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AN EXAMPLE OF INDUCED WAVE CYCLOGENESIS
OR
SEVEN HOURS OF MODERATE RAIN AT VANCOUVER
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INTRODUCTION

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IT CAME TO PASS, THAT ON NOVEMBER THIRD, SEVEN HOURS (00 TO 06 GMT) OF MODERATE RAIN WAS OBSERVED AT VANCOUVER. MODERATE PRECIPITATION WAS ALSO RECORDED AT NEARBY LOCATIONS.

THE AUTHOR WILL PRESENT A BRIEF DISCUSSION ON THE GENESIS OF THE WEATHER SYSTEM RESPONSIBLE, PLACING THE EMPHASIS ON SATELLITE IMAGERY.

INITIALLY THE SITUATION WAS CHOSEN FOR THE MODERATE RAIN AT VANCOUVER. HOWEVER, UPON A CLOSER EXAMINATION, IT WAS FOUND THAT THE EVOLUTION OF THE DISTURBANCE WOULD PROVIDE AN EXCELLENT EXAMPLE OF THE "INDUCED WAVE" CYCLOGENESIS AS DESCRIBED IN THE LITERATURE.

DEFINITION OF INDUCED WAVE CYCLOGENESIS

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A SHORT WAVE DISTURBANCE ADVANCES ACROSS THE "COLD" AIR TO THE REAR OF AN ORIGINAL BAROCLINIC ZONE. THE SHORT WAVE THEN "TRIGGERS" A WAVE ON THE ORIGINAL BAROCLINIC ZONE. THE MAIN JET STREAM AND FRONTAL ZONE OF THE RESULTANT MATURE CYCLONE ARE THOSE OF THE ORIGINAL ZONE WHICH HAS RESPONDED TO THE DISTURBANCE.

CLOUDS AND WEATHER PATTERNS OF THE INDUCED WAVE CYCLOGENESIS

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FIGURES 1A TO 4A REPRESENT THE FOUR MAIN STAGES OF THE EVOLUTION OF THE DISTURBANCE. WHEREAS FIGURES 1B TO 4B DO ILLUSTRATE THE GENERALIZED DEVELOPMENT OF THE "INDUCED WAVE". LASTLY FIGURES 5A AND 5B DEPICT THE SYSTEM FULLY DEVELOPED AND THE ASSOCIATED SURFACE PATTERN RESPECTIVELY.

A. FIRST PHASE (FIGS. 1A, 1B)

CASTING A CONCERNED GLANCE OVER THE PACIFIC, WE NOTE A LARGE AMPLITUDE TROUGH BOUNDED ON EITHER SIDE BY EXTENSIVE CLOUD MASSES (A FEW 500 MB HEIGHT CONTOURS HAVE BEEN SKETCHED ON THE PICTURE FROM THE CMC INITIAL ANALYSIS AT 00 GMT, NO DECENT PHOTOGRAPH WAS AVAILABLE FOR 00 GMT).

EAST OF THE TROUGH AN EXTENSIVE NORTHWARD INTRUSION OF MOISTURE AND CLOUD FROM THE TROPICS IS EVIDENT. THUS THE MAIN BAROCLINIC ZONE STRETCHES FROM HAWAII TO THE WASHINGTON COAST. THE ASSOCIATED JET STREAM (DENOTED BY ARROWS) LIES JUST ALONG THE NORTHERN CLOUD EDGE. A NORTHERN JET (NOT SO OBVIOUS) LIES ACROSS THE ALEUTIAN ISLAND CHAIN.

NO WAVE DEVELOPMENT IS EVIDENT ALONG THE SOUTHERN MAIN STREAM.

EMBEDDED WITHIN THE EXTENSIVE FIELD OF OPEN CELLULAR CLOUD WE DO NOTE A SMALL ORGANIZED AREA OF BRIGHTER CLOUD (OUTLINED BY DASHES). THIS AREA OF ENHANCED CUMULUS (GENERALLY 3 TO 5 DEGREES ACROSS) HAS TRACKED FROM THE NORTHWEST. OFTEN SUCH AN AREA IS OBSERVED IN THE "COLD" AIR BEHIND A MAJOR CLOUD BAND AND BETRAYS THE PRESENCE OF A VORTICITY MAXIMUM AND ASSOCIATED 500 MB TROUGH LOCATED ALONG THE UPWIND EDGE OF THE AREA. NOT ALL SUCH AREAS DEVELOP OR INDUCE A WAVE. COMPARING THE PICTURE TO THE SKETCH BELOW WE DO NOTE A SIMILARITY TO THE IDEALIZED PATTERN ILLUSTRATING THE FIRST PHASE OF THE INDUCING WAVE PROCESS.

B. SECOND PHASE (FIGS. 2A, 2B)

THE ENHANCED AREA (DASHED) HAS ARRIVED AT THE MAIN STREAM AND DEFORMED SOMEWHAT INTO A QUASI COMMA STRUCTURE.

FURTHER THE REAR EDGE OF THE BAROCLINIC ZONE HAS ALSO BEGUN TO DEFORM AS WELL. THE CIRRUS DECK AHEAD HAS PUSHED NORTH ACROSS CENTRAL B.C. AND DEVELOPED A SHARP DISTINCTIVE POLEWARD EDGE. THE SHARPENING OF THE CLOUD EDGES ARE INDICATIVE OF A STRONG SHEAR AND BAROCLINIC ZONE. IN ADDITION, WE MAY POSTULATE THAT THE CLOUD PATTERNS WILL TEND TO ADVANCE RAPIDLY EAST AS THE SYSTEM ACROSS THE ALEUTIANS HAS BEEN ADVANCING RAPIDLY. THIS IS EASILY OBSERVED FROM THE MOTION OF THE WELL MARKED SUBSIDENCE BOUNDARY (DENOTED BY THE DASH-DOT LINE) TO THE REAR.

A CASUAL GLANCE AT THE SKETCH BELOW REVEALS A GOOD CORRELATION BETWEEN THE ACTUAL DEVELOPMENT AND THE SECOND PHASE OF THE INDUCED WAVE.

C. THIRD PHASE (FIGS. 3A, 3B)

HERE A FAIRLY WELL DEVELOPED COMMA HEAD IS VISIBLE WITH THE COMMA TAIL NOT PRESENT BUT LIKELY OBSCURED BY THE CIRRUS DECK ABOVE. THE TWO JET STREAMS APPEAR TO HAVE MERGED AS WELL.

THE CIRRUS HAS NOW MARKEDLY DEFORMED JUST TO THE REAR OF THE COMMA HEAD, AND A BROAD FEATHERY CIRRUS DECK EXTENDS AHEAD.

AN INTERESTING FEATURE HERE ARE THE TRANSVERSE LINES (OR CLOUD TRAILS) APPEARING AS IRREGULAR WAVES IN THE CIRRUS DECK JUST OFF THE WEST COAST OF VANCOUVER ISLAND, ALONG THE 564 CONTOUR LINE. THESE LINES ARE GENERALLY ORIENTED 50 TO 90 DEGREES TO THE WINDS FLOW AND ASSOCIATED WITH WIND SPEEDS OF 80 KNOTS OR MORE. THE 500 MB WIND AT THE NORTHWEST CORNER OF WASHINGTON WAS REPORTED AT 75 KNOTS AT THIS TIME. THESE LINES ARE BELIEVED THE RESULT OF HORIZONTAL (POSSIBLE VERTICAL) SHEAR. THE CONCENTRATED ZONE OF CLOUD THUS

BESPEAKS OF A BAND OF STRONG SHEAR AND BAROCLINICITY (THE HORIZONTAL TEMPERATURE GRADIENT BETWEEN THE EXTREME NORTH AND SOUTH ENDS OF VANCOUVER ISLAND FROM 850 TO 500 MB WAS OF THE ORDER OF 10 C).

AGAIN A FAIR RELATIONSHIP EXISTS BETWEEN THIS STAGE AND THE ONE CORRESPONDING TO THE THIRD INDUCED WAVE CASE.

D. FOURTH PHASE (FIGS 4A,4B)

FOUR HOURS LATER A WELL DEFINED COMMA IS EVIDENT (OUTLINED BY THE DASHED CURVE). PART OF THE CLOUD DEBRIS LEFT FROM AN EARLIER SYSTEM OVER NORTHWESTERN BC HAS PARTIALLY MERGED WITH THE GENERAL COMMA CLOUD AREA.

NOTE THE "SLOT" IN THE MIDDLE AND HIGHER CLOUD DECK JUST TO THE LEFT OF THE MAIN COMMA HEAD.

THE DISTINCTIVE DRY "SLOT" AND SUBSIDENCE BOUNDARY IS EVIDENT JUST TO THE REAR WHERE THE JET CROSSES THE DASHED LINE. NEAR THIS LOCATION (AROUND 130W 45N) ONE MAY SAFELY PLACE A STRONG WIND MAXIMUM.

AT THIS TIME, THE SYSTEM IS DEVELOPED AND WITHIN THE AREA SOUTH OF THE JET STREAM AND BOUNDED BY THE DASHED CURVE MODERATE RAIN WAS REPORTED AT THE TIME BY A NUMBER OF STATIONS. THESE LOCATIONS (EX. VANCOUVER, ABBOTSFORD, HOPE, PAT BAY, NANAIMO) ALL RECORDED BETWEEN 25 TO 35 MM OF PRECIPITATION DURING THE TIME INTERVAL (ABOUT 6 HRS) THAT THE DISTURBANCE WAS PRESENT.

NOTE THE SIMILARITY BETWEEN THE SYSTEM AND THE SKETCH OF THE GENERALIZED FOURTH PHASE OF THE "INDUCED WAVE" CYCLOGENESIS".

E. DEVELOPED PHASE (FIGS. 5A,5B)

OF IMPORTANCE HERE IS THE VERY WELL MARKED SUBIDENCE BOUNDARY ACROSS WESTERN WASHINGTON. THIS IS COMMONLY BELIEVED TO BE A GOOD INDICATOR THAT THE VORTICITY COMMA CLOUD PATTERN IS STRENGTHENING: THE CLOUD EDGES BECOME BETTER DEFINED. THIS IS ESPECIALLY TRUE ALONG THE REAR EDGES. THE FRONT EDGE IS, OF COURSE, LIKELY TO REMAIN FEATHERED. FURTHER THE "CLEAR" ZONE TO THE REAR OF THE COMMA EDGE WILL BECOME CLEAR (COMPARE FIGS. 4A AND 5A).

FIGURE 5A GIVES THE CORRESPONDING SURFACE ANALYSIS. NOTE THE AREA OF MODERATE RAIN ALONG THE COLD FRONT. OFTEN THE MOST SEVERE ACTIVITY IS POSITIONED JUST AHEAD OF THE STRONG SUBSIDENCE BOUNDARY TO THE REAR OF THE COMMA.

OF INTEREST TO THE OPERATIONAL METEOROLOGIST IS THE RELATIONSHIP BETWEEN THE CLOUD PATTERN AND THE SURFACE LOW. A ROUGH RULE FOR PLACING THE SURFACE LOW CENTRE IS: THE SURFACE LOW WILL USUALLY CONSOLIDATE AT A LOCATION SOMEWHERE NEAR THE REAR EDGE OF THE COMMA HEAD, AND ON THE CYCLONIC SIDE OF WHERE THE JET IS SHOWN CROSSING THE REAR EDGE. IN THIS EXAMPLE THE RULE IS SUBSTANTIATED WHEN WE COMPARE FIGURE 5A AND 5B.

CONCLUSION

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HOPEFULLY, THE SEQUENCE OF EVENTS ILLUSTRATED WILL ALERT OTHER OPERATIONAL METEOROLOGISTS TO A SIMILAR CHAIN OF EVENTS.

ONE WORD OF CAUTION, WHEN A SHORT WAVE DISTURBANCE CROSSES THE "COLD" AIR TO THE REAR OF AN ORIGINAL MAIN BAROCLINIC ZONE IT MAY INDUCE A WAVE ON THE MAIN STREAM OR A COMPLETELY NEW CYCLONE MAY DEVELOP BEHIND THE OLDER ZONE (I.E. A COLD AIR VORTEX SITUATION).

ACKNOWLEDGEMENTS

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0515 03ND78 35E-22A 00451 19311 UC2

FIG. 1A.

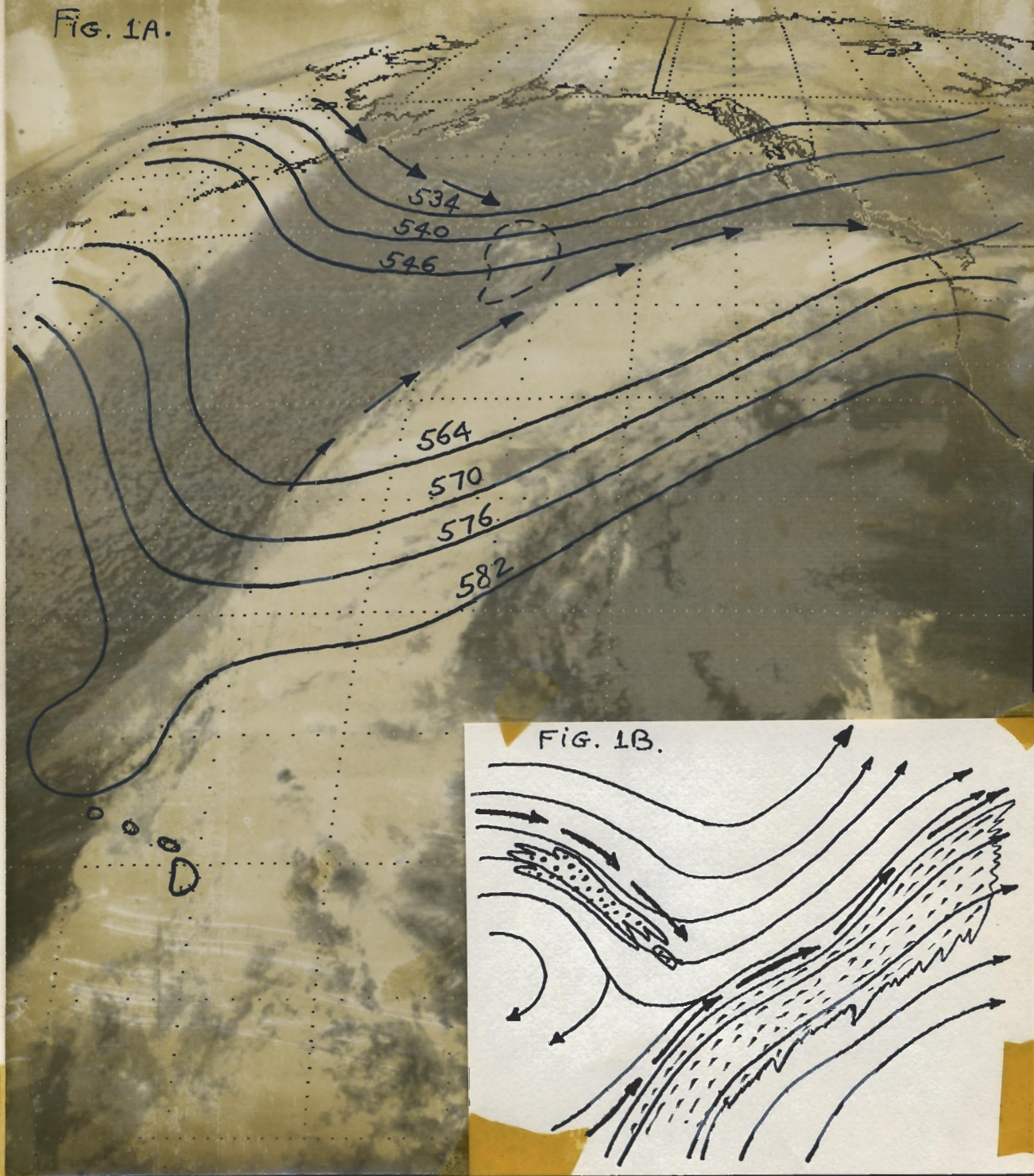


FIGURE 1A. SATELLITE PICTURE FOR NOV 3 1978 AT 0515 GMT. THE SOLID LINES ARE THE 500MB HEIGHT CONTOURS (DECAMETERS) FROM THE CMC 00 GMT ANALYSIS. THE AXIS OF MAXIMUM WINDS (ARROWS) IS SHOWN. AN AREA OF ENHANCED CUMULUS IS OUTLINED BY DASHES. FIGURE 1B. A SKETCH SHOWING THE FIRST PHASE OF AN INDUCED WAVE CYCLOGENESIS. THE SOLID LINES ARE STREAM LINES WITH THE ARROWS THE MAXIMUM WINDS AXIS. THE DASHED AREAS ARE CLOUDS.

Fig. 2A.

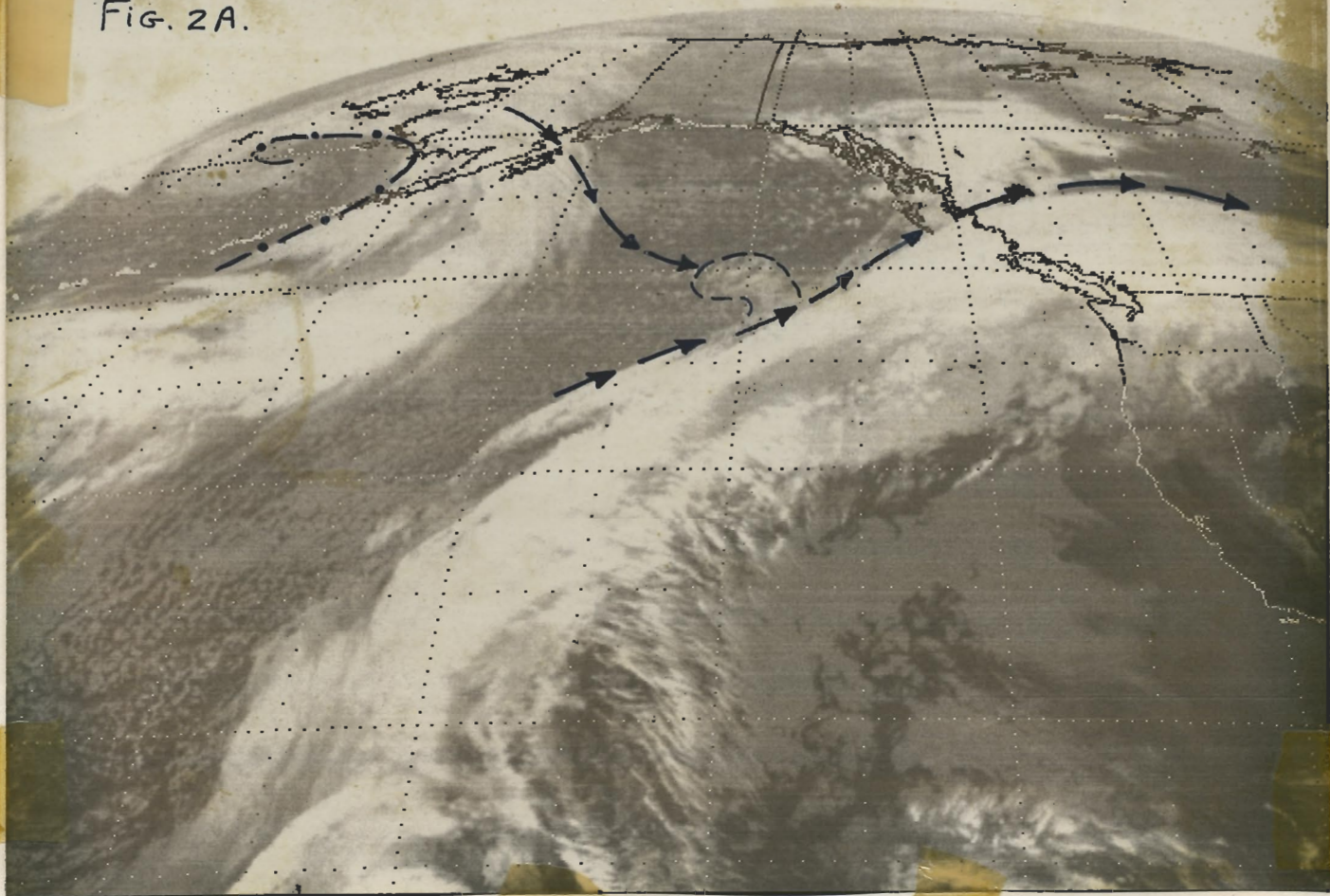


Fig. 2B.

FIGURE 2A. SATELLITE PICTURE FOR NOV 3 1978 AT 1817 GMT. AXIS OF MAXIMUM WINDS DENOTED BY ARROWS AND CUMULUS AREA BY DASHES. THE DASH DOT LINE DEFINES SUBSIDENCE BOUNDARY.

FIGURE 2B. IDEALIZED SKETCH OF THE SECOND PHASE OF INDUCED WAVE CYCLOGENESIS.

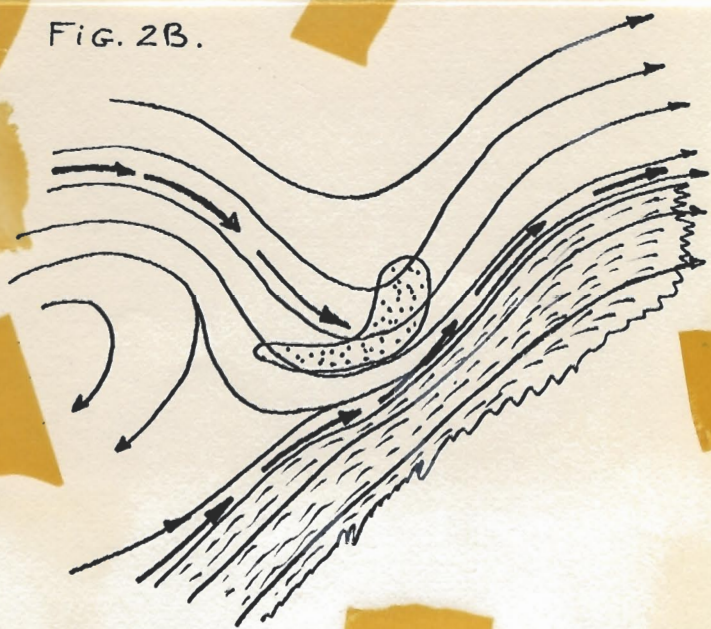




FIGURE 3A. SATELLITE PICTURE FOR NOV 3 1978 AT 2315 GMT. SOLID LINES ARE 500MB CONTOURS (DECAMETERS) FROM CMC ANALYSIS AT 00 GMT. AREA OF ENHANCED CLOUD OUTLINED IN DASHES. ARROWS DENOTE MAXIMUM WIND AXIS.

Fig. 3B

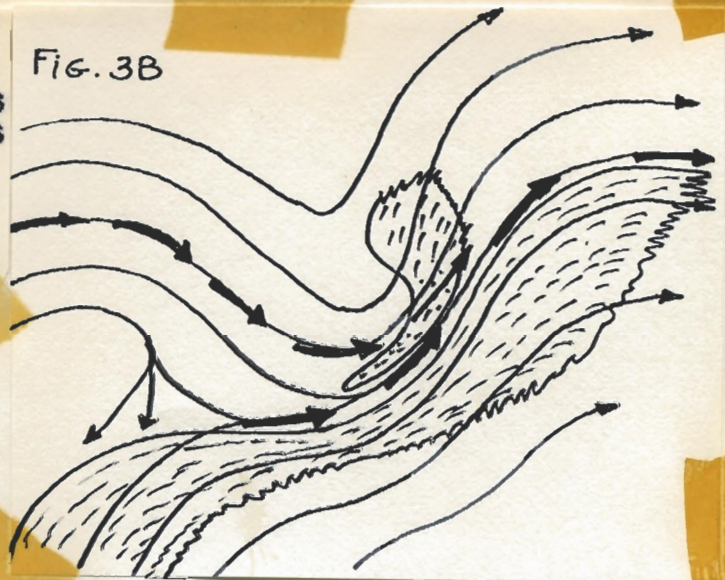


FIGURE 3B. THE THIRD PHASE OF THE INDUCED WAVE CYCLOGENESIS.

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0315 04NOV78 35E-22A 00412 19371 UC2

FIG. 4A.

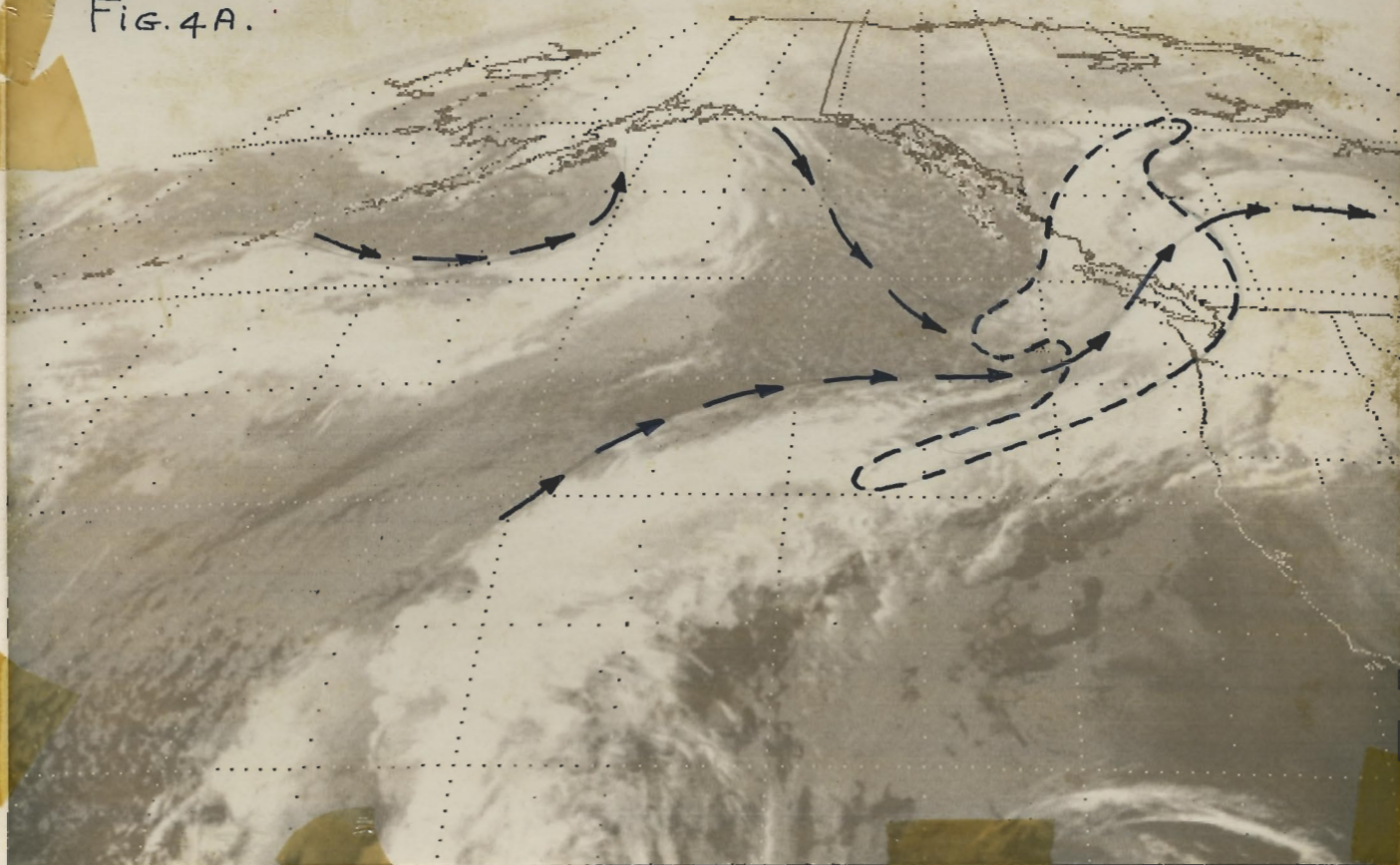
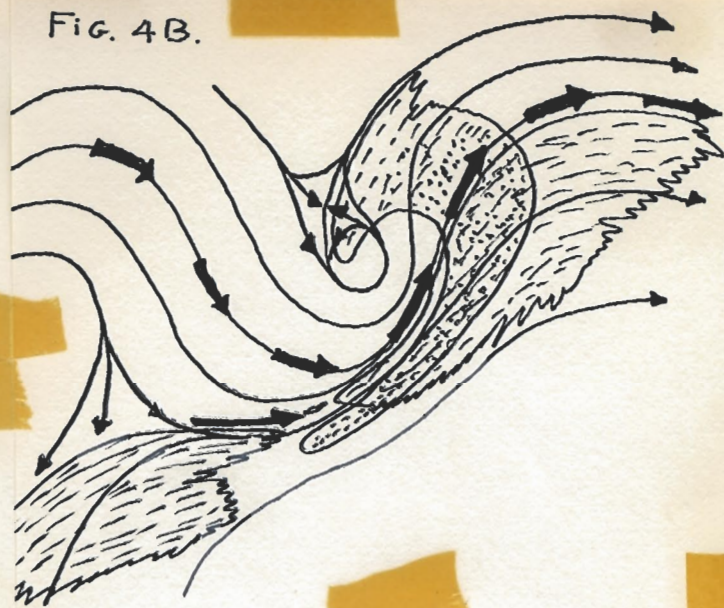


FIGURE 4A, SATELLITE PICTURE FOR NOV 4 1978 AT 0315 GMT, ARROWS ARE THE AXIS OF MAXIMUM WINDS FLOW AND THE DASHED CONTOUR OUTLINES THE COMMA SHAPED SYSTEM.

FIGURE 4B, REPRESENTS THE FOURTH PHASE OF THE INDUCED WAVE CYCLOGENESIS.

FIG. 4B.



0715 04N078 35E-22A 00451 19261 UC2

Fig. 5A.

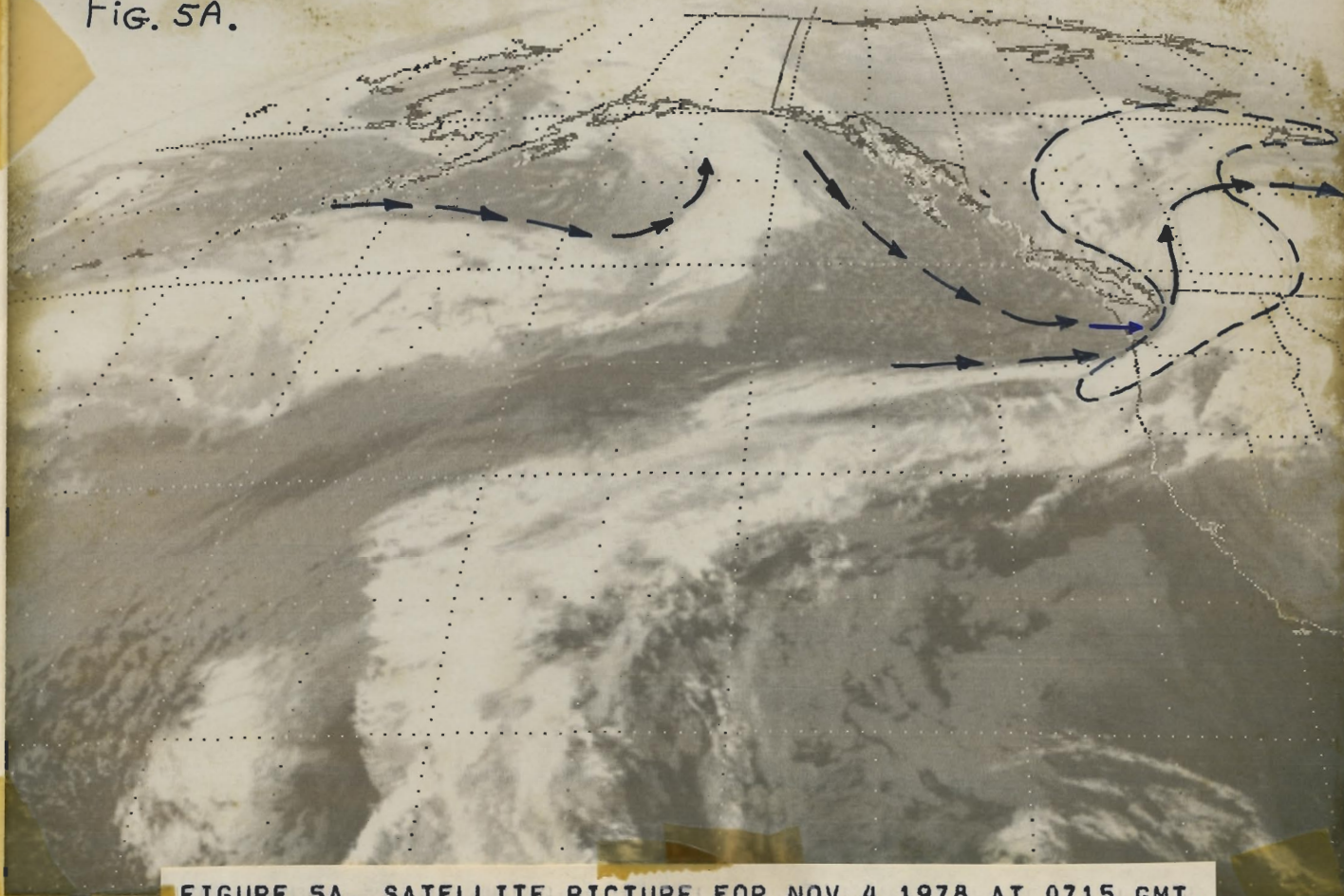


FIGURE 5A. SATELLITE PICTURE FOR NOV 4 1978 AT 0715 GMT, AXIS OF MAXIMUM WIND DENOTED BY ARROWS AND COMMA CLOUD STRUCTURE OUTLINED BY THE DASHED LINE.

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Fig. 5B.

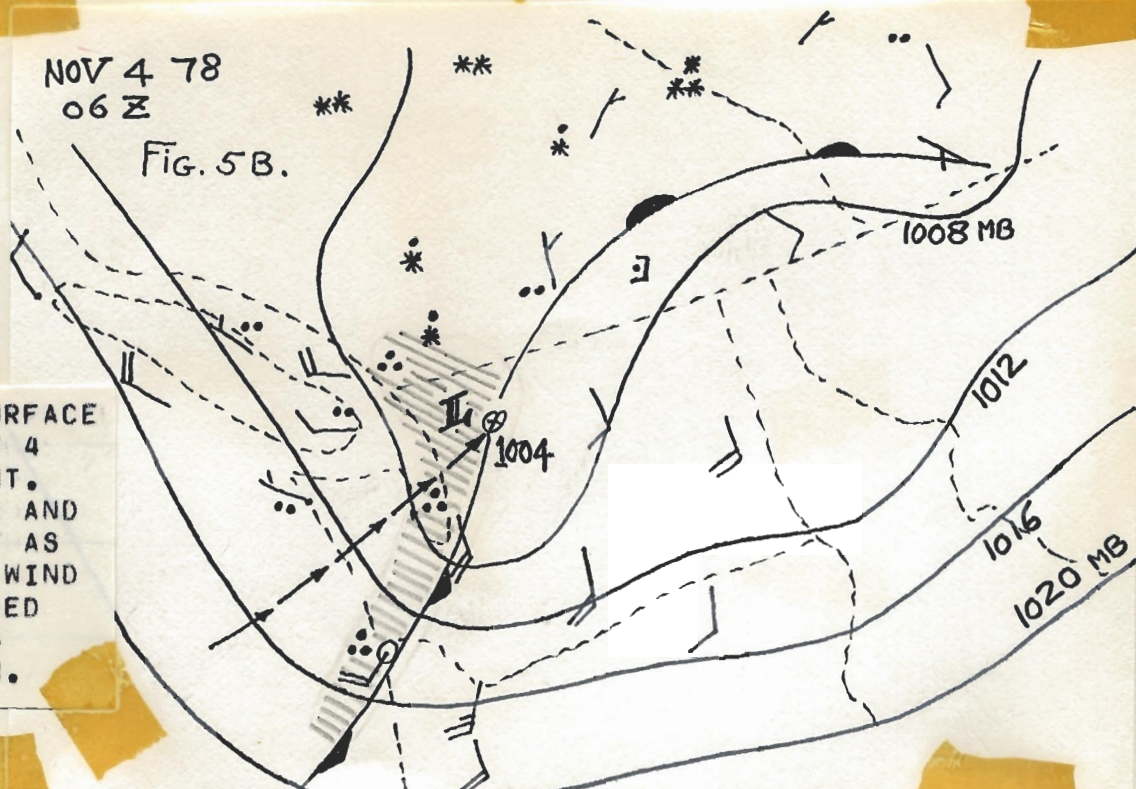


FIGURE 5B. SURFACE CHART FOR NOV 4 1978 AT 06 GMT. GIVES ISOBARS AND SURFACE FRONT AS WELL AS SOME WIND VECTORS. SHADED AREA OUTLINES MODERATE RAIN.