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Relationship of Cloud Systems to Wind and Vorticity Fields.

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A. GENERAL COMMENTS

At the Pacific Weather Center, most of the attention of the prognostician-analyst (P/A) is centered over the Pacific. Sadly, this is an area with a paucity of data. The atmosphere is sounded at ocean station PAPA only. Possibly, there may be a few usable aircraft wind reports. Most of the upper air data is created by standard routines. Subjective bogussing by the meteorologist seems to be discouraged. Sometimes it seems those at CMC responsible for the construction of the analysis "forget" the users of these products. A bad analysis during periods of intense atmospheric flow will result in forecast fields that "mother nature" knows nothing about.

Since one of the main forecast tools is the computer forecast of the 500 mb height field (with vorticity analysis of the wind field), it is important that the P/A be convinced that the initial field over the Pacific is accurate. This is best accomplished by use of the most reliable source of information over the Pacific-the GOES satellite image. The cloud formations seen on the satellite pictures are compared with the vorticity and height fields as seen on the analysis. Using preconceived models an evaluation is made. If the initial field is realistic, the P/A will be encouraged to use the computer prognosis based on that initial field. He will then look at the forecast changes in the height and vorticity fields and try to envision the future shape and position of the cloud systems.

With the advent of fine resolution hard-copy GOES pictures (available at PWC) and the production of time-lapse movies (available to our American frields), much more has been realized as to the structure of cloud systems and their evolution. Briefly the wind and vorticity fields have regular features about a cloud system. Also the wind and the vorticity fields change in a regular manner as the cloud system evolves. The remainder of this paper is a summary of the typical structure of the wind and vorticity fields about cloud systems in various stages of evolution.

B. METHOD

Due to the lack of data coverage over the Pacific, the development of models to verify the analysis must be restricted to areas where ground truth information is available. Cases for study were restricted to the eastern portion of the North

American continent. The density of radiosonde stations should result in the most accuracte upper air analyses available.

With each case,

1. The isotach field was analyzed using the 500 mb winds.
2. The wind streams were analyzed using the 500 mb winds.
3. The positions of the wind maximums along the streams were located.
4. The associated vorticity field was examined and the significant features analyzed.

Using a GOES satellite picture valid at (or near) the same time as the analysis,

5. The outline of the cloud system was taken.

Then,

6. The relevant features of the wind field and the outline of the cloud system were superimposed on a composite diagram.

Results of these studies are described in the following section.

C. MODEL STRUCTURE

In all cases the following features were common,

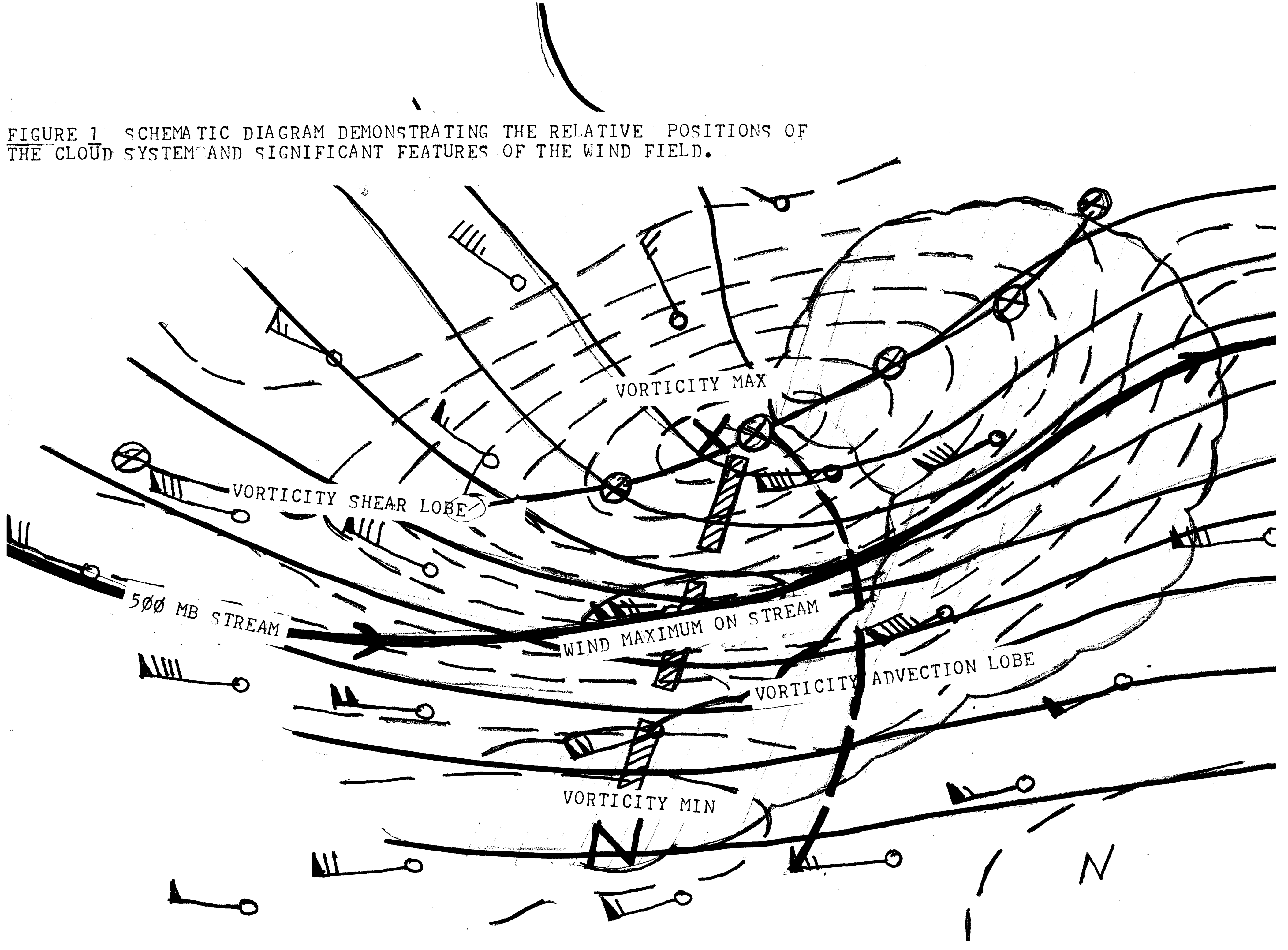
1. Wind Maximum - The wind maximum is found between the vorticity maximum and the vorticity minimum. The vorticity gradient is largest where the wind maximum is present.
2. Vorticity "Advection Lobe"-This vorticity lobe extends from the vorticity maximum across the airstream ahead of the wind maximum. Essentially this lobe is the dividing line between the channel part of the airstream (where little vorticity advection occurs) and the advection part of the airstream (where most of the positive vorticity advection occurs). (See figure 1).
3. Vorticity "Shear Lobe"- This lobe extends from the vorticity maximum parallel to the airstream. (See figure 1). The vorticity shear lobe is the dividing line between the strong negative vorticity advection area in the colder part part of the airstream and the channel flow along the airstream. (See figure 1)
4. Cloud System-The cloud system is always found arched about the wind maximum. (See figure 1). The tip of the comma head tends towards the vorticity maximum. The body of the cloud system is found just downstream from the vorticity advection lobe. The tail extends backwards to lie to the right of the wind maximum.

D. ADDITIONAL COMMENTS

Well formed cloud systems tend to evolve in two ways.

1. Mode A
   (a) The cloud system as in Model 1 (See figure 2) will evolve from stages 1→2→3 as the cloud system moves from the west side of the long wave ridge position to the east side of the ridge position.
   (b) While the cloud system evolves from stages 1→2→3 the intensity of the wind maximum increases. This causes the subsidence boundary to move further and further downstream from the wind maximum.

FIGURE 1 SCHEMATIC DIAGRAM DEMONSTRATING THE RELATIVE POSITIONS OF THE CLOUD SYSTEM AND SIGNIFICANT FEATURES OF THE WIND FIELD.



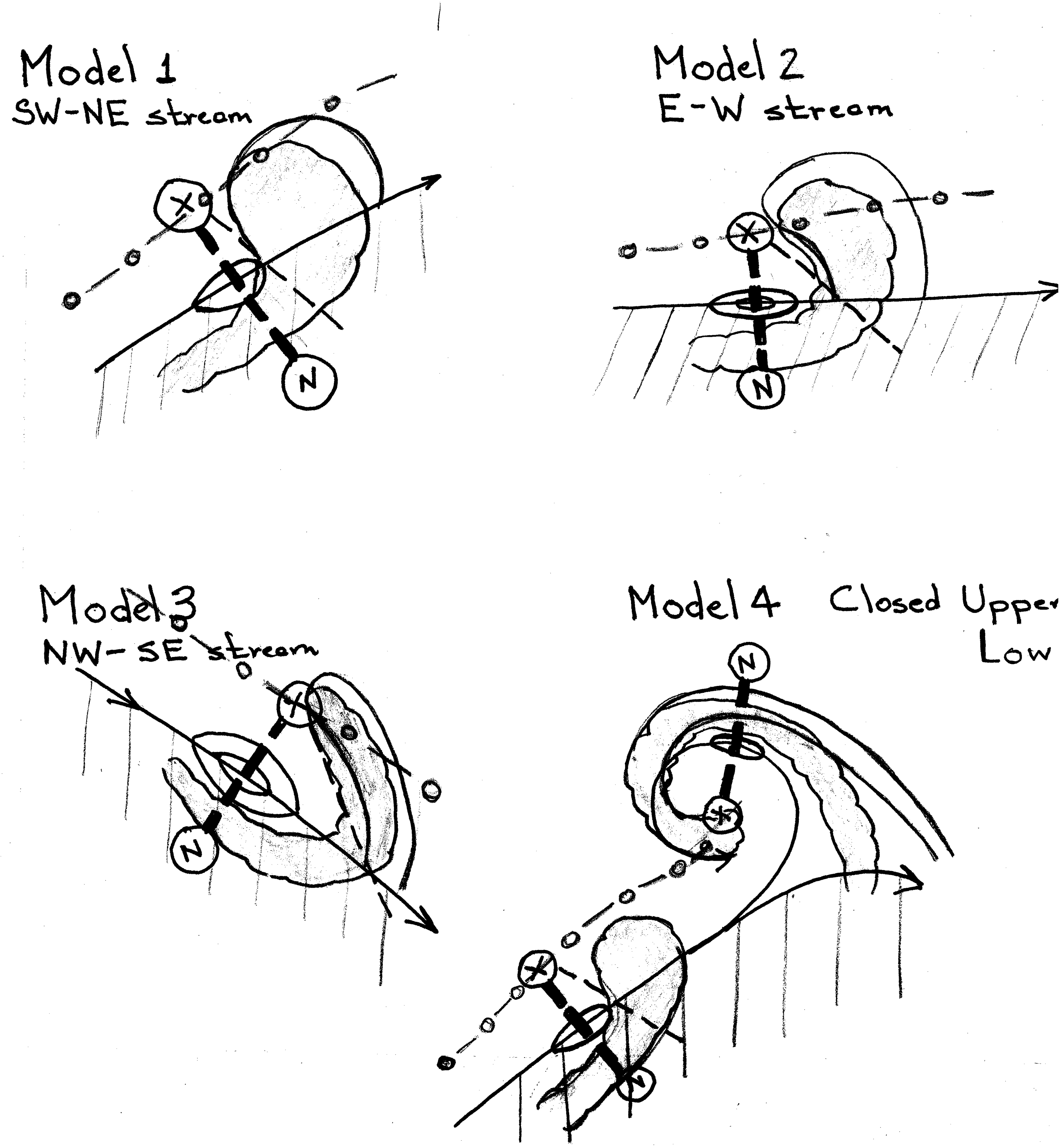


FIGURE NO 2 SCHEMATIC DIAGRAMS ILLULSTRATING THE USUAL PLACEMENT OF THE CLOUD SYSTEMS WITH RESPECT TO IMPORTANT FEATURES OF THE WIND FIELD

5ØØ MB STREAM

WIND MAX ON STREAM

VORTICITY MAX

VORTICITY MIN

LINE CONNECTING MAX AND MIN THROUGH WIND MAXIMUM

VORTICITY ADVECTION LOBE

VORTICITY SHEAR LOBE

COMMA CLOUD SYSTEM CIRRUS JET STREAM CIRRUS

2. Mode B

(a) The cloud system such as in 1 will evolve from 1→4 (See figure 2) if a closed circulation is present along the airstream downstream from the wind maximum.

(b) As the cloud system moves into the area of the closed circulation the point of the cloud system rotation and the vorticity center become coincident. Wind maxima are difficult to place. Significant vorticity advection lobes become indistinquisable.

(c) As the cloud system evolves from 1→4, the cirrus edge moves furthur downstream from the lower cloud boundary giving the inverted slope..

E. CONCLUDING REMARKS

Assuming that models as in figures 1 and 2 are realistic in a qualitative manner, the P/A may use an "inverse procedure" based on these models to evaluate the 500 mb analysis over the Pacific. He will look for the significant features of the wind field (wind maximum, vorticity maximum, vorticity minimum, vorticity lobes) to be "well placed" with respect to the cloud systems. If this is the case he may deem the initial analysis acceptable. If not he will have to reject the analysis and the computer prognosis based on that initial field.

Subsequent notes will deal with and give examples of this procedure.

F. REFERENCES

1. R.B. Weldon, Satellite Training Notes, NESS

G. ACKNOWLEDGEMENTS

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