Non-convective stratiform clouds

- Large-scale ascent under conditions of potential stability can drive the formation of cloud layers by slow cooling.
- Weak forced ascent (~10 cm s^{-1}) over a deep tropospheric layer and several hours can lead to thick cloud layers, e.g. warm conveyor belts
- As warm front approaches, clouds develop from thin high clouds (cirrus, cirrostratus) to thicker mid-level clouds (altostratus), and finally developing into thick rain-bearing clouds (nimbostratus) as the warm front nears. All these types typically have cloud tops that are well below freezing. Indeed much of the cloud layer can exist below freezing.
- Ice nucleation likely takes place by homogeneous freezing of haze particles near cloud top (T < 235 K, -38°C)
- Aggregation of ice crystals as they fall slowly through the cloud layer can produce large, irregular ice crystals that eventually can fall through the freezing level (~0°C) and melt to form rain drops. Much of the rain produced in midlatitude cyclones is produced this way.

The idealized cyclone structure from Bjerknes and Solberg (1926) as reproduced in Carlson (1998)

The cross-sections above and below the plan view are E-W cross-sections through the cyclone center (top) and through the cold-warm-cold sector to the south of the cyclone center (bottom)

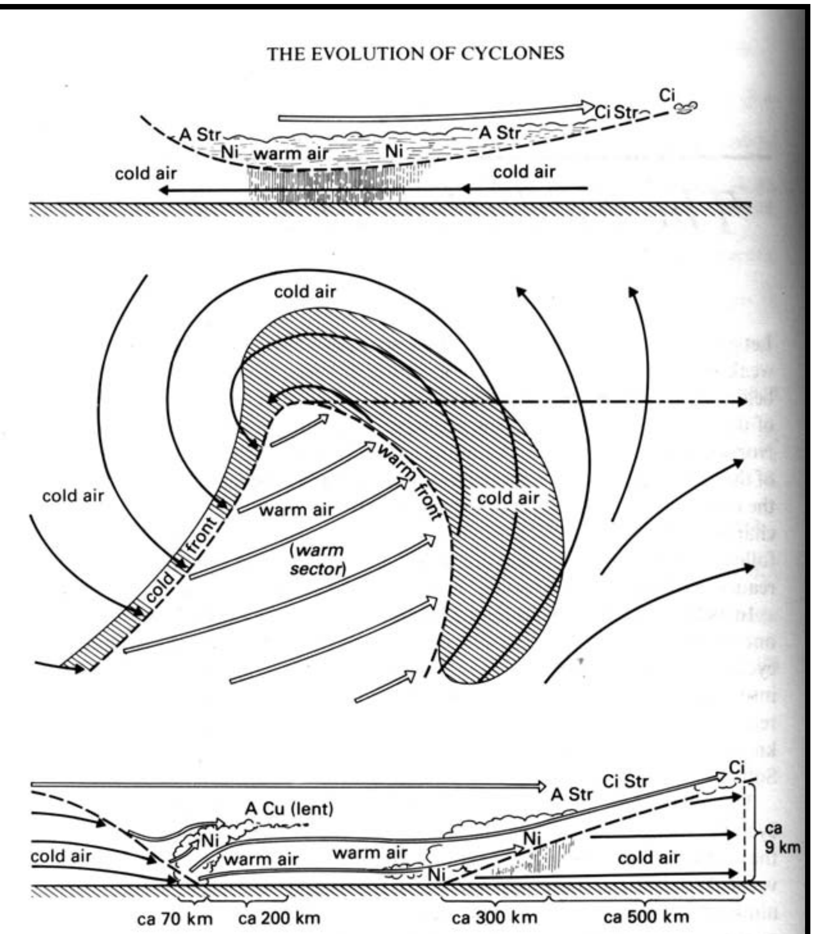
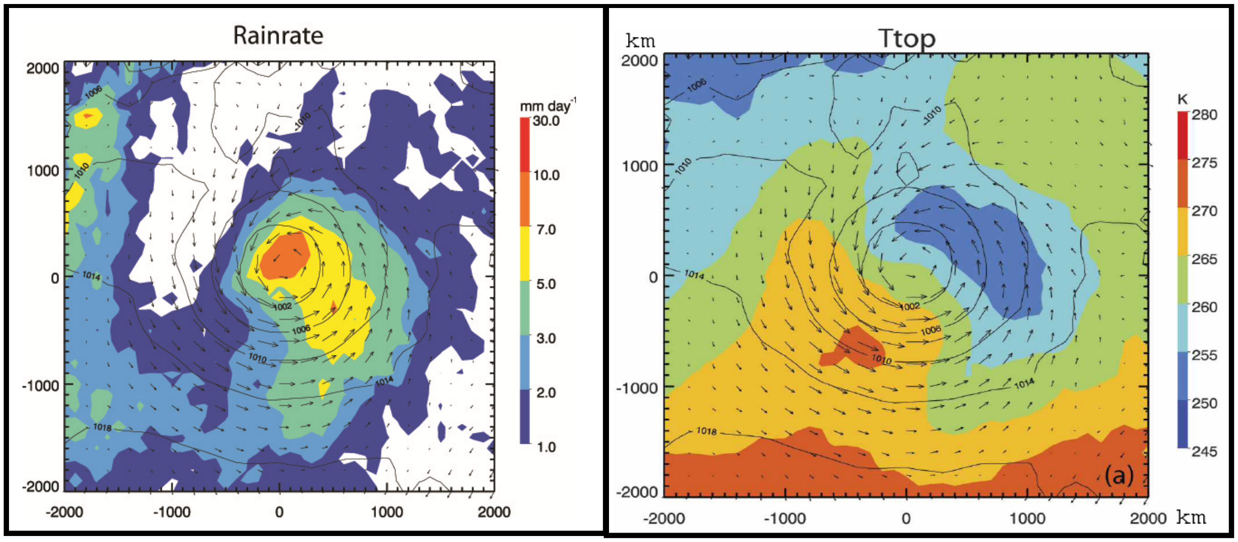
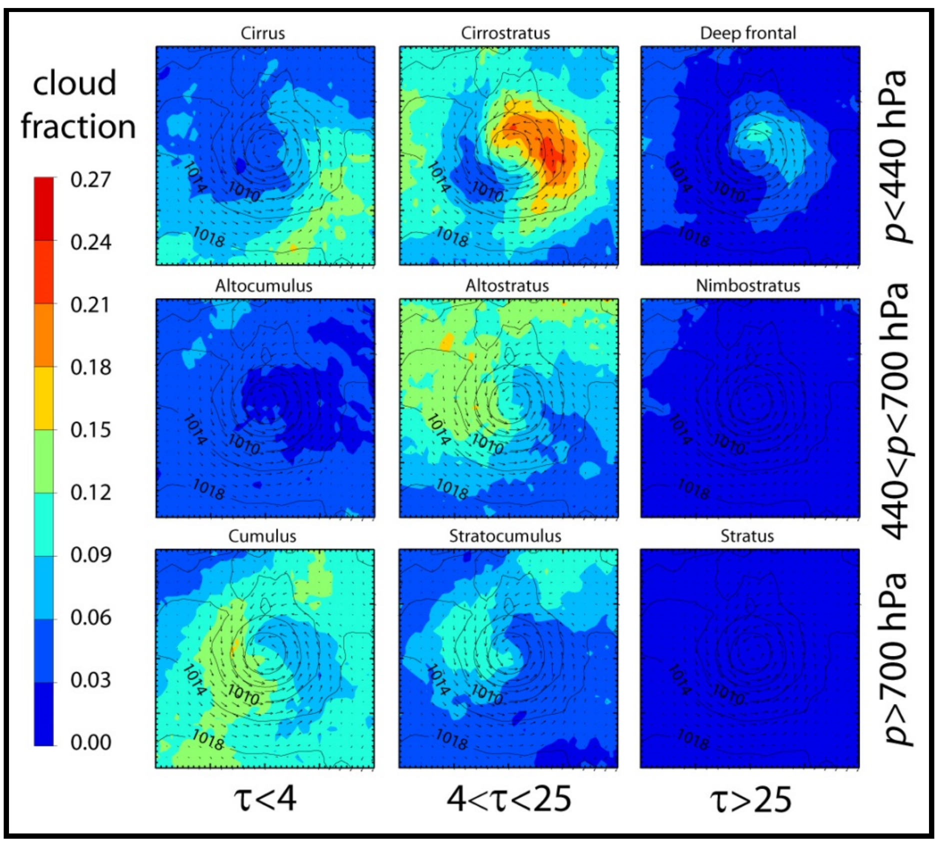


Figure 10.1 Idealized cyclone. (From Bjerkens and Solberg, 1926.)



Above: Cyclone-centric composites of mean rainrate (left) and cloud top temperature (right) from satellite sensors. Cloud top temperatures are coldest to the right of the cyclone center where the warm conveyor belt has driven large-scale ascent over a deep tropospheric layer. Note that, although the composite mean cloud top temperature in this region does not fall below the temperature required for homogeneous freezing, the composite mean encompasses a great deal of variability and many of the clouds sampled are indeed colder than -38°C . Reproduced from Wood and Field (J. Clim., 2007).

Below: Cyclone-centric composites of the frequency with which ISCCP-based cloud types (based on cloud optical depth [horizontal] and cloud top pressure [vertical]) are detected.



Examples of quasi-Lagrangian ice crystal evolution from the top to the bottom of an altostratus cloud observed over the North Sea. The distance between the top and bottom rails of each strip is 800 micrometers. Reproduced from Field (J. Atmos. Sci., 1999).