PACIFIC REGION TECHNICAL NOTES

81-021

October 5, 1981

THE UPSLOPE EFFECT?

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INTRODUCTION

For many years, meteorologists have noticed that accumulated precipitation on the windward side of a mountain chain was greater than that on the lee side of the same mountains. Most textbook explanation of this phenomenon are usually referred to as the classical "orographic upslope effect".

CLASSICAL EXPLANATION

The classical explanation was mostly formed by assumption rather than observation. The usual explanation is close to the following.

(1) THEORY

The airflow when encountering a mountain range is made to flow up the range resulting in; adiabatic expansion of the air parcel, cooling to saturation, causing condensation, cloud formation and enhancement of precipitation. On the lee side of the mountains the air is allowed to subside. Cloud entrained in the subsidence area evaporates. Refer to Figure Number 1.

This effect results in a precipitation pattern whereby the precipitation is heavy to the windward side of the mountains and light to the leeward side.

(2) EFFECT ON OPERATIONAL FORECASTS

The operational forecaster generally attributes cloud and precipitation to upslope conditions when they occur along or near a mountain range in the absence of an organized weather system. Area forecasts for aviation and public uses would often mention "showers near the mountains".

ANOTHER THEORY

The remainder of the note develops another possible explanation for the orographic effect.

(1) DEFORMATION IN THE WIND FIELD

If a strong deformation area exists in a wind field, bands of cloud will seemingly merge in the deformation zone. Each band of cloud seems to

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contribute to the cloud layer. Also, the precipitation field is enhanced in a non-linear manner. It is important to note that this effect occurs on the upstream side of the deformation line. See Figure Number 2.

(2) PRECIPITATION CLOUDS - LOW OR MIDDLE

The classical frontal models assume that most precipitation occurs where layered cloud is the most extensive in the vertical. We still see the "after effects" of this theory by the over emphasis on so called "middle cloud" in operational system analysis and prognosis.

Observation of high resolution satellite imagery seems to indicate that most precipitation occurs in areas where the cloud is highly convective and probably lower based but not necessarily extensive in the vertical.

(3) EFFECTS OF MOUNTAIN RANGES

What are the effects of the mountain ranges roughly aligned parallel to the B.C. coasts? Rather then a surface wind being forced upward and then downward over the mountain range it is more likely that the wind flow tends to be deflected parallel to the mountain range. This effect causes deformation in the wind field. The "deformation effect" of mountains is inherent in the conservation of potential vorticity theorm in a barotropic atmosphere. This effect is consistent with the high frequency and persistence of low pressure centres at all levels just off the North American coasts.

(4) TOTAL EFFECT

With the above concepts in mind, an alternate explanation of the high cumulative amounts of precipitation along the B.C. outer coasts is possible.

Cloud bands produced over the oceans propagate in the flow towards the coast and the mountain range. These cloud bands are frequently small scale clusters of convective cloud. When the cloud band undergoes deformation (induced by the mountains) it stretches and slows and tends to persist along the mountain range. The mountain range tends to coincide with the deformation line of very low levels. Higher level cloud associated with the band can propagate over the mountain range until it reaches the deformation zone at its atmospheric level.

Since most precipitation falls out of the lower based cloud, the windward side of the mountain receives more precipitation.

Often more than one cloud band is formed in the stream. Each successive band approaches the deformation zone on the windward side of the mountain.

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The net effect seems to result in more intensive precipitation than the sum of the individual bands. This gives the appearance of classical orographic enhancement. (See Figure 3).

SUMMARY

The main effect of a mountain chain is to cause deformation in the wind field. At levels lower than the mountain ridges the deformation zone lies to the windward side of the mountains. When cloud bands are formed in the stream, they propagate downstream, deform, slow and become quasi-stationary in the deformation zone. When another band undergoes the same process and merges with the preceeding band, the interaction results in a sudden expansion of the precipitation areas. The result is a seemingly classical "orographic" effect.

The actual "proof" of such an effect will require a high resolution observation network with high resolution visual image loops, radar loops, etc.

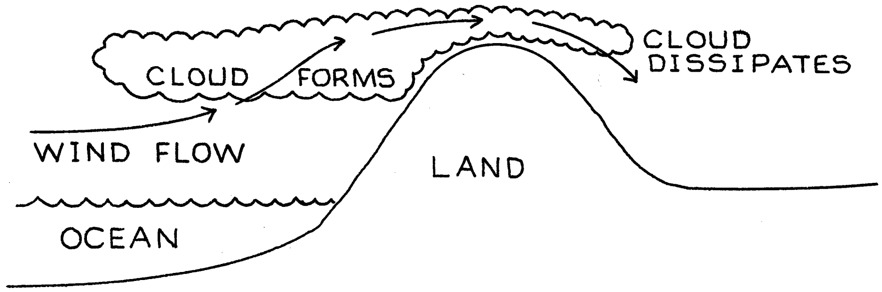

FIGURE 1.

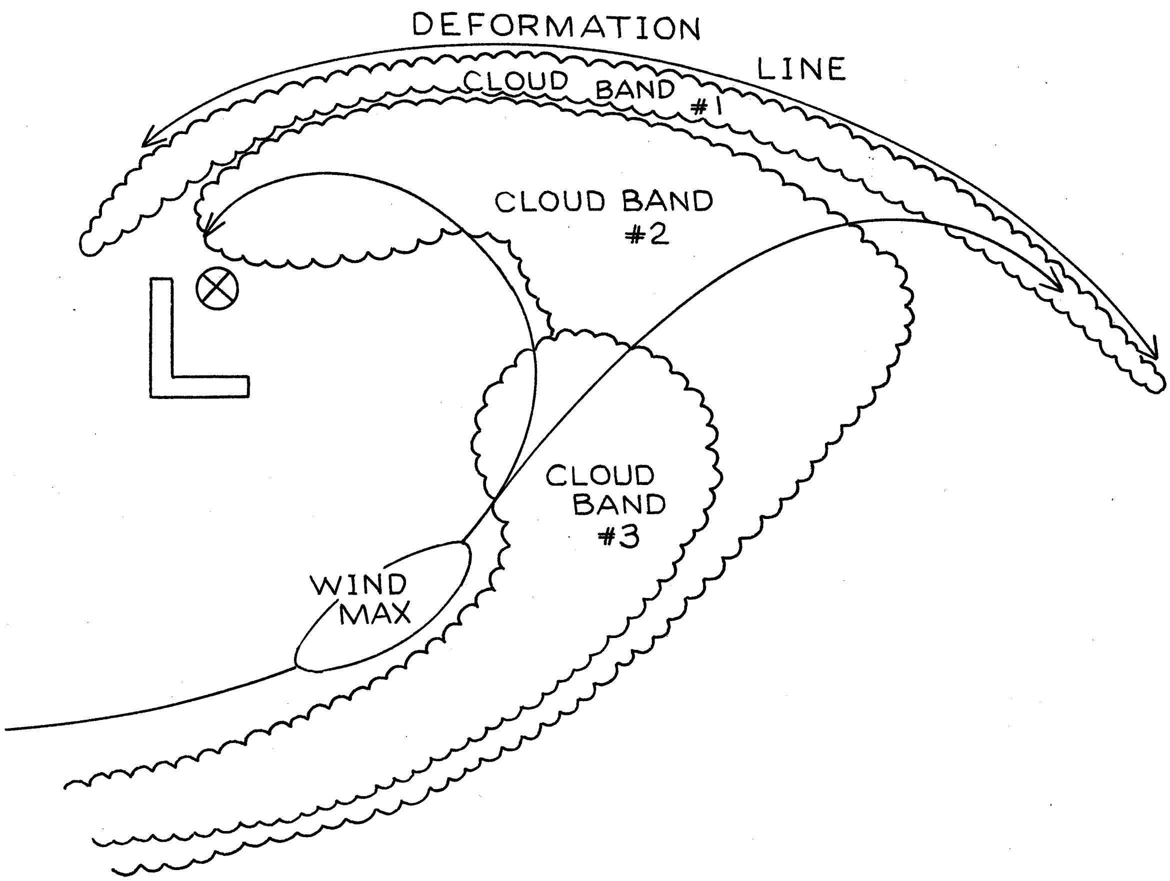

FIGURE 2.

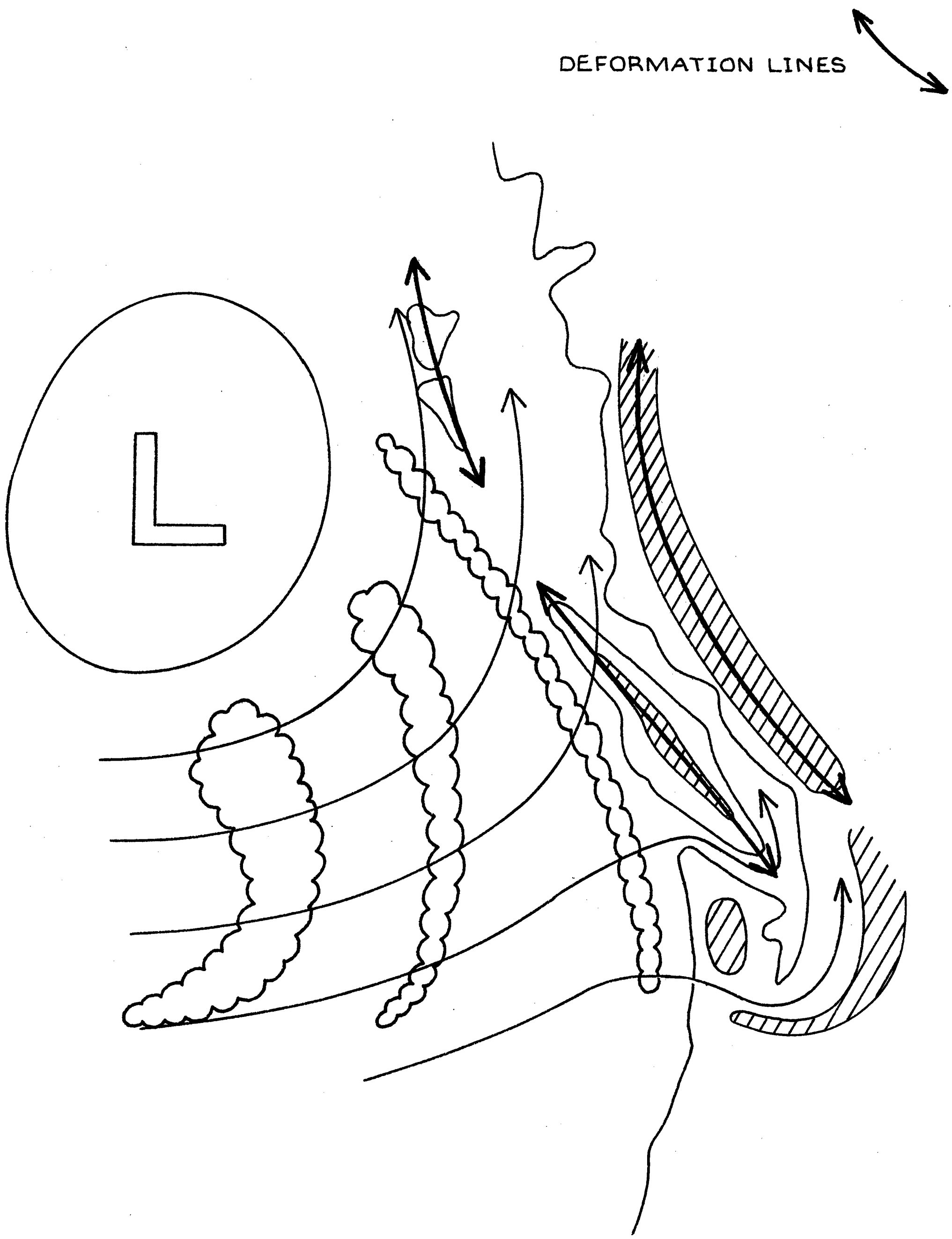

FIGURE 3.