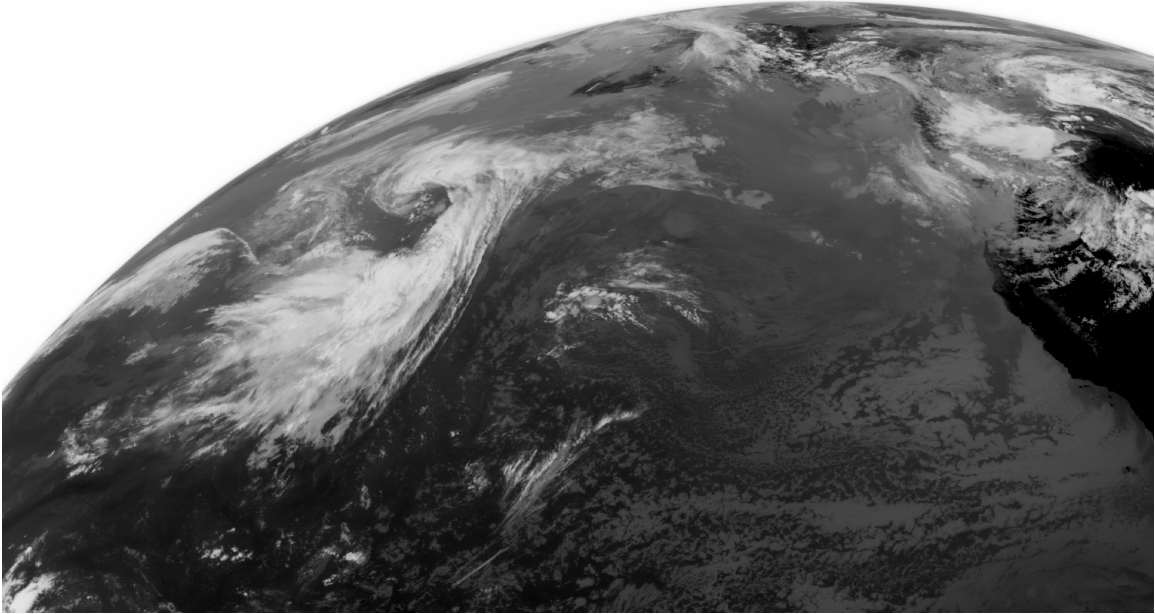
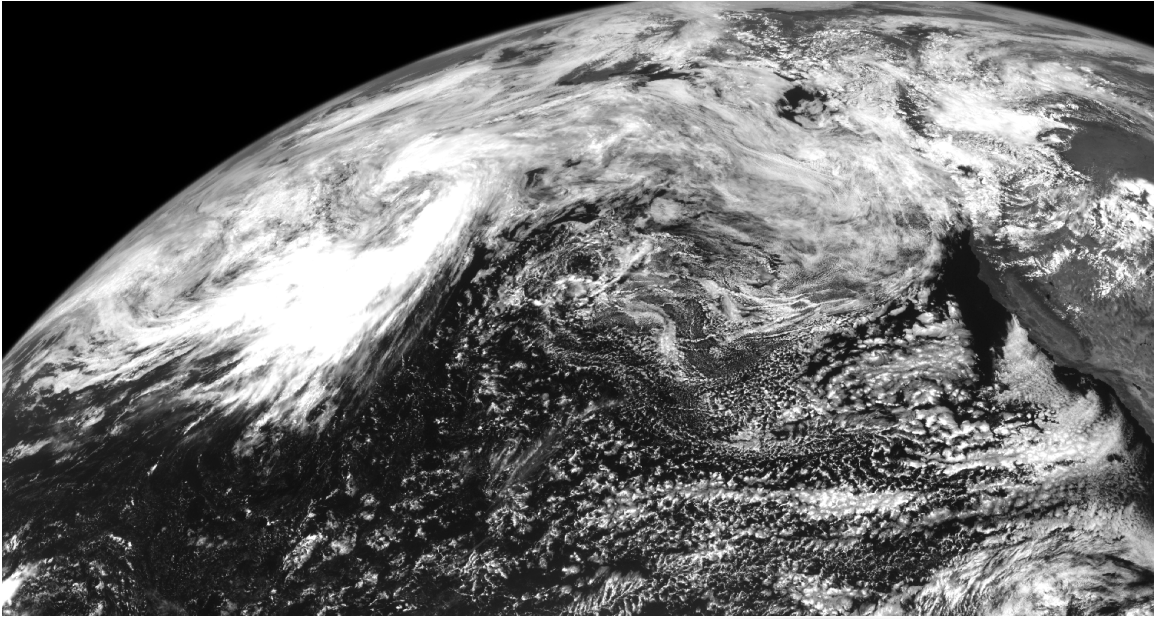


Figure Visible (upper) and infrared (lower) images taken by the GEOS-10 geostationary meteorological satellite on November 2, 2001. North American continent is at the east part of the images.



**Figure 10.1** Idealized cyclone. (From Bjerkens and Solberg, 1926.)



The same as above but for July 17 2001.