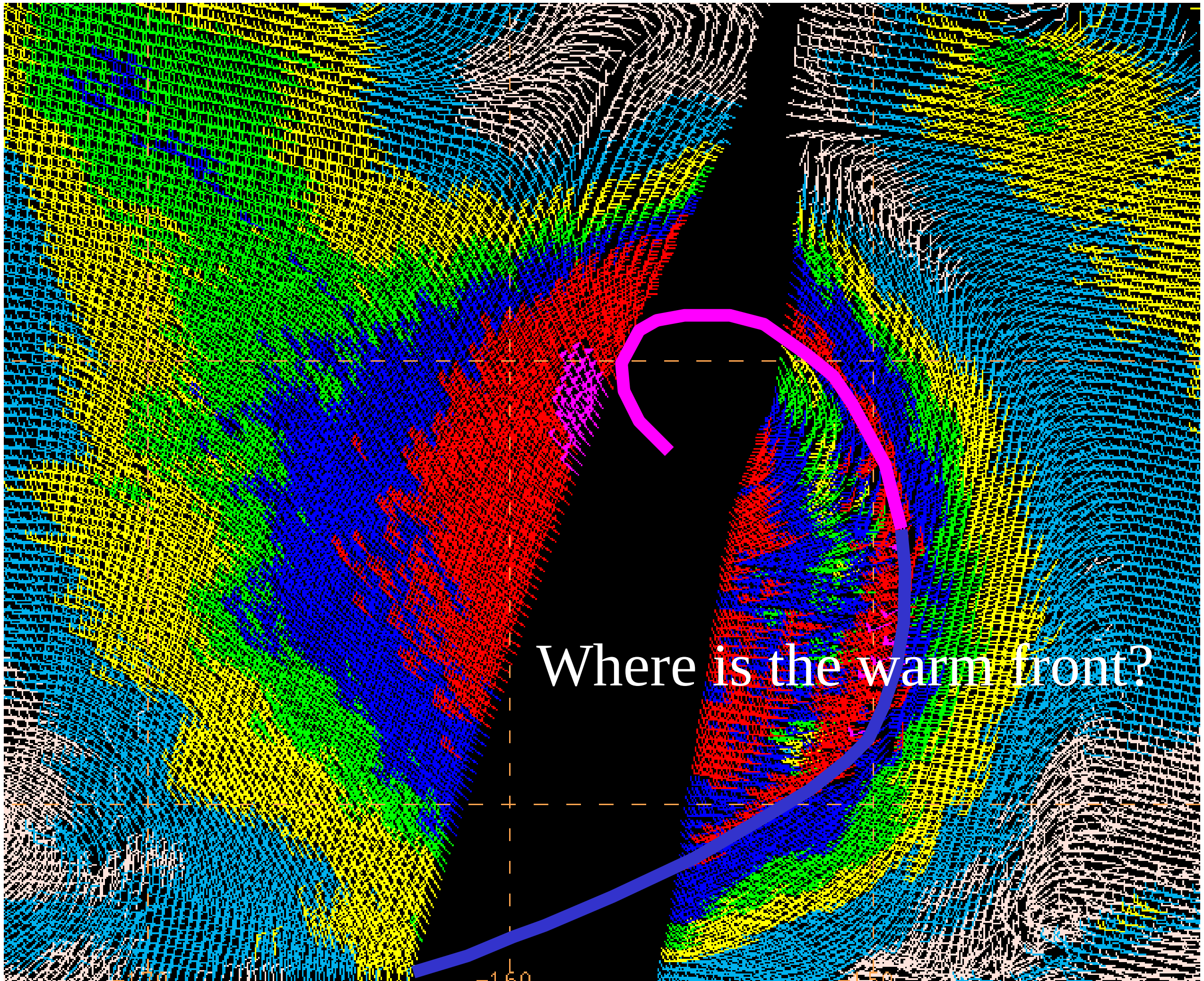
Types of Cyclogenesis

From

Images in Weather Forecasting

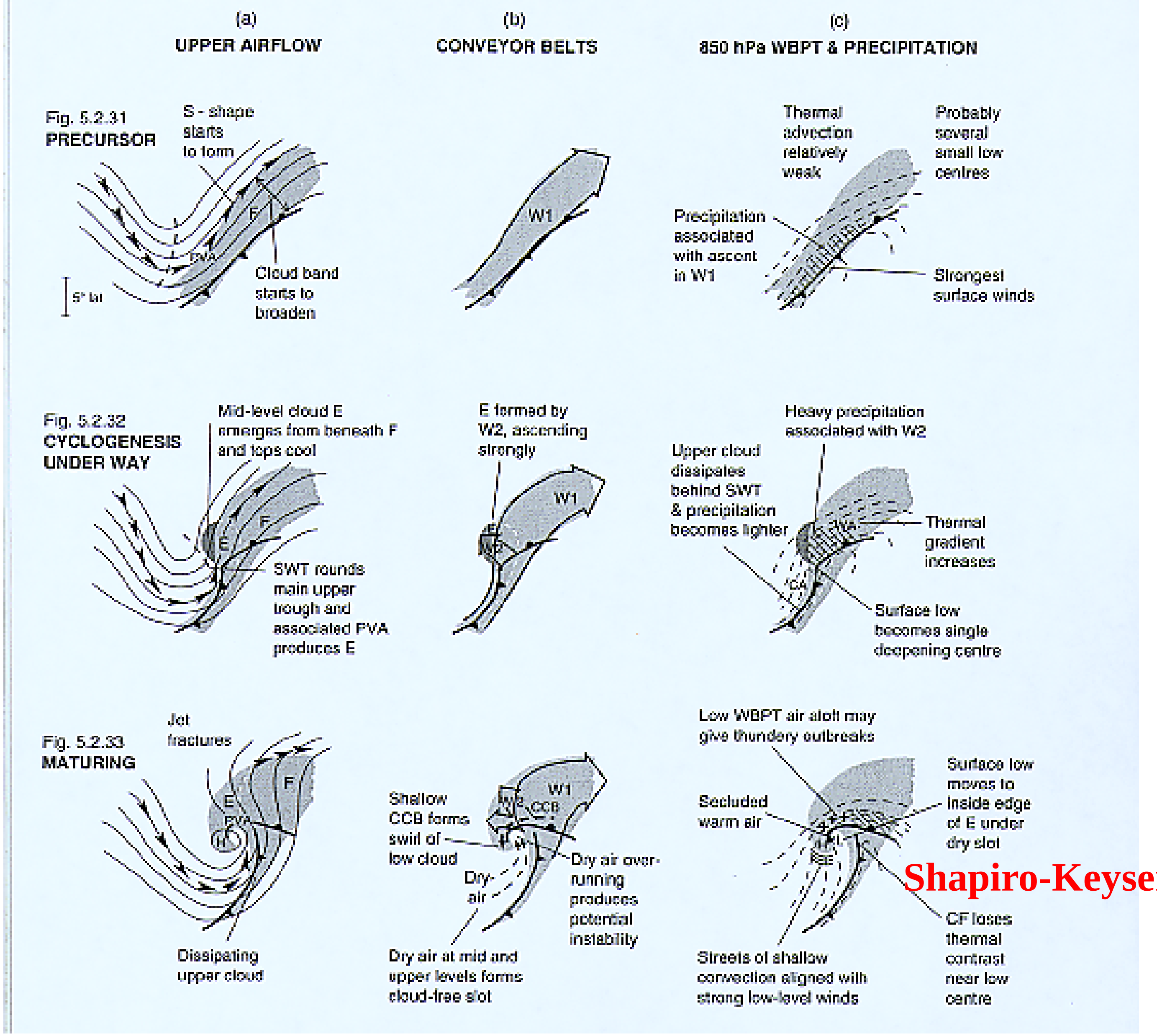
Bader, et al.



It would be nice if there were just Norwegian and Shapiro Keyser cyclones…but the atmosphere has a way of making things a bit more complicated. In the book Images in Weather Forecasting, Bader, et al. presented a classification scheme for types of cyclogenesis. This work was done initially by two forecasters from Pacific Region (McLennan and Neil, 1988) and refined by Martin Young of the UKMET Office in 1994.

The classification scheme came up with two types of cyclogenesis events. In this training paper I reversed the order of the types. A flow chart was in the package I distributed and splits the types of events by whether a single upper level stream exists or two streams exist. Under the single stream, three types of events are described: Meridional Trough, Diffluent flow, and Confluent flow. The cyclones described by the Norwegians fall into the Diffluent flow, Shapiro Keyser - Confluent Flow and Meridional Trough.

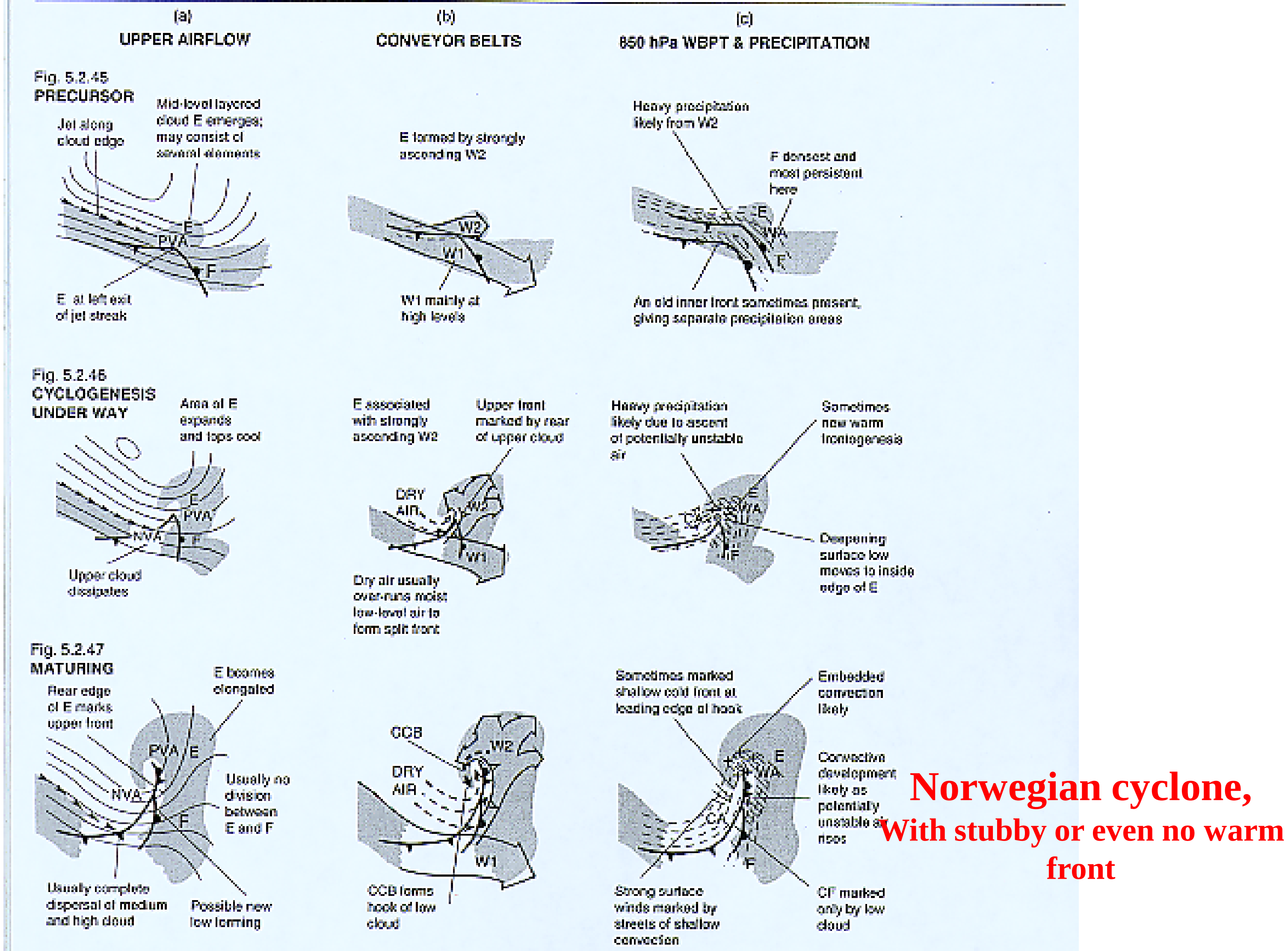
Under the 2 main streams categories, 4 different types of cyclogenesis are described. Three of these can be termed cold air cyclogenesis and include: Cold air, the Instant Occlusion, and the Induced wave. The last category under 2 main streams is the Split flow cyclogenesis which may indeed start as cold air cyclogenesis.



Shapiro-Keyser, T-bone

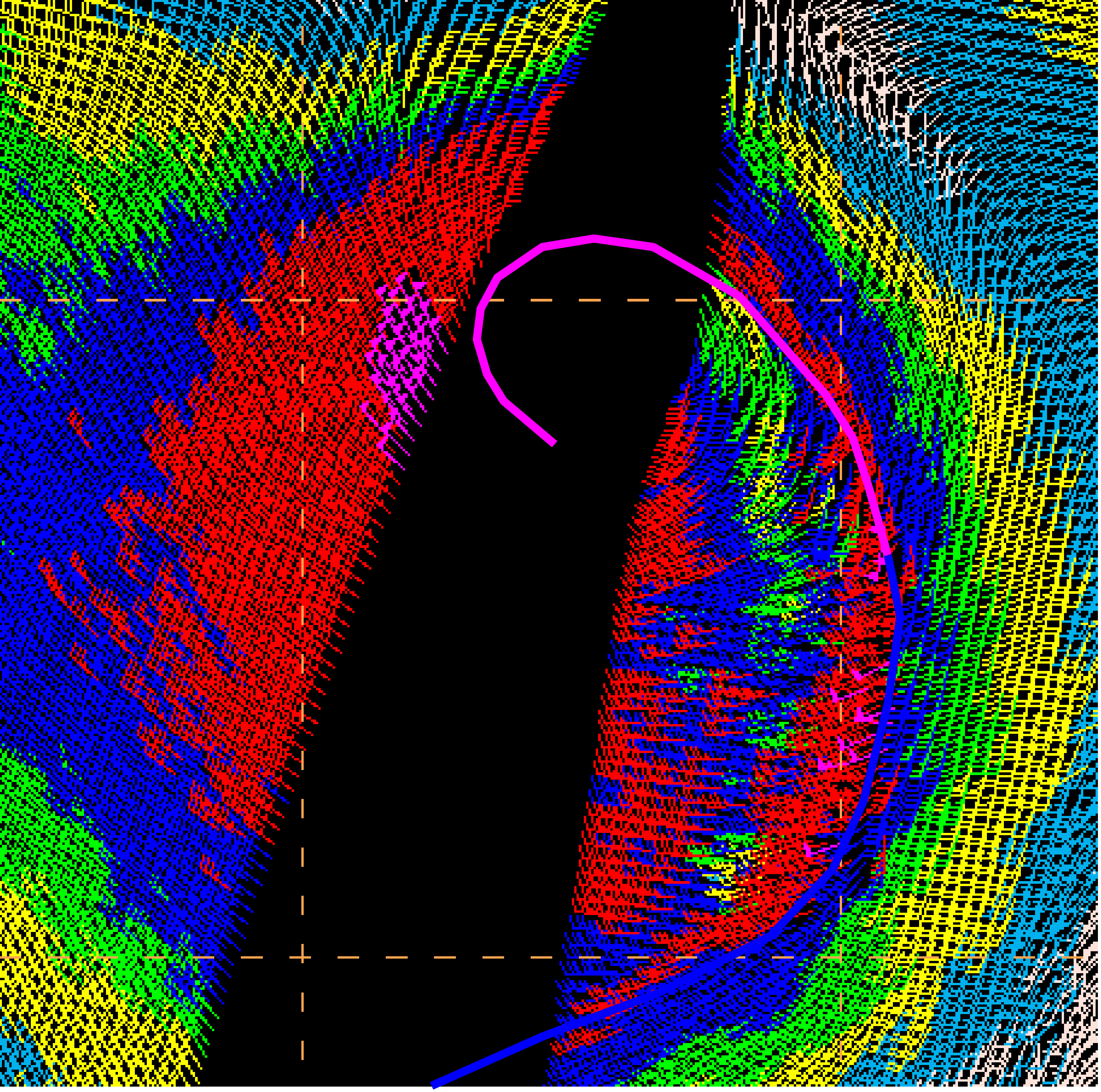
Meridional trough cyclogenesis

Full latitude trough – Shapiro Keyser structure



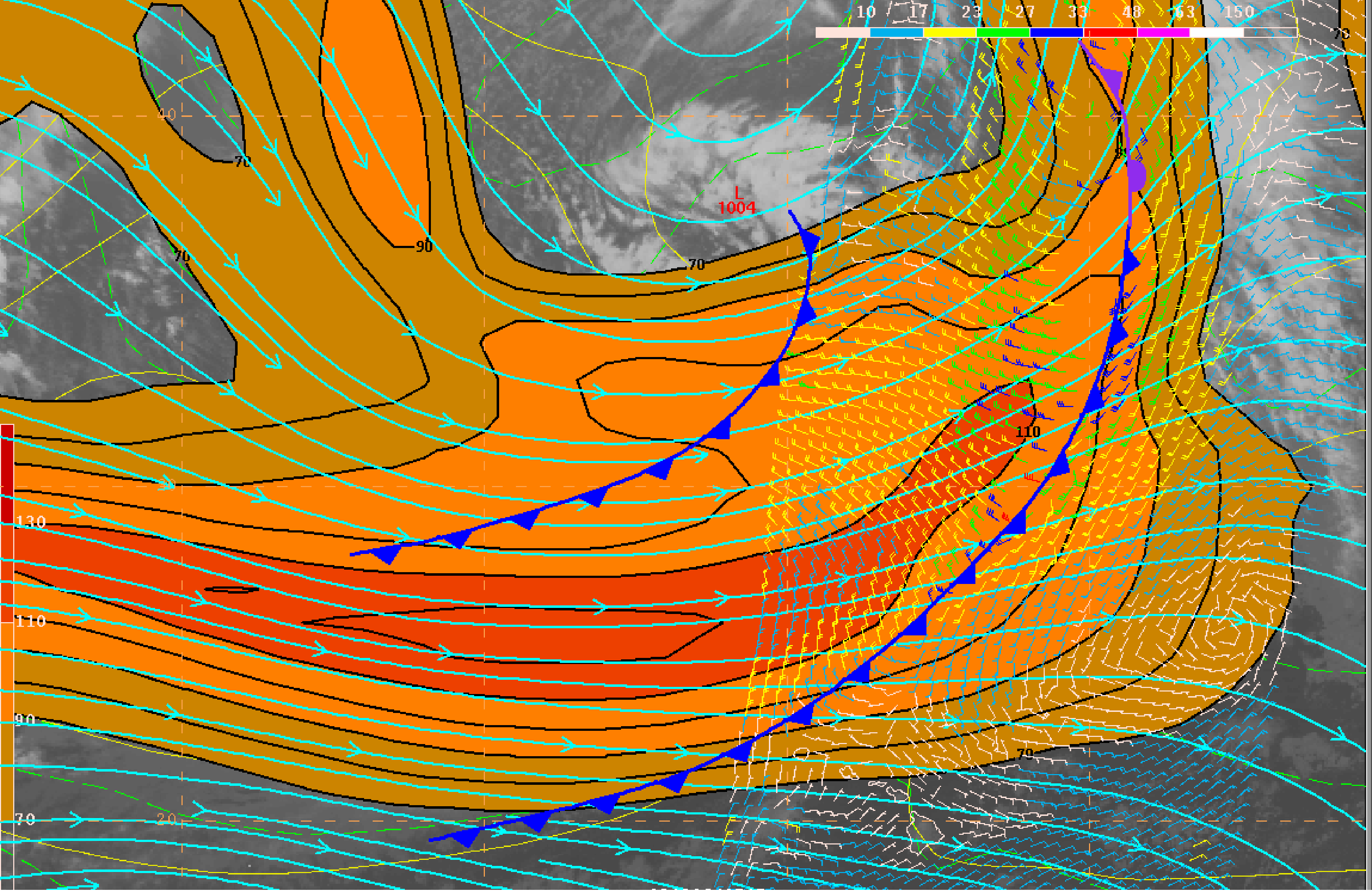
Flat trough, diffluent flow cyclogenesis

Norwegian structure with a short stubby warm front or no warm front

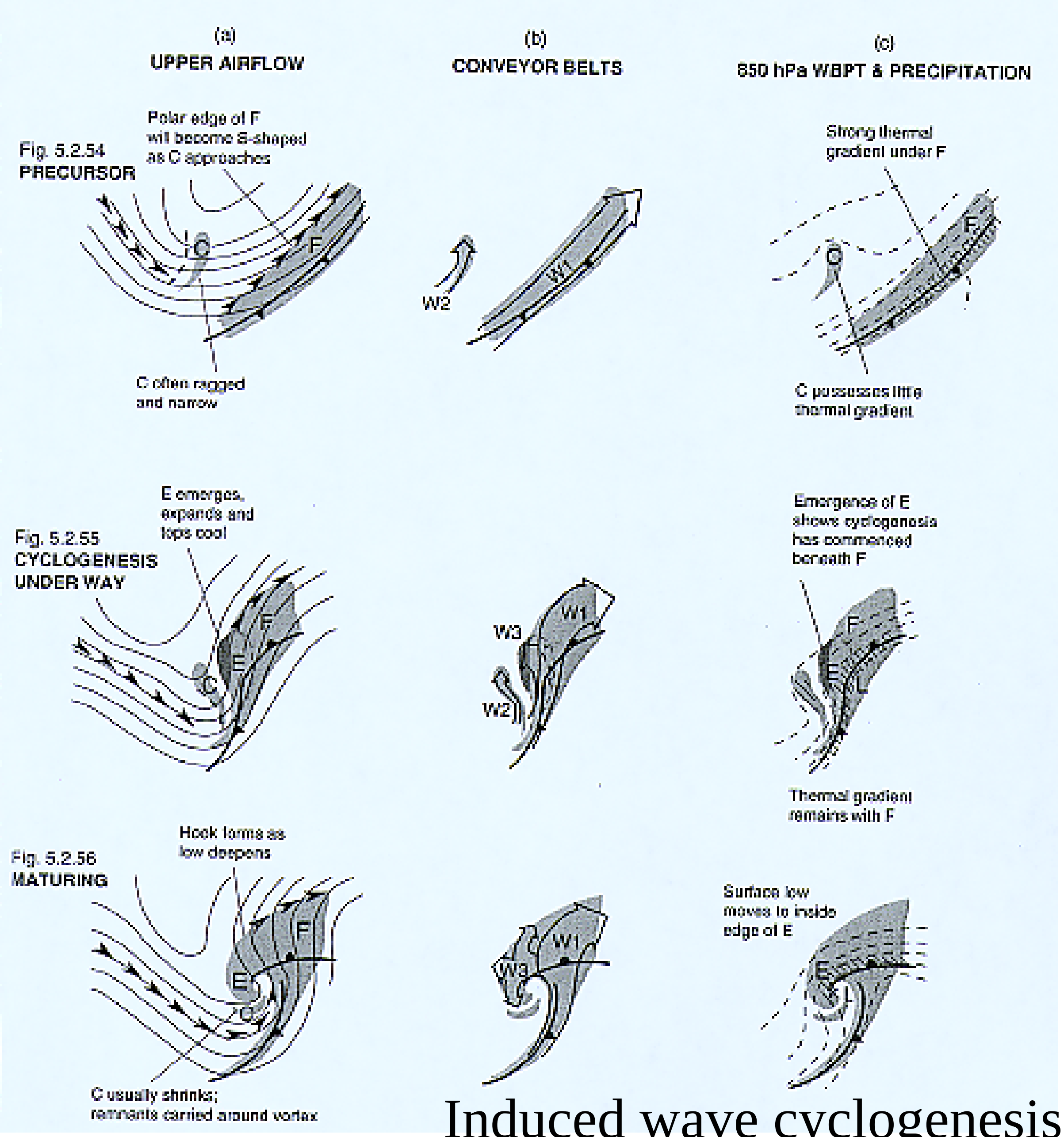


This cyclone was located at the diffluent leading edge of a zonal trans-Pacific jet. All the baroclinicity is associated with the cold front with little if any in the warm sector. QuikSCAT shows no turning of winds in advance of the cold front.

The upper level can be used to estimate the type of frontal structure associated with a mid-latitude cyclone.

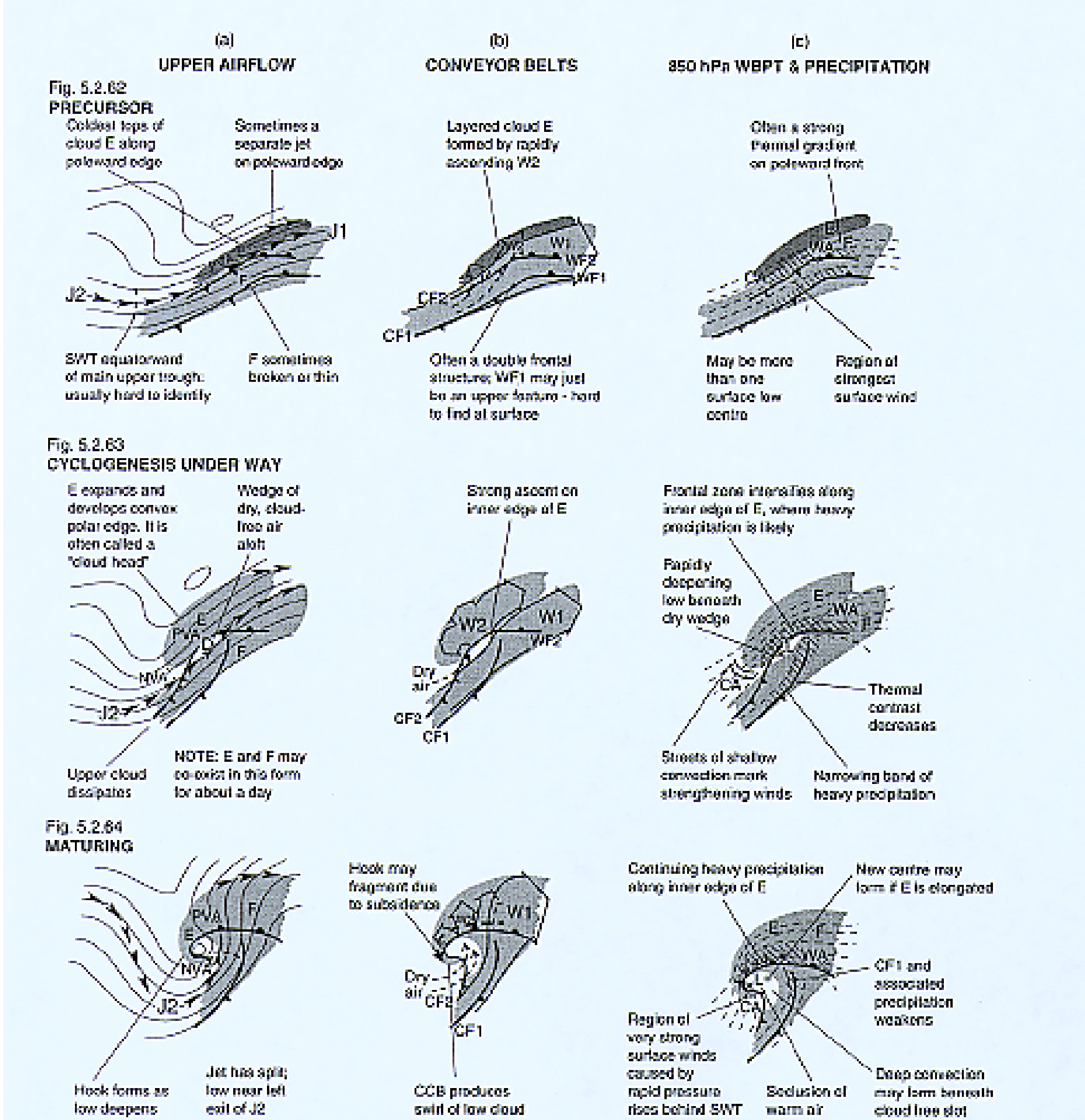


A flat trough with diffluent flow…QuikSCAT winds show a continuous occluded to cold frontal boundary with no significant turning of winds to indicate a warm front. Upstream in the cold air cyclogenesis and frontogenesis are occurring. Hit return…250 mb streamlines indeed show a fairly straight flow with an area of diffluence aloft.



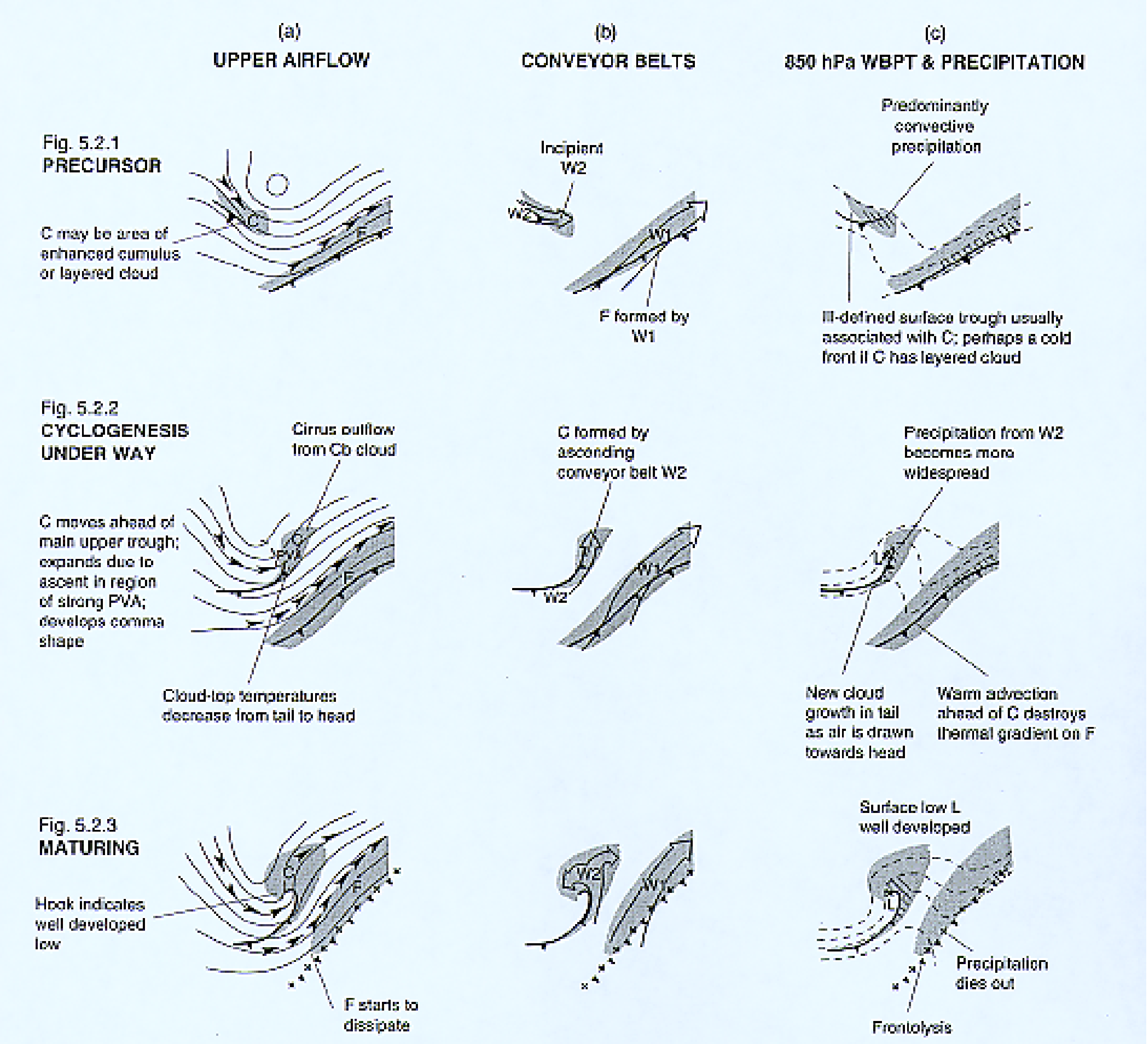
Induced wave cyclogenesis

Vort lobe trailing a main baroclinic band forces or induces low development along the band. Jets are coupled with both confluent and diffluent segments…associated divergence is a result of both a right rear entrance and left front exit regions. Frontal structure tends to follow the Shapiro Keyser Model.



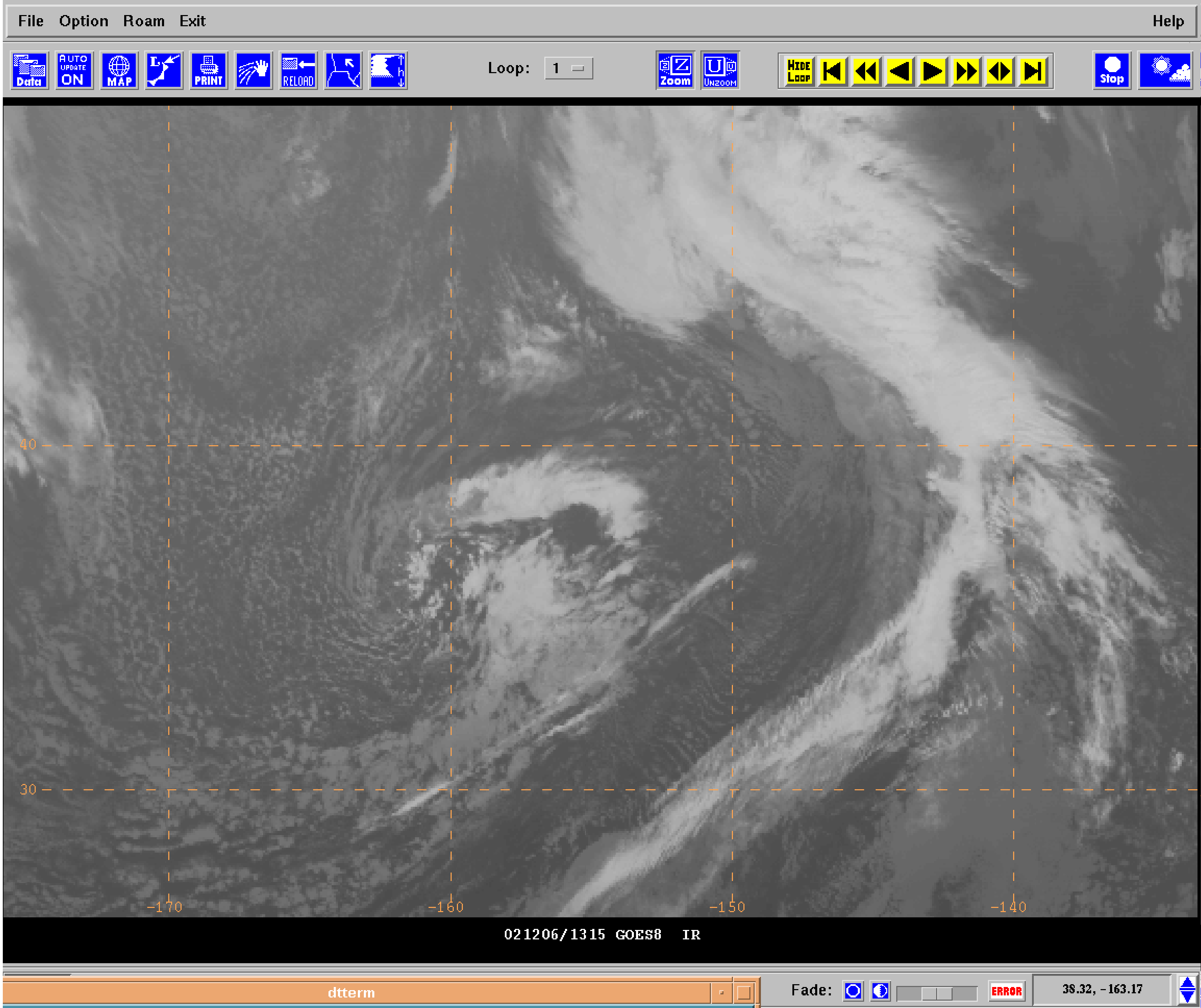
Flat trough, confluent flow cyclogenesis

Jet structure may initially fairly straight over the developing cyclone will break as the mid level wave amplifies. The open wave takes on a Shapiro-Keyser T-bone structure as the jet fractures into two jet streaks.



Cold air cyclogenesis

There are two separate streams with a developing comma well separated from the main baroclinic band. The cold stream is dominant and surface frontogenesis and cyclogenesis take place in what was once thought to be a homogeneous cold air mass. Latent heat release is a key factor contributing to increasing baroclinicity in the cold air. Since the area of cold frontogenesis is under a diffluent trough…there is no warm front.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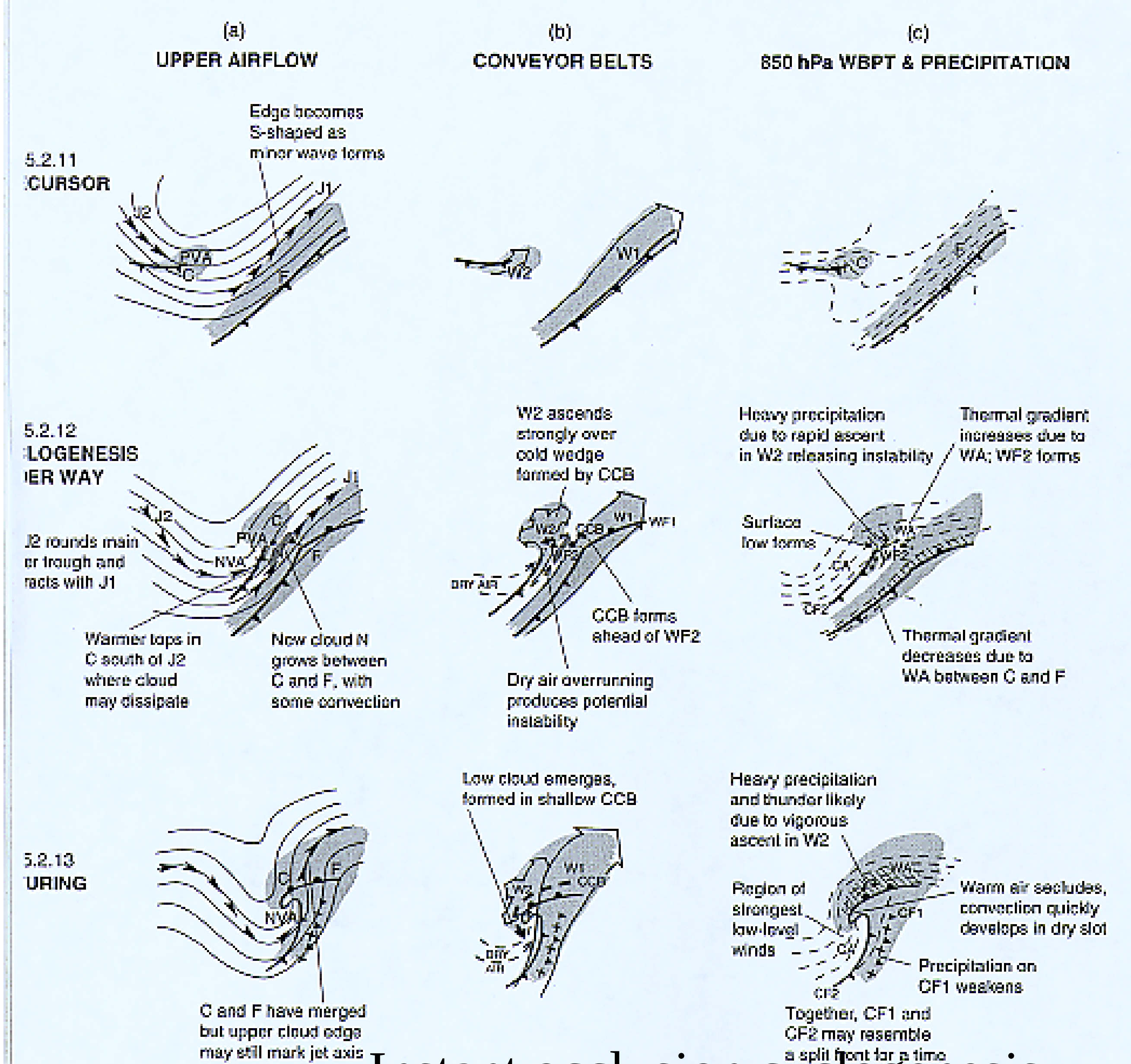
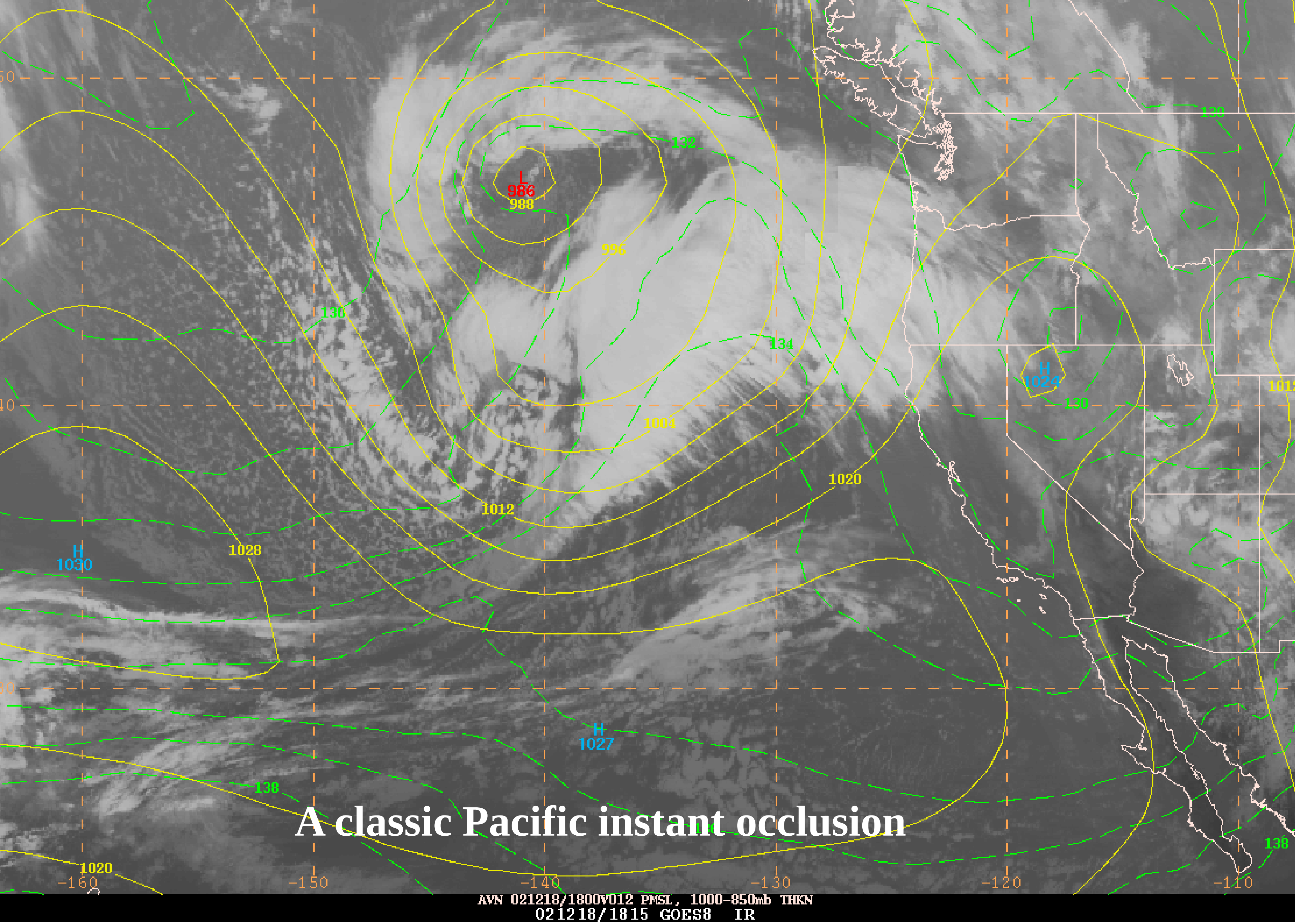


Instant occlusion cyclogenesis

In my mind this is by far the most difficult to comprehend….specifically the evolution of the fronts as they merge (reinforce) each other. I am not sure I agree with the frontal structure in the third or mature phase as depicted. It implies a bight or indentation in the warm sector. However, similar to other models, the end product takes on a Shapiro Keyser shape due to the influence of coupled jets.

A classic Pacific instant occlusion

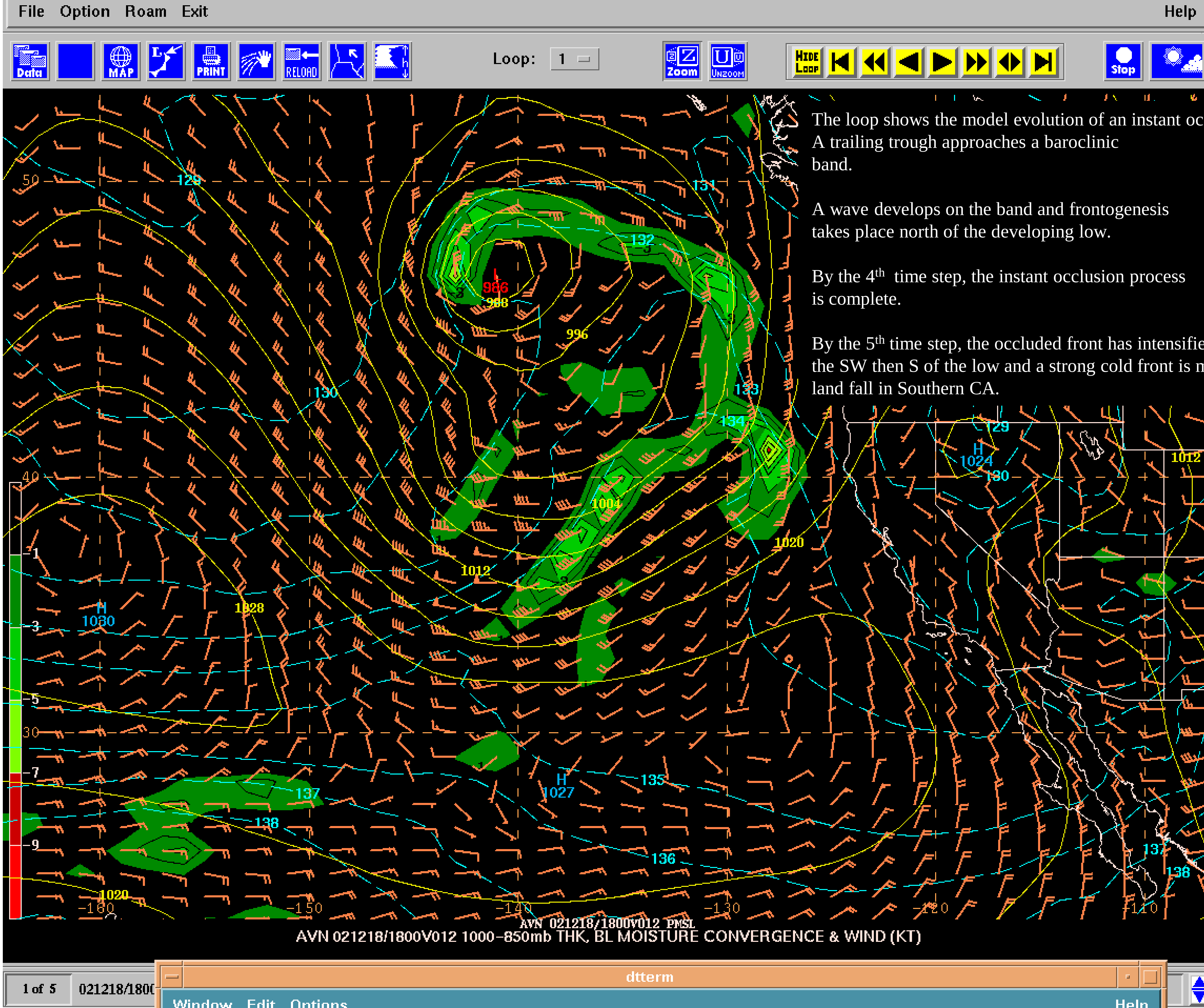


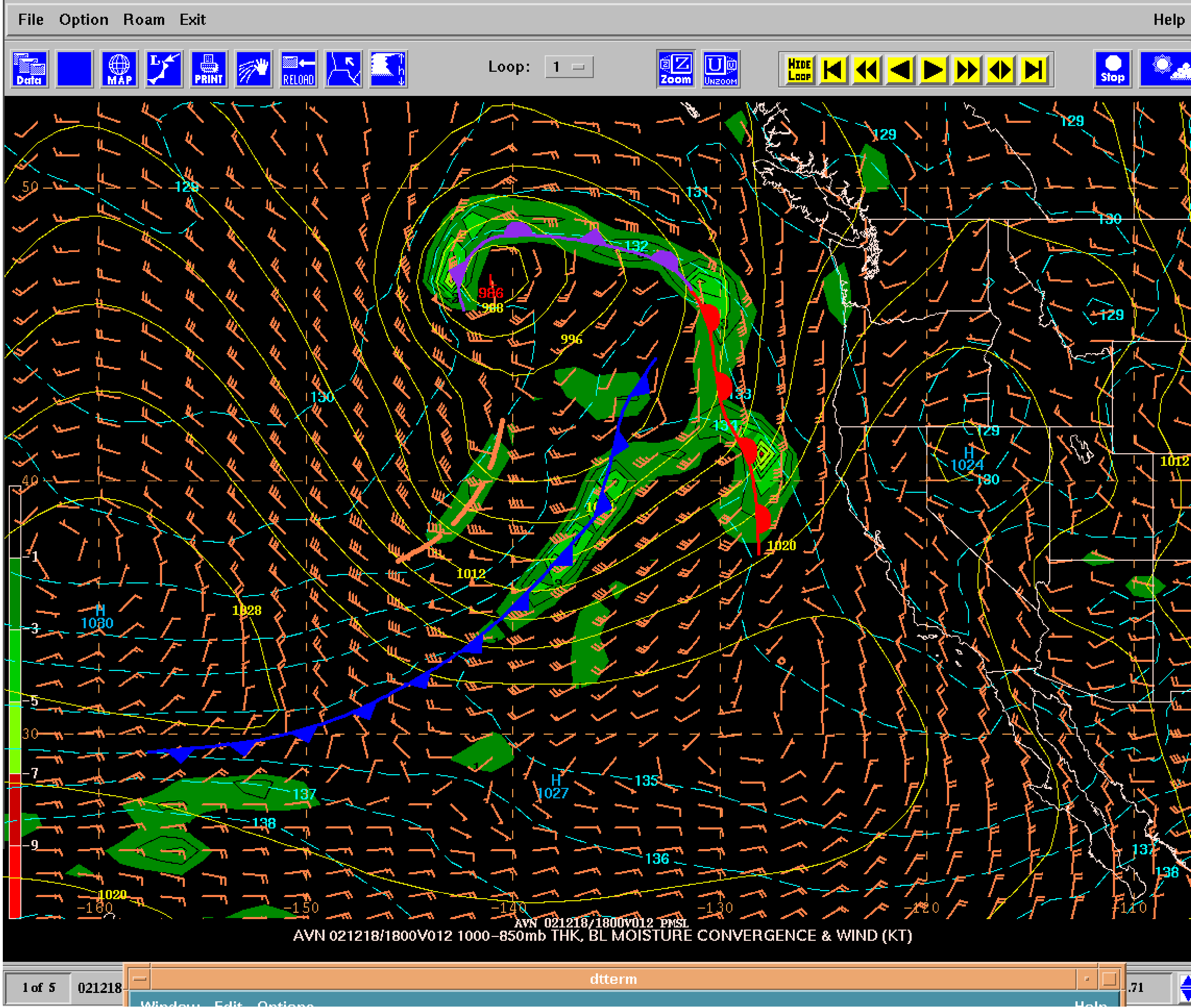
The loop shows the model evolution of an instant occlusion. A trailing trough approaches a baroclinic band.

A wave develops on the band and frontogenesis takes place north of the developing low.

By the 4th time step, the instant occlusion process is complete.

By the 5th time step, the occluded front has intensified to the SW then S of the low and a strong cold front is making land fall in Southern CA.

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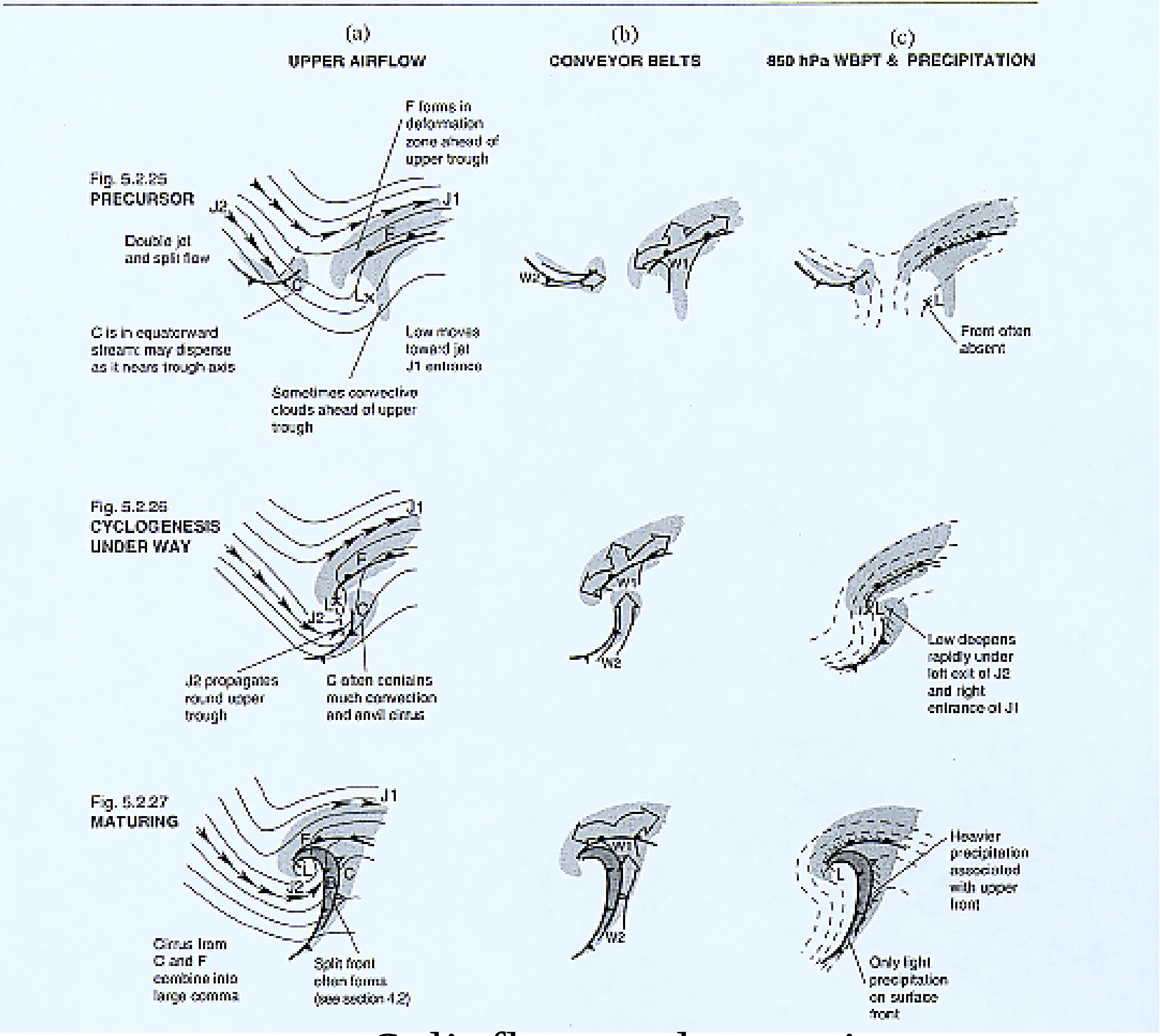

Split flow cyclogenesis

This may be a fairly common type of cyclogenesis as the warm frontal baroclinicity is provided by a northern stream and the cold frontal thermal gradient by a more southern stream. I think a T-bone shape in the mature phase is more realistic.

The bottom line is cyclogenesis, frontal development and evolution are fairly complex. There indeed may be more types of cyclogenesis…others have come up with classification schemes that are far more complicated…but I do not think as useful to us.

If you take anything from this series…the upper level flow determines the frontal structure and evolution.