tional forecasting purposes (Bader *et al*., 1995) have refined the model in Figure 3. They have concentrated on defining the moist flows in terms of so-called conveyor-belt flows. Figure 4 shows the cloud-head flow in Figure 3 to be made up partially of a cold-conveyor-belt (CCB) flow originating ahead of the surface warm front. This is overridden by a flow originating from the warm sector, referred to as a secondary warm conveyor belt (W2). It is the latter, high θ_w, flow that is itself overrun by the low θ_w dry intrusion to produce the potential instability responsible for the convective events as discussed in section 4.

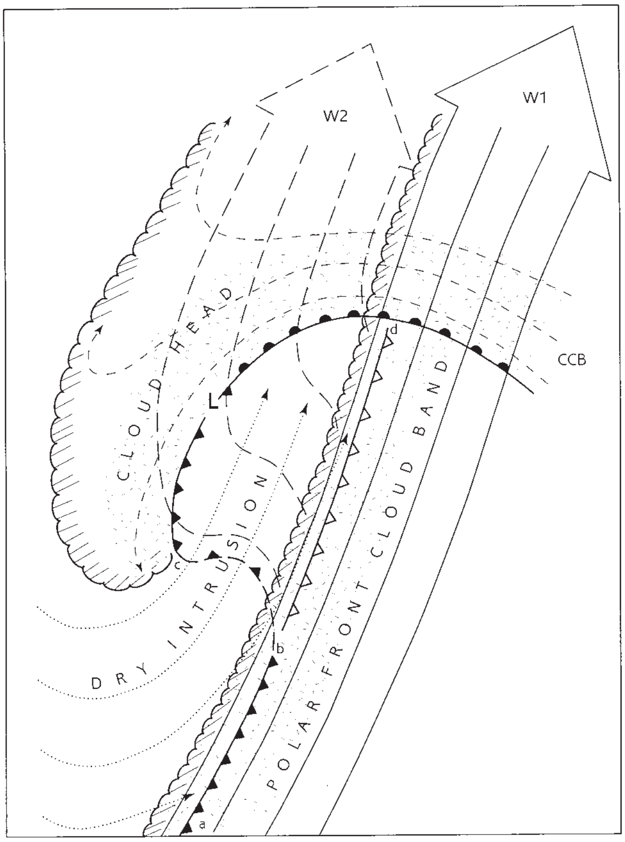

Figure 4. *Structure of a developing extratropical cyclone (confluent-flow type). The cyclone centre (L) is travelling towards the top right. The surface warm front is shown conventionally. Part of the bent-back front (cd) is plotted as a cold front with closely spaced frontal symbols. The main surface cold front (ab) is shown similarly. In between the two sharp surface cold fronts (bc) there is a diffuse surface cold front drawn dashed with widely spaced frontal symbols. The cold front drawn with open symbols (bd) is an upper cold θ_w-front (UCF) marking the edge of the dry intrusion. Principal airflows, drawn relative to the system, are: the main warm conveyor belt (W1) (solid lines), the secondary warm conveyor belt (W2) (long-dash lines), the cold conveyor belt (CCB) (short-dash lines) and the dry intrusion (dotted lines). The cold-air sides of the main cloud features are drawn scalloped and hatched: the polar-front cloud band is due to W1, and the cloud head is due to the combined effect of W2 and the CCB. Precipitation (stippled areas) reaches the surface along the left side of W1, near the cold fronts, and above the warm frontal zone; precipitation also falls from the inner parts of the cloud head starting at the bent-back front. The two main areas of precipitation are separated by a dry slot where the shallow W2 flow (shallow moist zone) is capped by the dry intrusion. The dry slot is usually characterised by partial shallow cloudiness.*

Also shown in Figure 4 is a major flow of high θ_w air labelled W1. This is the primary warm conveyor belt (WCB) responsible for the polar-front cloud band which for simplicity was omitted from Figure 3. This flow and its associated cloud shield deepens as it travels towards, and eventually rises above, the warm frontal zone. Its left-hand boundary is often sharply defined in the satellite imagery where it encounters dry-intrusion air undercutting it, sometimes to a greater degree than shown in Figure 4.

The overall situation depicted in Figure 4 corresponds to the frontal-fracture stage of Shapiro & Keyser's (1990) cyclone life-cycle model. However, the precise configuration of the principal flows depends on the larger-scale ambient flow (Bader *et al*., 1995). We shall confine ourselves here to drawing a contrast between two major archetypes identified by Young (1994). The first of these, corresponding to Figure 4, occurs in association with confluent troughs. The second common archetype, shown in Figure 5, occurs in association with diffluent troughs. Here, the secondary WCB extends to a greater distance away from the primary WCB before rising in the cloud head, and it is overrun by dry-intrusion air over a broader front.

3. Relationship of the dry intrusion to the cold frontal structure

Figure 6 shows a Met. Office Limited-Area Model portrayal of the dry intrusion for a case conforming to the diffluent-trough archetype in Figure 5. Over the previous nine-hour period the cloud head had emerged

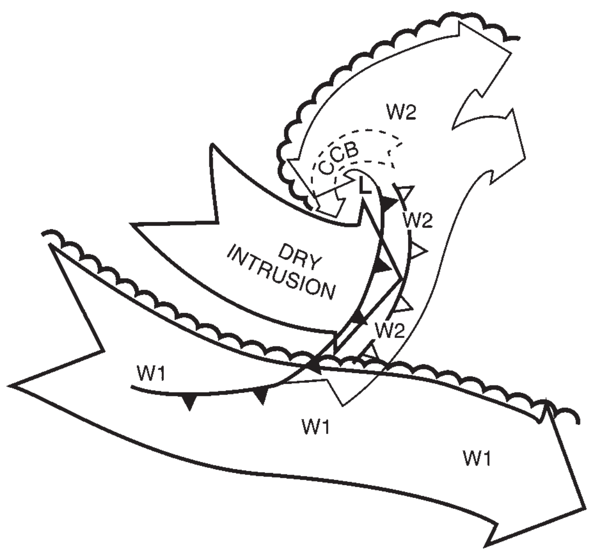

Figure 5. *Conceptual model showing system-relative airflow associated with the diffluent-flow type of cyclogenesis. The arrows labelled W1 and W2 are the primary and secondary warm conveyor belts. The dashed arrow labelled CCB is a cold conveyor belt. The dry intrusion is seen to overrun W2 over a broad region to produce an upper cold front at its leading edge. (After Young, 1994.)*

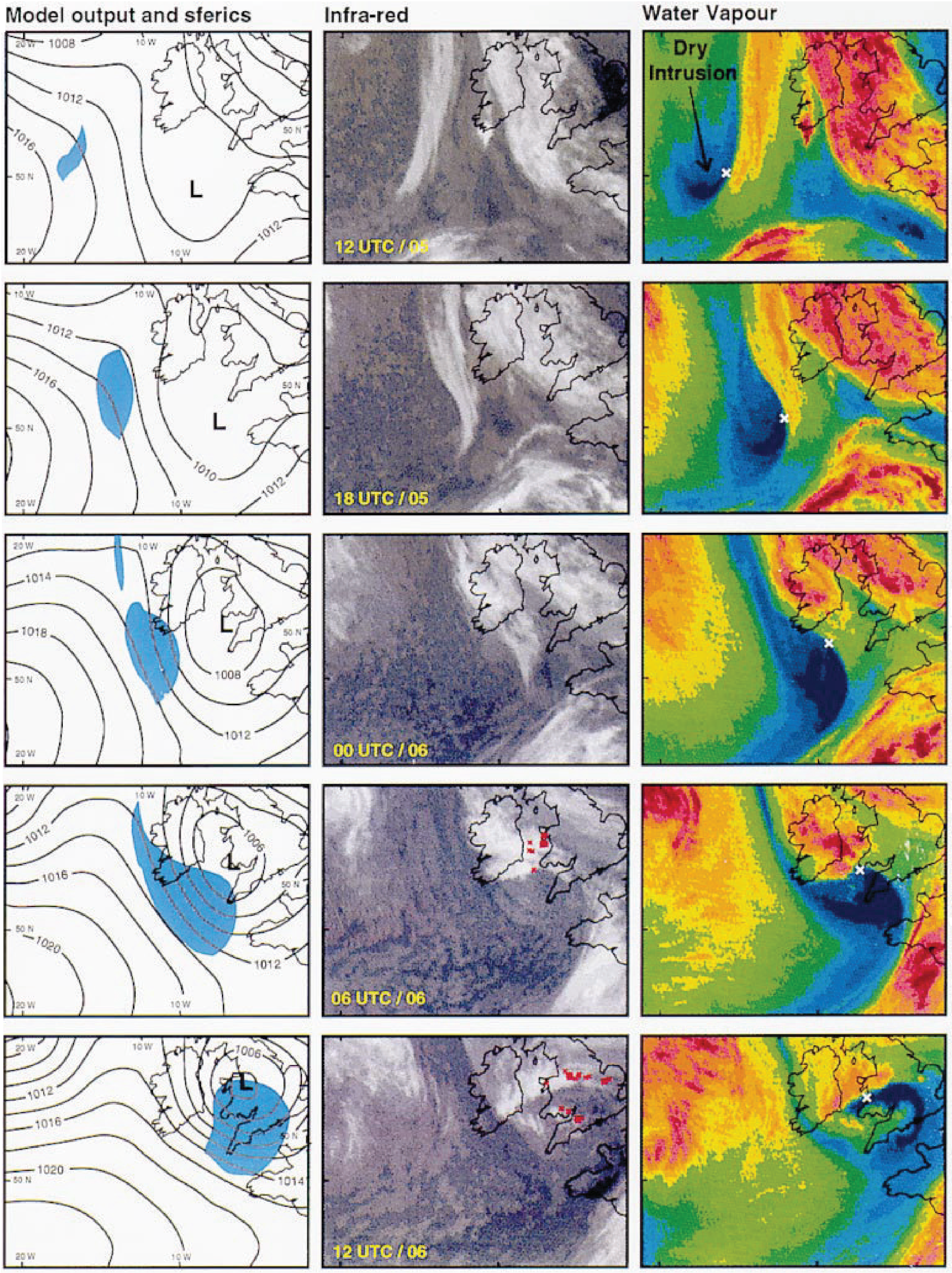

Figure 10. *Evolution of a thundery dry-intrusion event, from 1200 UTC on 5 August (top row) to 1200 UTC on 6 August 1996 (bottom row). Left column: Met Office Limited-Area Model analyses (contours represent mean sea-level pressure in mb; the blue area represents 500 mb absolute vorticity in excess of $20 \times 10^{-5}\ s^{-1}$). Middle column: Meteosat infra-red imagery (coldest clouds white) and sferics reports within ± 20 minutes of the analysis time (red crosses). Right column: Meteosat WV imagery (warm colours moist, cold colours dry). Times of the WV imagery are 30 minutes later than for the corresponding IR images. The white crosses in the right-hand column denote the centre of rotation of the leading edge of the dark zone (blue area) in the WV imagery as seen in action replay. (Courtesy of N. M. Roberts.)*