Frontogenesis

B. Geerts and E. Linacre 1/'02

What is frontogenesis?

Frontogenesis is the generation or intensification of a front. It occurs when warm air converges onto colder air, and the horizontal temperature gradient amplifies by at least an order of magnitude. Whenever a region experiences horizontal convergence (and therefore uplift), any pre-existing gradient will increase. A prerequisite for frontogenesis is that the atmosphere is *baroclinic*, i.e. that temperature advection occurs (Note 12.H).

In the atmosphere this convergence and uplift tends to be focused along narrow lines, which then become fronts. Sometimes other boundaries form, separating areas with distinctly different dewpoints, for instance, but such boundaries are not referred to as fronts, because dynamically they don't behave like a front. A temperature difference is essential in the definition of a front because it implies a density difference.

A good example of a non-frontal boundary is the *dryline*, which is often present as a meridional line through western Texas in spring and summer. It separates dry air to the west from humid air to the east. A similar boundary sometimes occurs in northern Argentina.

Frontogenesis is possible, in theory, without convergence and uplift. It is possible that the streamlines of air come together (confluence) without uplift. Or differential heating (from the ground up) in calm air can produce a temperature gradient, i.e. is frontogenetic. But in practice fronts correspond to lines of convergent flow, and uplift.

There are two types of fronts: mesoscale ones and synoptic-scale ones. The latter are most widely known, and they are the ones that are shown on surface weather charts.

Mesoscale fronts

Mesoscale fronts are entirely contained within the PBL, and they are always of the cold-frontal type. Mesoscale cold fronts will develop whenever a temperature gradient develops in the PBL, and the atmosphere aloft is rather undisturbed. The cold air will move towards the warm air and displace it, so a mesoscale front is self-destructive and short-lived. Dynamically, a mesoscale front behaves like a density current (Section 14.D). Examples include a sea breeze, a lake breeze, katabatic flow (Section 14.3), and thunderstorm outflow. The weather station network is too coarse to see mesoscale fronts, and only recently has their widespread presence been revealed by detailed satellite and radar imagery. These fronts are important, especially in summer, as they may control the development and orientation of thunderstorms.

Synoptic-scale fronts

The various types of synoptic-scale fronts are described Section 13.3. Synoptic-scale fronts may exist for many days, while mesoscale fronts only last a few hours (say 1-12 hours). They are also deeper, and their presence is associated with a jet stream aloft. The typical lifecycle of a frontal disturbance is described in Note 13.B.

The boundary between mesoscale and synoptic scale isn't always clear. For instance, a shallow quasi-stationary front sometimes develops in winter along the East Coast of N. America, especially around the Carolinas. This front, known as the *coastal front*, separates offshore air warmed by the Gulf Stream from much colder onshore air. The latter is sometimes trapped between the coastal front and the Appalachian Mountains (a situation known as *cold-air damming*). The coastal front may exist for several days. It may move a little offshore as a cold front, or retrograde onshore as a warm front. It may become deeper, and a wave disturbance can develop along the boundary: a deep frontal disturbance results, this time triggered by a surface baroclinicity, not a short wave aloft.

A somewhat different situation of meso-synoptic-scale interaction obtains south of Australia, where in summer the long south coast separates a cold ocean from a warm continent. Sometimes there is a high over southeastern Australia, and a low to the southwest (2). Hot, dry air may drive the maxima over 40�C in Adelaide. This warm advection is responsible for the *pre-frontal trough* that sometimes occurs ahead of the cold front that is associated with the southern low (1). As this low moves westward with the jet stream, the cold front associated with it experiences frontogenesis near the coast. The temperature in Adelaide may drop 20K as the cold front passes, and the disturbance may continue as a *southerly change* towards Melbourne and Sydney (Section 13.3). This southerly change continues to propagate along the Southeast Coast as a shallow current, independent of the frontal low, and often without upper-level forcing.

Reference

(1) Hanstrum, B.N., K.J. Wilson and S.L. Barrell 1990. Prefrontal troughs over southern Australia. *Weather and Forecasting,* **5**, 22-31.