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SATELLITE OBSERVED CLOUD FIELDS AND THEIR RELATIONSHIP TO FLOW PATTERNS

- Part A -

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INTRODUCTION

Over the past months, satellite meteorologists at PWC have been studying satellite observed cloud-flow pattern correlations. This was primarily done for two reasons. The first being to check out numerical product initialization. The second, to develop techniques to generate cloud fields from flow patterns and vice versa. (Both necessary with the coming demise of OWS PAPA.) Streamline analysis is often used within the operational forecast program at PWC and another field (utilizing vorticity) was introduced for the study. The results are broken up and distributed in two parts to meet Technical Note length requirements.

Part A deals with cloud-flow pattern correlation findings.

Part B outlines a technique for locating and forecasting synoptic scale cloud features from flow patterns.

A third report, a by-product of the study, is being issued as a separate paper and outlines some of the strengths and weaknesses found in the CMC Streamline analysis package.

PART A

Two case studies are presented to show characteristics cloud-streamline associations. Flow pattern analysis used in the studies:

- CMC 250mb streamline analysis were used in the studies. The reasons were two-fold. First, the availability of high level aircraft wind reports over the Pacific allowed verification. Secondly, unobstructed high level cloud shields associated with synoptic scale systems generally lie closer to the 250mb than to other mandatory levels.
- An emperical Streamline Analysis.
  Roger Weldon of NESS/NOAA has shown success in relating cloud patterns to upper motion fields. He has found that cloud boundaries relate well to elongation axis or deformation zones if one uses the relative vorticity isolines as a streamline field. Also local wind maxima isolated by using the vorticity maxima-minima pairs across a stream produces a surge area within the back edge of a cloud system. In this study the absolute vorticity isolines were lifted from the 500mb analysis and used as pseudo streamlines in order to check cloud relationships. (Weldon has stated that the relative vorticity field fits best as relative motion streamlines of air parcels, but the more readily available absolute vorticity field provides a decent substitute.)

CASE STUDY I (Fig. 1)

00Z - 23 Aug. 80

SITUATION (Fig. 1a)

A ridge over the eastern pacific. A cold trough over western North America and another along 170W. The satellite photo (Fig. 1c) shows two synoptic cloud systems associated with the troughs as well as a minor one over southeastern Alaska - southern Yukon.

RELATIONSHIP OF STREAMLINES TO CLOUD PATTERNS

The BC cloud shield is located on the backside of a cold trough within a different zone of an approaching jet. This type of system often comes down the cold side of the trough with little significant cloud or defined shortwave but develops rapidly when rounding the base of the trough. In this case, the core of maximum winds on the 250mb streamline analysis lies well upstream north of the Charlottes and the main portion of the high cloud trails the trough. Other cloud edges are not well marked by features in the 250mb streamline flow.

This cloud shield can be better defined if one uses the 500mb vorticity isolines as streamlines (Fig. 1b). The back edge is fairly well defined by the vorticity maximum axis (not necessarily the shortwave trough as the vorticity field has been isolated from the contour analysis). The leading edge is aligned along the deformation zone that stretches from the western North West Territories to central Alberta. The southern cloud boundary relates well to the vorticity minimum axis from southwest Washington into southeastern BC.

The cloud system just east of 165W lies along the warm side of the 250mb streamline trough. Implied convergence along 55N between 140 to 160W fits fairly well with the northern cloud edge. The cloud shield can be more closely defined using the 500mb vorticity isolines as pseudo streamlines. The cloud shield is bounded by a vorticity maximum axis on the west, a strong deformation zone on the north, a weaker one to the southeast, and is cut off along the right edge of the tightest vorticity gradient.

The smaller cloud area over southeastern Alaska - southern Yukon also bears mention. CMC and PWC 250mb analysis suggest a low over the central Yukon. Modelling would put the main cloud area north and east of the low. However, if one were to use the vorticity isolines as streamlines, the cloud is better defined within the area between the weak vorticity maximum axis along 145W between 57 and 60N and the deformation zone from south central Alaska to the central panhandle. In this case, the southern edge is not well defined.

FIGURE 1

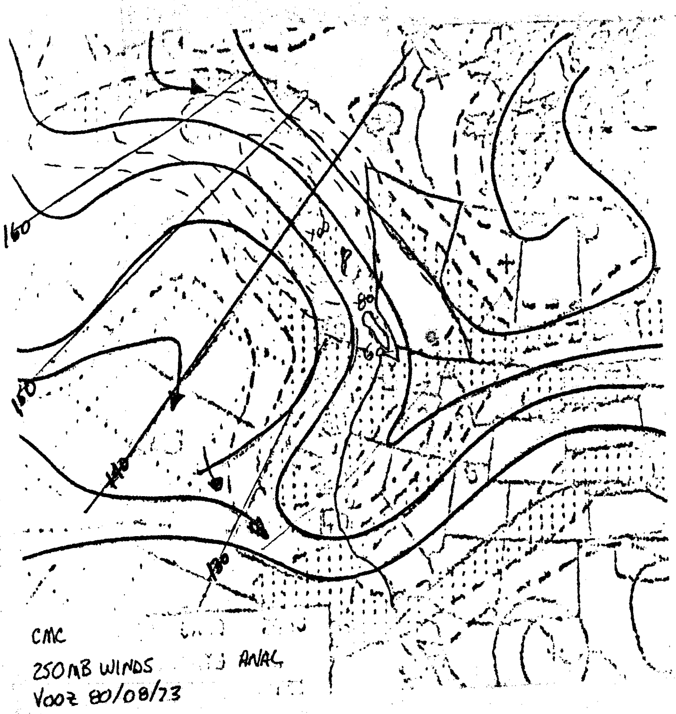

FIGURE 1A

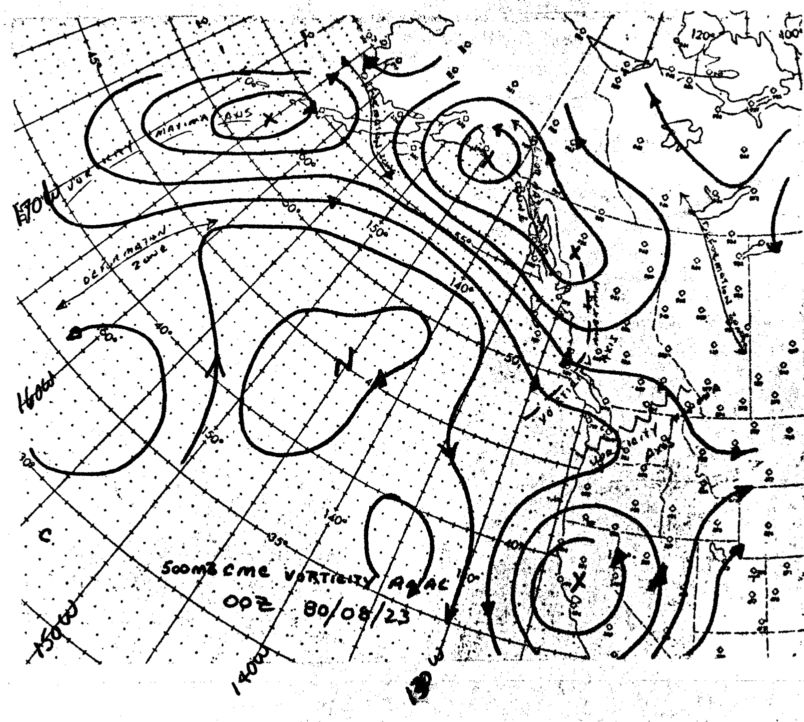

FIGURE 1B

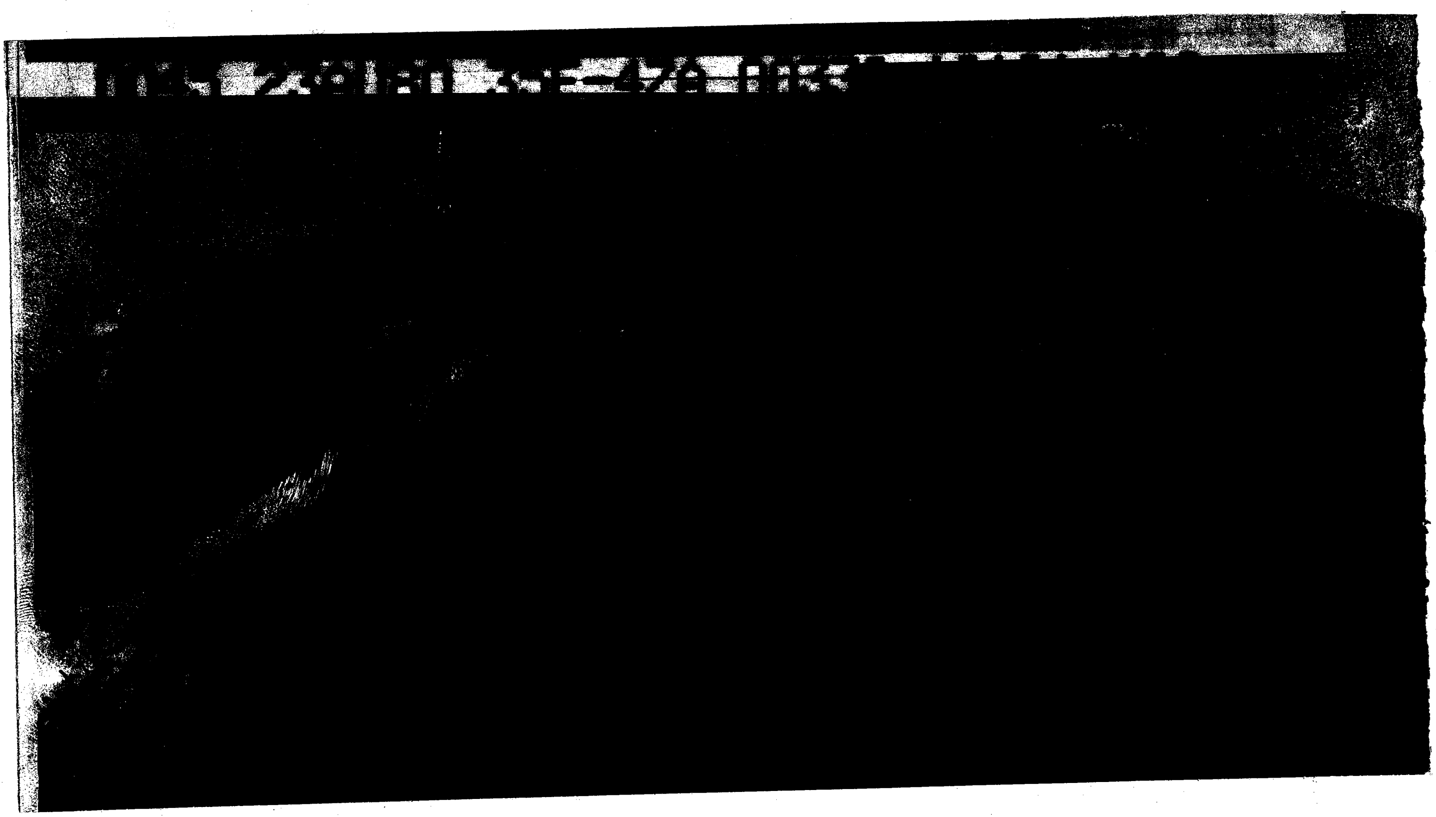

FIGURE 1C

CASE STUDY II (Fig. 2)

12Z - 24 Aug. 80

SITUATION (Fig. 2a)

Nearly zonal flow across the northeastern pacific with troughing along 120, 150 and 180W.

RELATIONSHIP OF STREAMLINES TO CLOUD PATTERNS (Fig. 2c)

The cloud system extending from east central BC over southern Alberta lies in advance of the 250mb streamline trough with a dry surge area associated with the wind maxima. The southern edge of the cloud lies north of the confluent zone just south of the Alberta - U.S.A. border. The leading and northern cloud edges have poor relationship to the 250mb streamline fields.

This cloud shield is better defined by using the vorticity field as relative streamlines (Fig. 2b) The back edge is founded by the vorticity maximum axis with indentation by the local wind maxima (as determined by vorticity maxima pair as per Weldon). The southern edge lies within the strongest vorticity isoline gradient. The northern edge lies south of a strong deformation zone.

The cloud system crossing the Gulf of Alaska lies ahead of a weak 250mb trough. The winged back edge characteristic of a wind surge area is not well shown by the wind field. The northern and leading cloud edge are not correlated to any significant ridging or features in the flow.

However, this cloud system is better bounded by the vorticity isolines (Fig. 2b). The cloud lies in advance of a vorticity maximum axis with back indentation from the local wind maximum defined by the strongest gradient between the vorticity maximum and minima over the Pacific.

The leading edge washes out across the vorticity minimum axis just off the northeastern pacific coast. The northern edge is bounded by the weak deformation over the northern Gulf of Alaska.

FIGURE 2

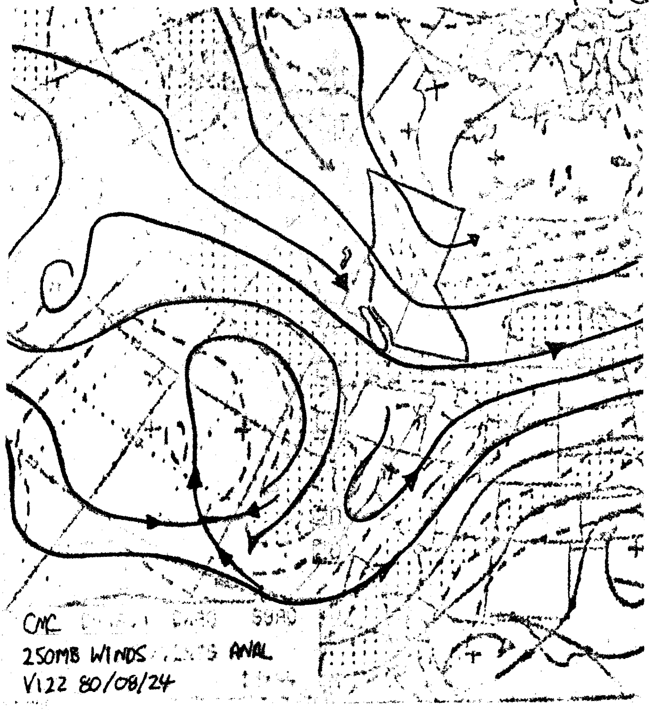

FIGURE 2A

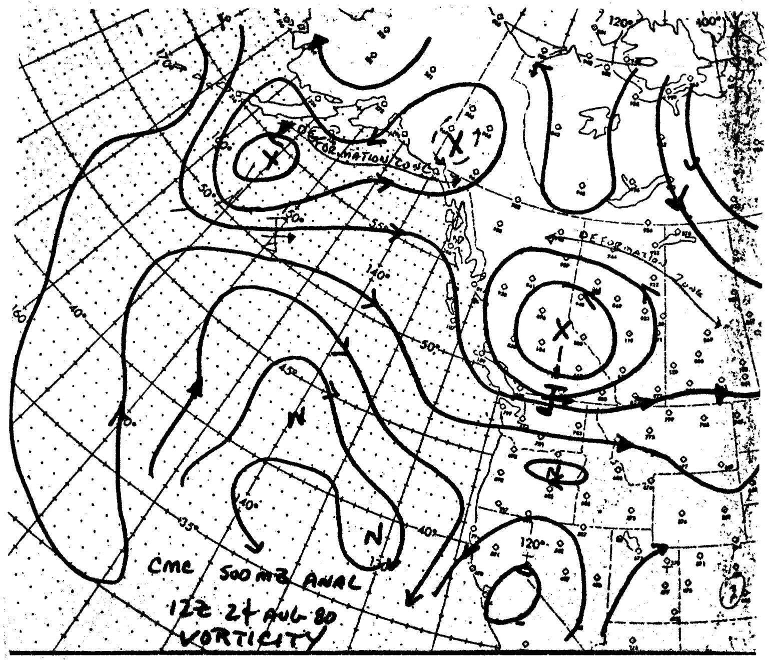

FIGURE 2B

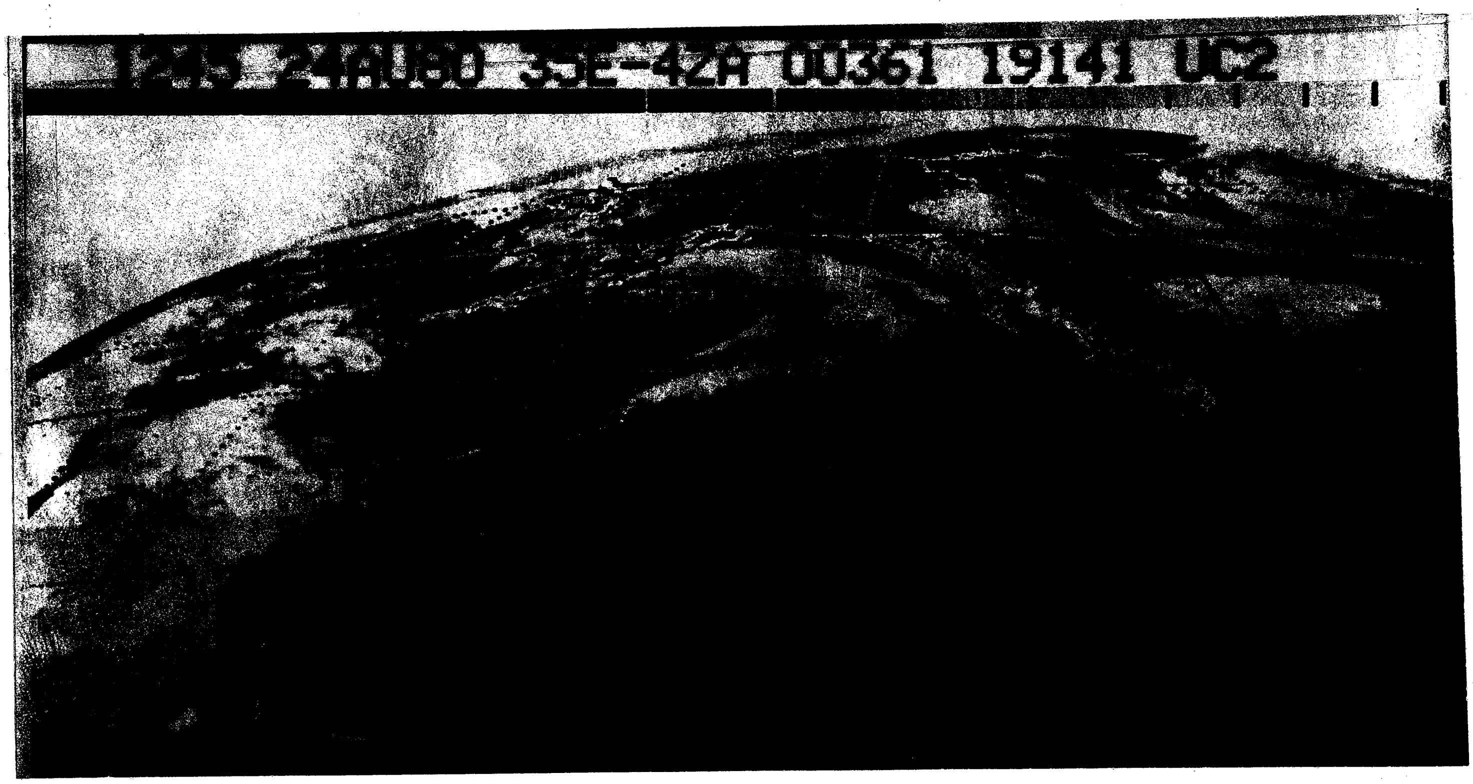

FIGURE 2C

RESULTS

Relationship of high cloud to the 250mb streamline analysis and to the 500mb absolute vorticity isolines.

250mb streamlines do not outline high cloud areas or edges well. However, cloud can generally be found in strongly diffluent areas and be seen dissipating across ridges. The cloud often has little relationship to the troughs. Cloud shields often cut across streamlines.

500mb absolute vorticity isolines used as pseudo-streamlines better define significant cloud areas and edges than the streamline field from the same model (in fact, from day to day observation, better than any other field including moisture and RH). Back cloud edges are usually well outlined by a vorticity maximum axis with dry indentation from the local wind maxima. (Determined from the paired cross stream vorticity maxima and minima. Weldon.) There appears to be a good relationship between the amount of indentation and the strength of the wind maxima. Cloud edges are usually quite distinct in advance of a deformation zone and across a strong vorticity minimum axis. The right hand cloud edge (relative to the stream) usually lies within a strong vorticity isoline gradient.

The systematic method of isolating significant synoptic scale cloud areas and edges has shown considerable promise and routinely outperforms RH moisture progs available at PWC. Part B of this study outlines such a technique.