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IDENTIFICATION OF CLOUDS AND OTHER FEATURES ON SATELLITE PICTURES

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THE BEST WAY OF IDENTIFYING DIFFERENT TYPES OF CLOUDS ON SATELLITE PICTURES IS TO COMPARE A VISUAL PICTURE WITH AN INFRARED (IR) TAKEN AT THE SAME TIME. IN ORDER TO ACHIEVE THE BEST ESTIMATE OF THE CLOUD TOP TEMPERATURE IT IS BEST TO HAVE DIFFERENT ENHANCEMENTS OF THE IR DATA. IN THIS EXAMPLE A VISUAL PICTURE, AN IR-ZA ENHANCEMENT, AND AN IR-EC ENHANCEMENT TAKEN WITHIN AN HOUR OF EACH OTHER WILL BE USED.

A VISUAL PICTURE IS TAKEN BY A TELEVISION CAMERA MOUNTED ON THE GOES SATELLITE. IN EFFECT, IT SENSES THE ALBEDO OF THE REFLECTING SURFACE, I.E. THE ABILITY OF THE SURFACE TO REFLECT SHORT-WAVE RADIATION EMITTED BY THE SUN AND TRANSMITTED TO THE SURFACE IN QUESTION. AN IR PICTURE IS CONSTRUCTED FROM THE TOTAL LONG-WAVE RADIATION REACHING THE IR SENSOR. THE RADIOMETER MEASURES RADIATION BETWEEN 10.5 AND 12.6 MICRONS ONLY. THIS IS THE SO CALLED "ATMOSPHERIC WINDOW" WHERE ATMOSPHERIC RADIATION IS AT A MINIMUM.

WHEN IDENTIFYING FEATURES FROM A SINGLE SATELLITE PICTURE, THE KEY COMPONENTS ARE EXPERIENCE AND PATTERN RECOGNITION. ADDITIONALLY AND/OR ALTERNATIVELY, A SYSTEMATIC APPROACH COULD BE TO COMPARE A VISUAL PICTURE WITH IR PICTURES OF VARIOUS ENHANCEMENTS. COMPARING A VISUAL PICTURE WITH AN IR-ZA ENHANCEMENT WOULD ALLOW ONE TO DISTINGUISH LOW CLOUDS FROM MIDDLE AND HIGHER CLOUDS. LOW CLOUDS REGISTER GREY AND WARM ON THE IR-ZA. HIGHER CLOUDS WOULD REGISTER WHITE AND COLDER. TO DISTINGUISH MIDDLE FROM HIGH CLOUD THE IR-ZA COULD BE COMPARED WITH THE IR-EC ENHANCEMENT. THE EC ENHANCEMENT ALLOWS FOR GREATER SENSITIVITY IN THE INDICATED CLOUD TOP TEMPERATURES IN THE COLD PART OF THE SPECTRUM. THE ABOVE IS BEST ILLUSTRATED BY AN EXAMPLE WHICH IS LATER INCLUDED IN THIS PAPER.

CIRRUS IS USUALLY THE HIGHEST CLOUD FOUND IN THE ATMOSPHERE. THEREFORE FROM THE POINT OF VIEW OF THE SATELLITE SENSORS IT IS UNOBSCURED. ALTOSTRATUS IS ALMOST ALWAYS OBSCURED BY CIRRUS. THIS CLOUD MAY LAY BY ITSELF IN PATCHES WHEN A SYSTEM IS GREATLY SHEARED WITH RESPECT TO ITSELF AND IS AT THE END OF ITS LIFE CYCLE. ALTOCUMULUS IS IDENTIFABLE ON VISUAL PICTURES BECAUSE OF THE SHADOWS THE PLUMES CAST ON THE MAIN CLOUD TOP LAYER. ALTOSTRATUS IS NOT IDENTIFABLE FROM ALTOCUMULUS ON THE INFRARED PICTURES. THIS IS A DIRECT RESULT OF THE FOUR MILE RESOLUTION LIMITATION OF THE RADIOMETER DATA. (AT 50 DEGREES LATITUDE THE RESOLUTION IS MORE LIKE 8 MILES). LOW CLOUDS SUCH AS FOG, STRATUS, AND STRATOCUMULUS ARE OFTEN FOUND IN REGIONS OF HIGH PRESSURE AND ARE UNOBSCURED BY HIGHER CLOUD. THIS MAKES THEIR IDENTIFICATION RELATIVELY EASY. CONVECTIVE CLOUD SUCH AS TCU'S AND CB'S ARE ALSO FOUND UNOBSCURED BY OTHER CLOUD AND THUS ARE EASILY IDENTIFIED.

FOR OUR EXAMPLE LET US NOTE THE PICTURES OF FIGURES 1 TO 3. HERE IS A TYPICAL MATURE EXTRA-TROPICAL STORM. THE DISTRIBUTION OF THE OVERLYING BAROCLINIC CIRRUS AND THE UNDERLYING COMMA CLOUD IS SHOWN IN THE SKETCH OF FIGURE 4. THE PICTURES ARE TAKEN CLOSE ENOUGH IN TIME TO CONSIDER THE CHANGE IN THE CLOUD PATERN TO BE NEGLIGIBLE. THE CLOUD TOP TEMPERATURES ARE READ OFF THE SCALES. THE NEAREST TICK TO THE FIRST ZERO OF THE FOURTH GROUP INDICATES ZERO DEGREES CENTIGRADE. THE INDICATED TEMPERATURES BECOME WARMER TOWARDS THE TOP OF THE PAGE AND COLDER TOWARDS THE BOTTOM OF THE PAGE. THE TICK MARKS ARE 10 DEGREES CENTIGRADE APART.

ON THE FIGURES ARE POINTS A TO G INCLUSIVE. THE CLOUD OR OTHER FEATURES AT THE INDICATED POINTS WILL BE DISCUSSED (BRIEFLY) AND (HOPEFULLY) THE IMAGERY WILL BE EXPLAINED.

(A) THIS CLOUD SHOWS A MEDIUM BRIGHTNESS ON THE VISUAL BUT IS INDISTINQUISHABLE ON THE BASIS OF BRIGHTNESS ALONE FROM OTHER CLOUDS IN THE PICTURE. HOWEVER ON THE IR-ZA THE MAIN GRAY SHADE SHOWS A CLOUD TOP TEMPERATURE OF ABOUT 5 DEGREES WITH SOME COLDER TOPS IN THE VICINITY. REFERING TO THE IR-EC, ONE SEES INDICATED CLOUD TOP TEMPERATURES AS COLD AS MINUS 25 DEGREES. THE ABOVE IS REPRESENTATIVE OF CUMULUS OR STRATOCUMULUS CLOUD WITH TCU'S OR CB'S EMBEDDED IN IT.

(B) THE COMMA CLOUD HEAD AT B IS OF VARIABLE BRIGHTNESS ON THE VISUAL BUT SHOWS UP WHITE ON THE IR-ZA. THE VARIABLE BRIGHTNESS ON THE VISUAL SUCH AS AT B IS INDICATIVE OF CONVECTION. THE WHITE DESIGNATION ON THE IR-ZA OF THE CLOUD TOP INDICATES A COLD RADIATING SURFACE. THE IR-EC INDICATES AN AVERAGE CLOUD TOP TEMPERATURE OF ABOUT MINUS 30 DEGREES TO MINUS FORTY DEGREES. THIS INDICATES AN AREA OF AC AND/OR TCU'S AND CB'S.

(C) THE COLDEST CLOUD TOP TEMPERATURE SHOWS UP AT THIS POINT AND REGISTERS AT ABOUT MINUS 55 (AS INDICATED BY THE IR-EC). THIS IS PROBABLY WHERE THE CIRRUS HAS ITS GREATEST OPACITY AND/OR THE UNDERLYING CLOUD LAYER UNDER THE CIRRUS IS THE HIGHEST.

(D) THIS POINT IN THE COMMA TAIL HAS LOWER CLOUD WITH THIN WISPY CIRRUS OVERHEAD. THE WISPY CIRRUS CAN BE SEEN ON THE VISIBLE PICTURE. AT POINT D THE CIRRUS IS VIRTUALLY TRANSPARENT. THE CLOUD TOP TEMPERATURE FROM THE IR-EC IS ABOUT MINUS 15. THIS IS REPRESENTATIVE OF STRATOCUMULUS.

(E) THIS POINTS SHOWS UP DARK IN THE VISUAL. THIS IS AN INDICATION THAT IT IS CLOUD FREE. THE IR SHOWS A WARM SURFACE AND GIVES AND INDICATED TEMPERATURE OF MINUS 5 TO MINUS 10 DEGREES. GIVEN THE LATITUDE AND TIME OF YEAR, THIS MUST BE THE OCEAN SURFCE.

(F) THIS POINT SHOWS THE COASTAL MOUNTAINS WITH THE SNOW CAPPED PEAKS (BRIGHT) AND THE FOREST COVERED VALLEYS (DARK)

(G) THIS POINT IS SIMILAR TO B ON ALL THREE PICTURES. IT IS OF VARIABLE BRIGHTNESS ON THE VISUAL BUT SHOWS UP WHITE ON THE IR-ZA AND GIVES AN INDICATED TEMPERATURE OF ABOUT MINUS FORTY ON THE IR-EC. THEREFORE IT MUST BE AN AREA OF AC AND/OR TCU'S AND CB'S. THE VISUAL INDICATES TWO SMALL SCALE COMMA CLOUDS (THE IR DOES RESOLVE THE CLOUD ELEMENTS AS WELL). TAKING IN ACCOUNT THE ORIGIN AND HISTORY OF THESE CLOUD SYSTEMS (IN A FIELD OF CB'S IN THE COLD AIR, ONE WOULD HAVE TO CONCLUDE THE SYSTEM IS COMPRISED MOSTLY OF TCU'S AND CB'S)

EACH POINT ON THE PICTURES COULD BE ANALYZED SIMILARLY. IN PRACTICE, THE CLOUD IN EACH PART OF THE SYSTEM IS IDENTIFIED BY EXPERIENCE. THE INDICATED CLOUD TOP TEMPERATURE IS READ OFF THE IR-EC ENHANCEMENT. IF A TEMPERATURE SOUNDING REPRESENTATIVE OF THE AREA OF INTEREST IS AVAILABLE, THE CLOUD TOP HEIGHT CAN BE FOUND.

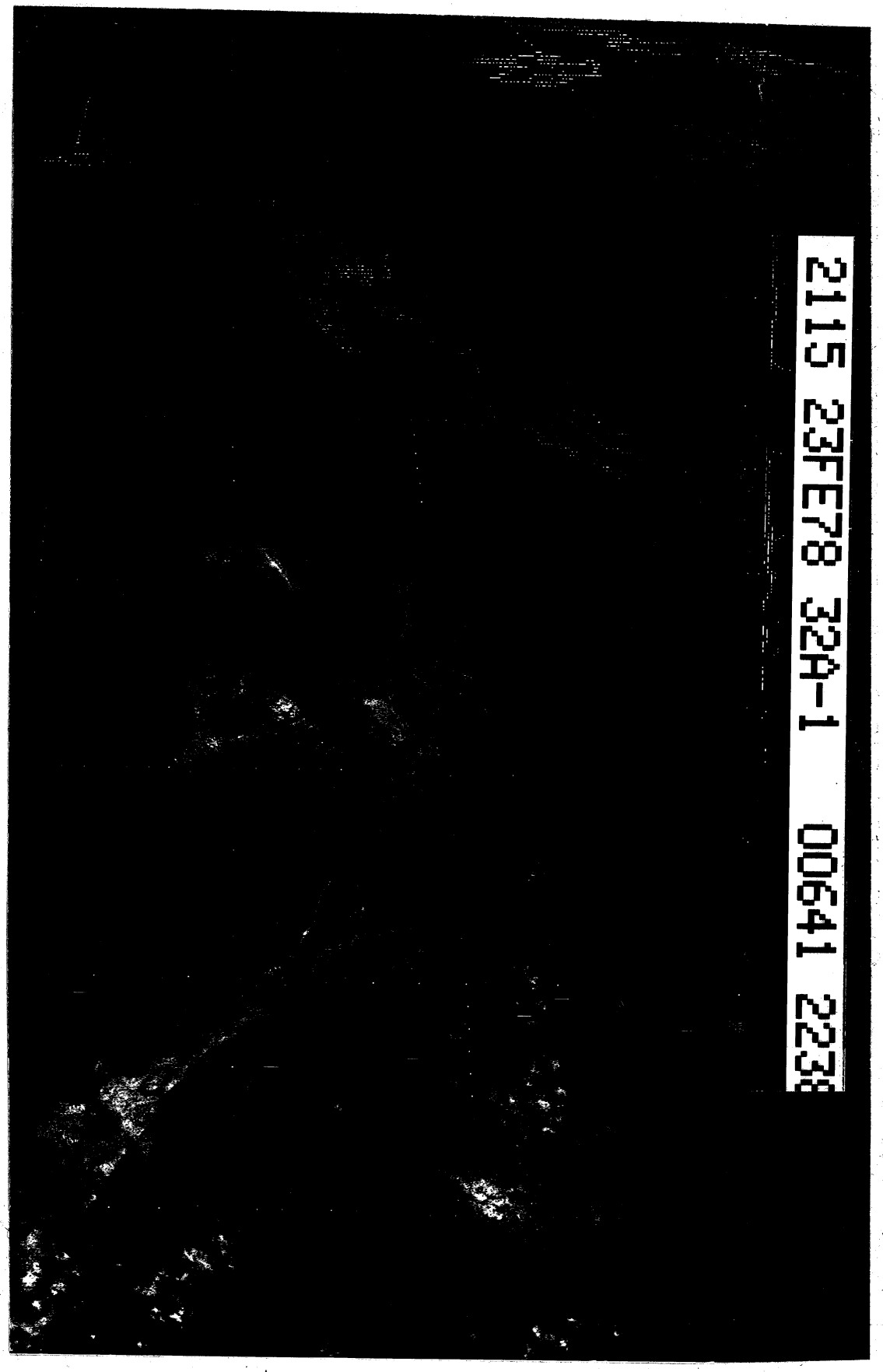

Figure 1. Visual picture taken at 2115z Feb 23, 1978 of a mature cloud system approaching the American coast.

Figure 2. Infrared picture (ZA enhancement) taken at 2145z.

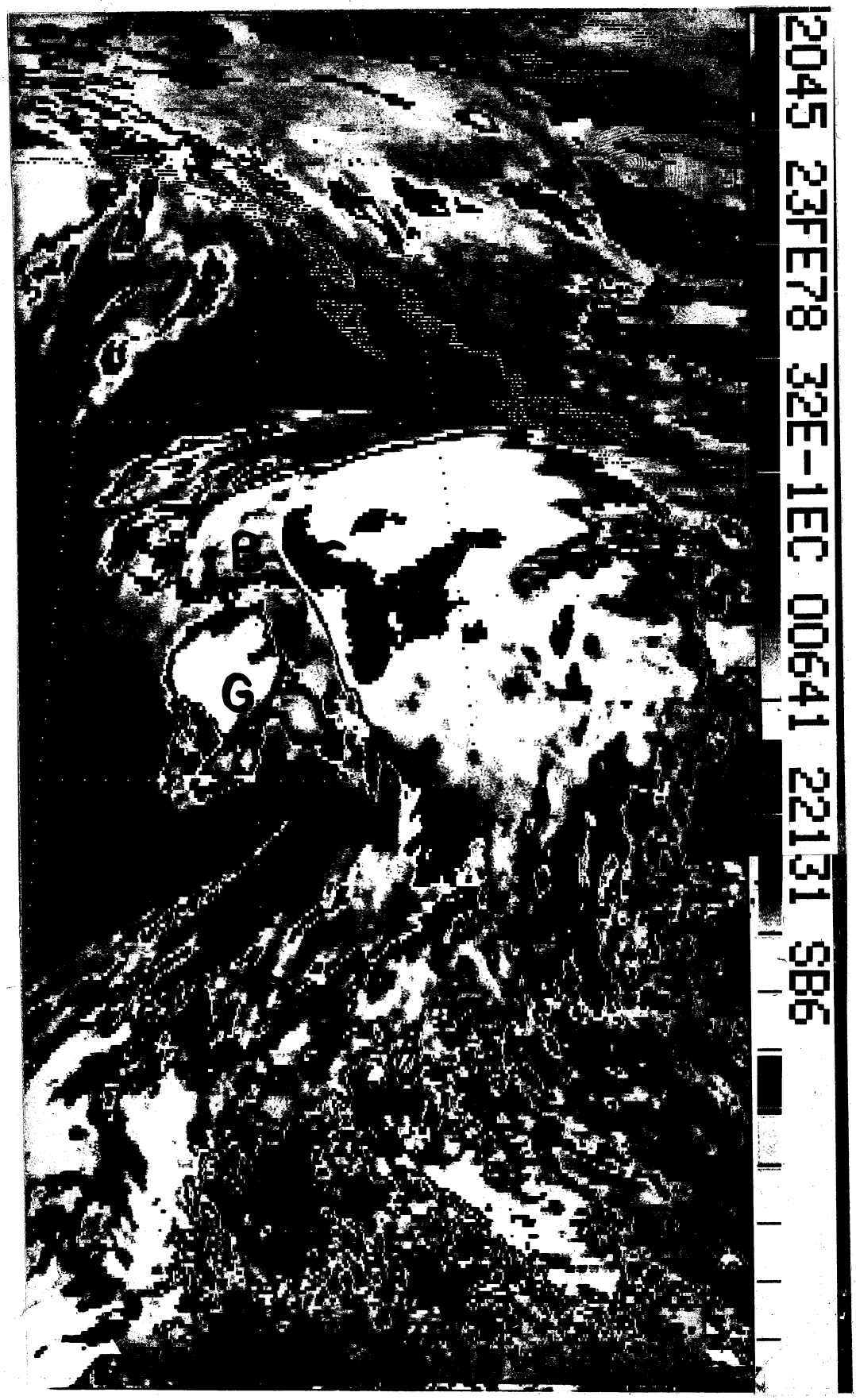

Figure 3. Infrared picture (EC enhancement) taken at 2045Z

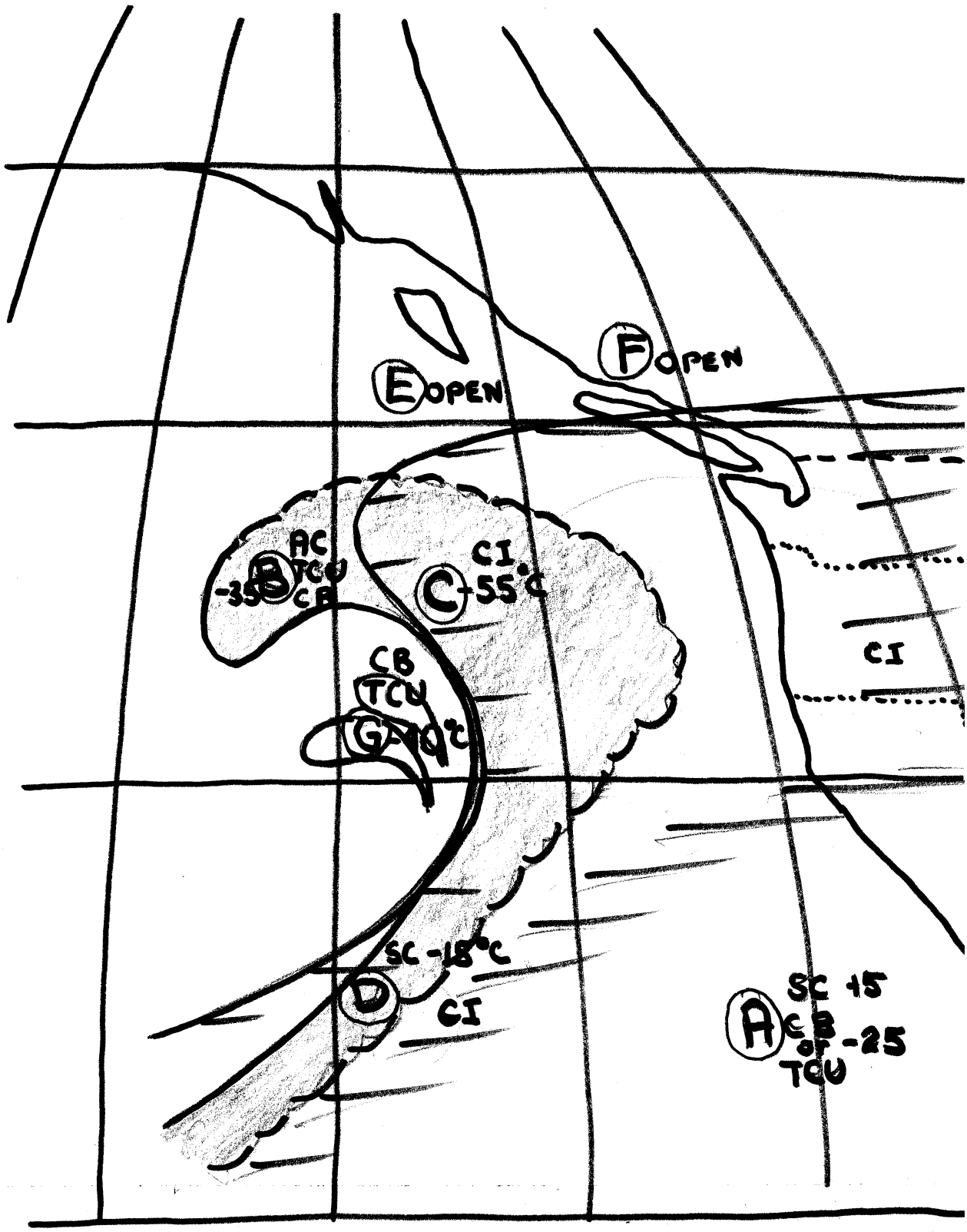

Figure 4. Comma cloud and baroclinic cirrus shield

Schematic representation of the system with the reference points marked and inferred clouds and cloud top temperatures marked.