Wave Cyclones--The Development of Frontal Systems

We have spent time learning to identify frontal systems on weather maps, and to understand the weather associated with various frontal systems, but we have not yet explored the question of how these systems arise. We know that as cold polar and arctic air moves southward, it must at some point encounter warm, moist air from the tropics. The boundary between these two types of air is a front, and if neither air mass is advancing, we would obtain a stationary front as depicted in the diagram below:

![Stationary Front](image)

Image courtesy University of Illinois

If the frontal boundary is disturbed, a wave forms in the boundary. This causes the warm air to begin circulating to the north, and the cooler air to circulate south to replace the warmer air.

![Wave Cyclone](image)

Image courtesy University of Illinois

There is a pocket of warm air in the middle of the frontal boundary; because less dense warm air has replaced more dense cool air in this pocket, this region becomes the developing low pressure center of the system. Winds begin to circulate counterclockwise around this low. As the low becomes more intense (we often say 'as the low deepens'), a mature weather system can form:
This image depicts the formation of a fully developed wave cyclone. A wave cyclone consists of the central low pressure with warm and cold fronts extending outward from the low. If you believe you have identified wave cyclones on your homework weather maps, it is important to have the warm and cold fronts extending outward from the low pressure center.

As you can see, winds are circulating counterclockwise around the low, so that the winds ahead of the warm front are from the east to southeast, winds in the warm sector are from the southwest, and winds behind the cold front are from the northwest. Cold fronts generally travel faster than warm fronts, so as the system evolves, the area contained in the warm sector decreases. Eventually, a portion of the cold front catches up with a portion of the warm front, producing an occluded front as shown here:
We can see how the occluded front develops by looking at a cross section of wave cyclone:

The image shows a cross sectional view of a wave cyclone before the occlusion occurs. The cold front toward the left separates a cold mass of air from the warm air in the warm sector. The warm front toward the right of this slide shows how the warm air is overrunning the cool air wedge. As the cold front advances more rapidly than the warm front, the cold front can eventually overrun the warm front. When this occurs, the less
dense warm air is forced to rise by the converging denser cold/cool air masses. Not surprisingly, occluded fronts are associated with low temperatures and cloudy and stormy weather.