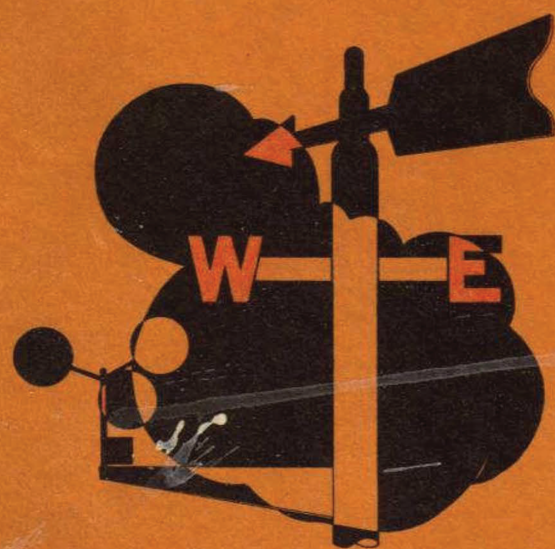
APPENDIX G

NAVIGATING WEATHER

NAVIGATION

Weather

WORKBOOK



RESTRICTED

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NAVIGATION WEATHER WORKBOOK

prepared by

ARMY AIR FORCES INSTRUCTORS' SCHOOL
(NAVIGATOR)

Selman Field, Monroe, Louisiana

for

AAFNS, SELMAN FIELD
MONROE, LOUISIANA

AAFNS, ELLINGTON FIELD
TEXAS

AAFNS, HONDO ARMY AIR FIELD
HONDO, TEXAS

AAFNS, SAN MARCOS ARMY AIR FIELD
SAN MARCOS, TEXAS

AUGUST, 1944

RESTRICTED

TABLE OF CONTENTS

PREFACE

The claim that it is important for you as a navigator to learn navigation weather is an understatement. The truth is, you must learn it. That's where this workbook comes in. By conscientiously filling in its pages you learn weather, and what is even more important, what the navigator does about it. Moreover, you end up with a handy guide for future reference. Therefore, tackle the job as it should be tackled.......with interest and enthusiasm!

These rules will help:

1. Each section in the workbook corresponds with a certain weather lecture. Glance over the respective section prior to each lecture for a preview of what to expect. This is especially helpful when training films are shown.

2. Use Air Force Manual No. 6, "Weather for Aircrew Trainees", as a reference book and source of information.

3. Pay close attention in class. From time to time the instructor will discuss questions in the workbook. Don't miss these discussions.

4. Keep the workbook up to date, and try to finish each part before going on to the next. Naturally you're expected to do your own work.

INTRODUCTION TO NAVIGATION WEATHER

Down through history, weather has always been a critical factor in war just as it has been in the present conflict in the case of the Japanese attack on Pearl Harbor, and Allied invasions of Sicily and Normandy. Weather is especially important in the battleground of the air. It is essential in planning the flight, whether it is a C-47 carrying cargo from Labrador to Scotland, or several air task forces bombing Berlin. Weather is employed in flight planning so that the various weather factors may be utilized to the best advantage.

The weather obligations of the navigator do not stop with preflight planning, however, for he must observe and interpret the unavoidable local departures from the general route forecast and alter his flight accordingly. Furthermore, he has a definite responsibility to report his observations back to the base weather officer as promptly as war conditions permit. The base weather officer cannot function efficiently without this help.

In order to interpret weather conditions properly, a navigator must have a general knowledge of the structure and motion of the atmosphere. He must have an ability to read certain maps, charts and codes. He must be able to identify cloud types and understand their significance. Also he should understand the flying hazards and flying procedures for each. He must know how to use a weather brief, and above all know how to use his weather knowledge in determining winds in flight under varying conditions.

The atmosphere is a mechanical mixture of a number of gases - nitrogen and oxygen being the principle constituents by volume. The air also contains a variable amount of water vapor and dust particles. In many respects, the water vapor is the most important constituent of the atmosphere in spite of the fact that its weight never exceeds 4% of the total weight. It is water vapor that is responsible for the clouds, fog, icing conditions, rain, and thunderstorms. Dust and other impurities exist in the atmosphere in variable amounts and when their concentration becomes high, visibilities are reduced - sometimes dangerously low.

The atmosphere is a compressible fluid and therefore is more dense near the earth than at high levels - $\frac{1}{2}$ of the atmosphere is below 18,000' and 3/4 below 34,000'. Normal atmospheric pressure at sea level is 29.92 in. of mercury or 1013.2 millibars.

Air temperatures normally decrease with altitude up to about 30,000 to 50,000 feet (depending upon the latitude and the season). This portion of the atmosphere is called the troposphere. Above this there is an isothermal layer (no change of temperature with height) which is called the stratosphere. The boundary between the stratosphere and the troposphere is the tropopause.

The troposphere will be the main concern of this course, since it is in this portion of the atmosphere that almost all flying is done. This portion also contains all the weather hazards such as thunderstorms, icing, fog, and clouds. The rate of decrease of temperature with height is called lapse rate and averages about 2°C/1000 feet in the troposphere.

QUESTIONS:

1. Name 4 different benefits to be derived from a weather brief.

   (1)

   (2)

   (3)

   (4)

2. Name 4 responsibilities that the navigator must assume concerning weather.

   (1) MUST BE ABLE TO READ CERTAIN MAPS, CHARTS, AND CODES

   (2) MUST BE ABLE TO IDENTIFY CLOUD TYPES AND UNDERSTAND THEIR SIGNIFICANCE

   (3)

   (4)

3. What two constituents of the atmosphere, although small in quantity, are responsible for much of our adverse weather conditions?

   (1) WATER VAPOR

   (2) DUST PARTICLES

4. Is the density of the atmosphere uniform throughout? NO

5. What is the normal sea level pressure? 14.7 LB/SQ.IN or 29.92 IN.Hg

6. How does temperature change with altitude? DROPS

7. Weather changes occur in what part of the atmosphere? TROPOSPHERE

8. What is meant by "insolation"? SUNSHINE

9. Change 12°C to the Fahrenheit scale. $\frac{9}{5} \times 12 + 32 = 53.6°F$

10. If it would take 12 grams of water to saturate a kilogram of air that actually contains 8 grams, what is the relative humidity? $\frac{8}{20} = 40\%$

AN INTRODUCTION TO THE SYNOPTIC WEATHER MAP

The synoptic weather map gives the most complete picture of the weather possible for a given area. It is prepared four times daily, (0030, 0630, 1230, 1830 GCT). There are a great number of stations that make weather observations and send in this data by means of teletype.

The dominant features of the weather map are in color. These important characteristics are: pressure centers, fronts, air masses, precipitation, thunderstorms, fog, and dust storms. The color for each of these features is represented on WX 2-2.

The patterns on the map are made by the isobars (lines which connect points of equal pressure). These isobars are drawn for pressure intervals of three millibars in order to present a picture of the pressure areas on the map. The high pressure areas and low pressure areas are represented by blue H's and red L's respectively.

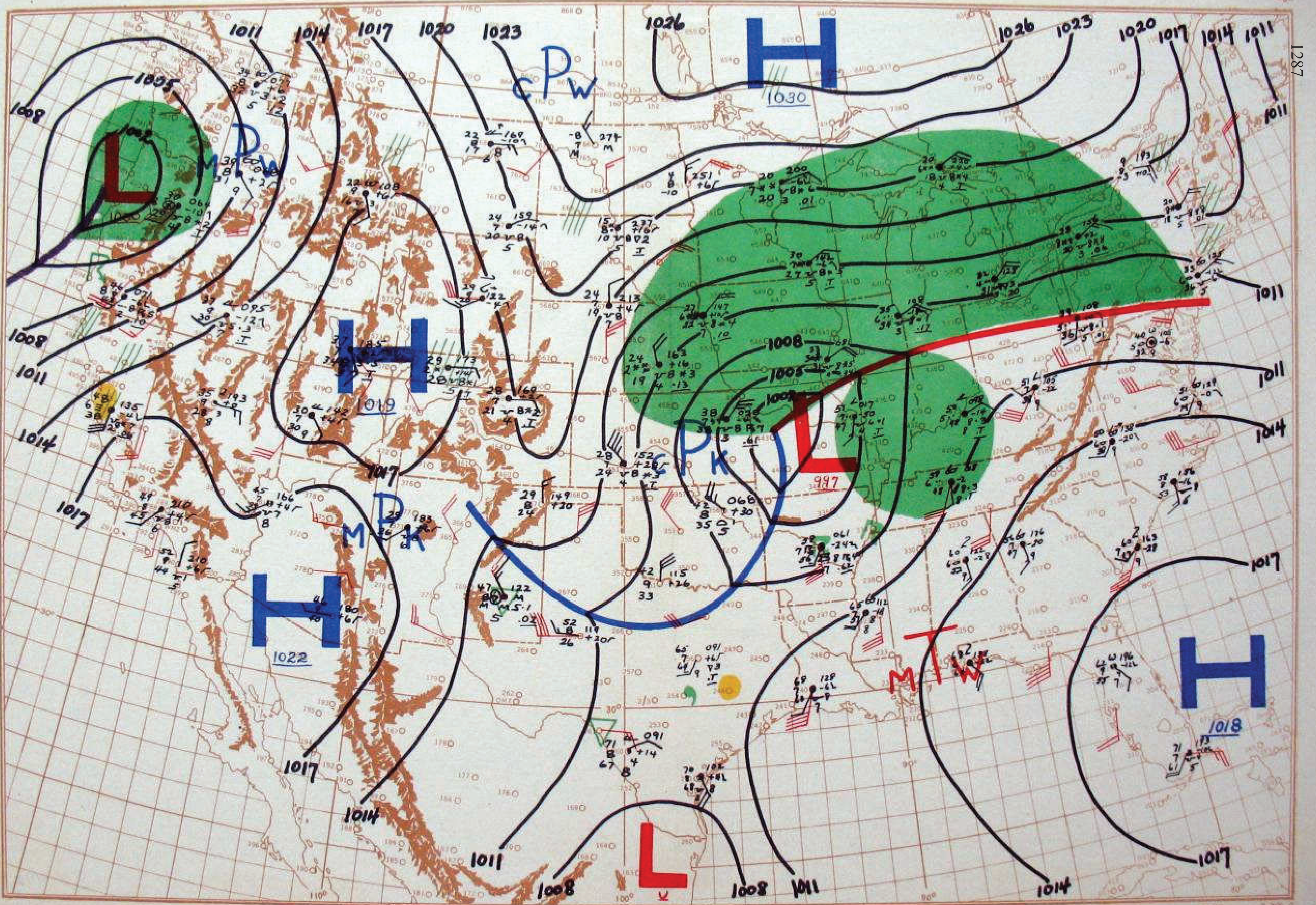
An air mass is named for its source of origin, hence we have mP (maritime polar), cP (continental polar), mT (maritime tropical), and cT (continental tropical). The air masses from cold source regions are labeled in blue, whereas those from warm source regions are labeled in red. The third letter "k" or "w" of the air mass designator indicates whether the air temperature is cold or warm as compared to the earth's surface over which it is passing.

A front on the weather map indicates the boundary zone between two air masses. Fronts are important because wherever different types of air come together, weather dangerous to flying is more likely to appear.

A warm front, indicated by a red line, is a front along which warm air is replacing cold air. A cold front, indicated by a blue line, is a front along which cold air is replacing warm air. The stationary front, indicated by alternate red and blue dashes (see color code), is a front which is not moving. An occluded front (purple line) is caused by a cold front overtaking a warm front.

The station model gives all pertinent data of a given weather station for the time of the map. It is arranged as shown in WX 2-3. The temperatures are given in degrees Fahrenheit and the pressures are given in millibars and tenths of millibars. The height of the low clouds and the visibility figures given in one digit are coded. The navigator should give considerable attention to the following:

1. Wind direction and velocity.
2. Amount of sky covered by clouds.
3. Temperature and dewpoint.
4. Height and type of clouds.



1008
1005
1002
L
mPw
cPw
1011
1014
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1008
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997
mPk
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1022
mTw
H
1018
L
1017
1014
1011
1008

1288

EXPLANATION OF WEATHER CODE FIGURES AND SYMBOLS

*Symbols are not used for "ww" when "present weather" is coded as 00, 01, 02, or 03, and are not used for "a" when "barometer characteristic" is coded as 3 or 8.

ww — Present weather

00 Cloudless. (From no clouds up to but not including one-tenth.)*	01 Partly cloudy. (From exactly one-tenth to exactly five-tenths.)*	02 Cloudy. (Over five-tenths up to and including exactly nine-tenths.)*	03 Overcast. (Over nine-tenths.)*	04 Low fog, whether on ground or at sea.	05 Haze, but visibility 1,000 meters, 1,100 yards, or more.	06 Dust devils seen.	07 Distant lightning.	08 Light fog (visibility 1,000 meters, 1,100 yards, or more)	09 Fog at a distance, but not at station.
10 Precipitation within sight.	11 Thunder, without precipitation at station.	12 Duststorm within sight, but not at station.	13 Ugly, threatening sky.	14 Squally weather.	15 Heavy squalls in last three hours.	16 Waterspouts seen in last three hours.	17 Visibility reduced by smoke.	18 Blowing dust, but visibility 1,000 meters, 1,100 yards, or more.	19 Signs of tropical storm (hurricane).
20 Precipitation in any form in last hour, but not at time of observation.	21 Drizzle in last hour, but not at time of observation.	22 Continuous or intermittent rain in last hour, but not at time of observation.	23 Continuous or intermittent snow in last hour, but not at time of observation.	24 Continuous or intermittent rain and snow, mixed, in last hour, but not at time of observation.	25 Rain showers in last hour, but not at time of observation.	26 Snow showers in last hour, but not at time of observation.	27 Hail, or rain and hail, showers in last hour, but not at time of observation.	28 Light or moderate thunderstorm, with precipitation in last hour, but no precipitation at time of observation.	29 Heavy thunderstorm, with precipitation in last hour, but no precipitation at time of observation.
30 Duststorm or sandstorm.	31 Duststorm or sandstorm, has decreased.	32 Duststorm or sandstorm, no appreciable change.	33 Duststorm or sandstorm, has increased.	34 Line of duststorms.	35 Storm of drifting snow.	36 Light or moderate storm of drifting snow, generally low.	37 Heavy storm of drifting snow, generally low.	38 Light or moderate storm of drifting snow, generally high.	39 Heavy storm of drifting snow, generally high.
40 Fog. (Visibility less than 1,000 meters, 1,100 yards.)	41 Moderate fog in last hour, but not at time of observation.	42 Thick or dense fog in last hour, but not at time of observation.	43 Fog, sky discernible, has become thinner during last hour.	44 Fog, sky not discernible, has become thinner during last hour.	45 Fog, sky discernible, no appreciable change during last hour.	46 Fog, sky not discernible, no appreciable change during last hour.	47 Fog, sky discernible, has begun or become thicker during last hour.	48 Fog, sky not discernible, has begun or become thicker during last hour.	49 Fog in patches.
50 Drizzle. (Precipitation consisting of numerous small drops.)	51 Intermittent light drizzle.	52 Continuous light drizzle.	53 Intermittent moderate drizzle.	54 Continuous moderate drizzle.	55 Intermittent heavy drizzle.	56 Continuous heavy drizzle.	57 Drizzle and fog.	58 Light or moderate drizzle and rain.	59 Heavy drizzle and light rain.
60 Rain.	61 Intermittent light rain.	62 Continuous light rain.	63 Intermittent moderate rain.	64 Continuous moderate rain.	65 Intermittent heavy rain.	66 Continuous heavy rain.	67 Rain and fog.	68 Light or moderate rain and snow, mixed.	69 Heavy rain and snow, mixed.
70 Snow.	71 Intermittent light snow in flakes.	72 Continuous light snow in flakes.	73 Intermittent moderate snow in flakes.	74 Continuous moderate snow in flakes.	75 Intermittent heavy snow in flakes.	76 Continuous heavy snow in flakes.	77 Snow and fog.	78 Snow grains.	79 Sleet; or ice crystals.
80 Showers.	81 Showers of light or moderate rain.	82 Showers of heavy rain.	83 Showers of light or moderate snow.	84 Showers of heavy snow.	85 Showers of light or moderate rain and snow.	86 Showers of heavy rain and snow.	87 Showers of snow pellets.	88 Showers of light or moderate hail, or rain and hail.	89 Showers of heavy hail, or rain and hail.
90 Thunderstorm, with precipitation falling at time of observation.	91 Rain and thunder in last hour, but only rain at time of observation.	92 Precipitation and thunder during last hour, but only snow, or rain and snow mixed, at time of observation.	93 Light thunderstorm, without hail, but with rain or snow, at time of observation.	94 Light thunderstorm, with small hail, at time of observation.	95 Moderate thunderstorm, without hail, but with rain or snow, at time of observation.	96 Moderate thunderstorm, with small hail, at time of observation.	97 Heavy thunderstorm, without hail, but with rain or snow, at time of observation.	98 Thunderstorm, combined with duststorm, at time of observation.	99 Heavy thunderstorm, with hail, at time of observation.

Cloud, barometer, visibility and wind codes

Code	C_L Form of low cloud	C_M Form of middle cloud	C_H Form of high cloud	N Total amount all clouds	a Barometer characteristic	h Height of low clouds or ceiling	V Visibility	F Beaufort scale of wind velocities in miles per hour	F (cont.)
0	No lower clouds.	No middle clouds.	No high clouds. (No cirrus clouds.)	Absolutely no clouds.	Rising then falling. Now higher than, or the same as, 3 hours ago.	0-163 feet	0-1/32 mile	0 Calm	10 55-64
1	Cumulus of fine weather.	Typical altostratus, thin.	Cirrus, delicate, not increasing, scattered and isolated masses.	Less than one-tenth.	Rising, then steady; or rising, then rising more slowly. Now higher than, or the same as, 3 hours ago.	164-327 feet	1/32-1/8 mile	1 1-3	11 65-73
2	Cumulus heavy and swelling, without anvil top.	Typical altostratus, thick (or nimbostratus).	Cirrus, delicate, not increasing, abundant, but not forming a continuous layer.	One-tenth.	Rising unsteadily, or unsteady. Now higher than, or the same as, 3 hours ago.	328-655 feet	1/8-5/16 mile	2 4-7	12 74-82
3	Cumulonimbus.	Altocumulus, or high stratocumulus, sheet at one level only.	Cirrus of anvil clouds, usually dense.	Two or three-tenths.	Rising steadily, or steady. Now higher than, or the same as 3 hours ago.*	656-983 feet	5/16-5/8 mile	3 8-12	13 83-92
4	Stratocumulus formed by the flattening of cumulus clouds.	Altocumulus in small isolated patches; individual clouds often show signs of evaporation and are lenticular in shape.	Cirrus, increasing, generally in the form of hooks ending in a point or in a small tuft.	Four-, five-, or six-tenths.	Falling or steady, then rising; or rising, then rising more quickly. Now higher than, or the same as, 3 hours ago.	984-1967 feet	5/8-1 1/4 miles	4 13-18	14 93-103
5	Layer of stratus or stratocumulus.	Altocumulus arranged in more or less parallel bands or an ordered layer advancing over the sky.	Cirrus (often in polar bands) or cirrostratus advancing over the sky but not more than 45° above the horizon.	Seven or eight-tenths.	Falling, then rising. Now lower than 3 hours ago.	1968-3280 feet	1 1/4-2 1/2 miles	5 19-24	15 104-114
6	Low broken up clouds of bad weather.	Altocumulus formed by a spreading out of the tops of cumulus.	Cirrus (often in polar bands) or cirrostratus advancing over the sky and more than 45° above the horizon.	Nine-tenths.	Falling, then steady; or falling, then falling more slowly. Now lower than 3 hours ago.	3281-4920 feet	2 1/2-6 miles	6 25-31	16 115-125
7	Cumulus of fine weather and stratocumulus.	Altocumulus associated with altostratus, or altostratus with a partially altocumulus character.	Veil of cirrostratus covering the whole sky.	More than nine-tenths but with openings.	Unsteadily falling, or unsteady. Now lower than 3 hours ago.	4921-6561 feet	6-12 miles	7 32-38	17 126-136
8	Heavy or swelling cumulus, or cumulonimbus, and stratocumulus.	Altocumulus castellatus, or scattered cumuliform tufts.	Cirrostratus not increasing and not covering the whole sky.	Sky completely covered with clouds.	Falling steadily, or falling. Now lower than 3 hours ago.*	6562-8201	12-30 miles	8 39-46	
9	Heavy or swelling cumulus (or cumulonimbus) and low ragged clouds of bad weather.	Altocumulus in sheets at different levels, generally associated with thick fibrous veils of cloud & a chaotic appearance of sky.	Cirrocumulus predominating, associated with a small quantity of cirrus.	Sky obscured by fog, duststorm, or other phenomenon.	Steady or rising, then falling; or falling, then falling more quickly. Now lower than 3 hours ago.	8202' and up, or no clouds	30 miles or more	9 47-54	

F-1288

COLORED SYMBOLS USED ON WEATHER MAPS

Cold front

Warm front

Stationary front

Occlusion

Cold front, just developing or weak

Warm front, just developing or weak

Stationary front, just developing or weak

Cold front, dissipating

Warm front, dissipating

Occluded front, dissipating

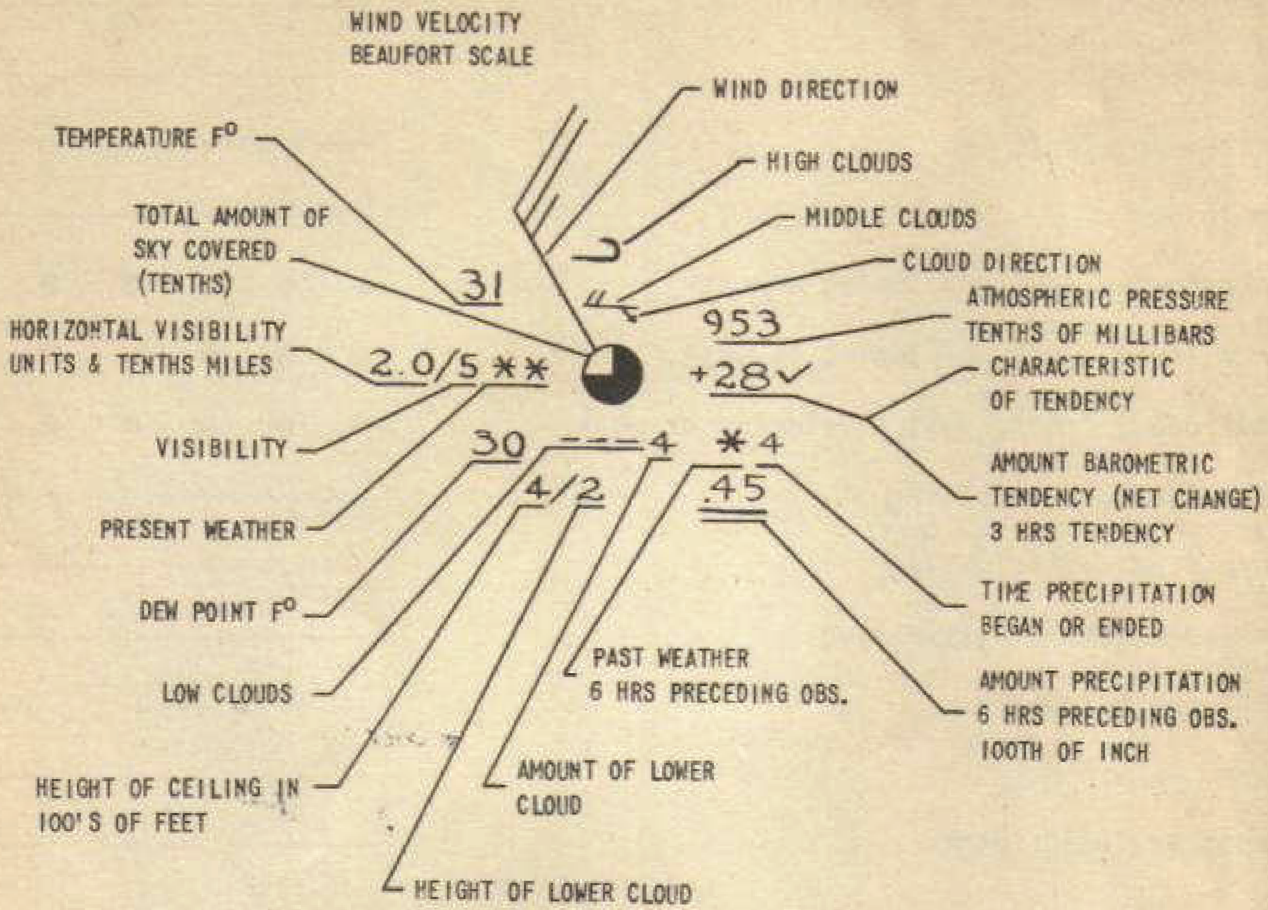
Upper cold front

Upper warm front

Upper occluded front

Continuous precipitation		Drizzle	
Intermittent precipitation		Showers	
Fog		Thunderstorm	
Dust or sand		Lightning	
High pressure area	H	Polar air	P
Low pressure area	L	Tropical air	T

STATION MODEL



QUESTIONS

1. Weather maps are drawn every ___6___ hours.
2. Fog is shown on the map by ___YELLOW___ shading.
3. The symbol ⌈⌉ indicates a ___THUNDERSTORM___.
4. A cold front is colored ___BLUE___.
5. A warm front is colored ___RED___.
6. An occluded front is colored ___PURPLE___.
7. A large blue "H" stands for high ___PREASURE___.
8. Air coming from the north Pacific is marked ___MPK___.

9. mTk indicates air COLDER than the ground over which it is moving.

10. Green shading indicates PERCIPITATION, (CONTINUOUS).

11. Air from central Canada blowing rapidly down to Iowa would be labeled cPk.

12. The pressure pattern is shown by ISOBARS.

13. What is the dewpoint shown on the accompanying station model? 30°F.

14. What is the wind direction shown on the station model? SE.

15. What is the temperature on the station model? 31°F.

16. What does an asterisk on the map indicate? SNOW.

17. How many layers of clouds may be reported on the station model? 3.

18. What scale is used for temperatures on the map? F.

19. How are showers shown on the map? [illegible] ∇ GREEN.

20. How is intermittent precipitation shown? ///// GREEN.

NOTES

AN INTRODUCTION TO THE VERTICAL CROSS SECTION

The vertical cross section supplements the weather map by giving the third dimension and adding tops of clouds, icing zones, turbulence, and winds aloft. It is insufficient by itself because it tells nothing of conditions either side of the proposed route. It is not a routine form, but it is prepared on request. A good vertical cross section is valuable especially when determining the best flight altitude.

NOTES

8-44

1293

WAR DEPARTMENT
AAF FORM NO. ...
FEB. ... 1943

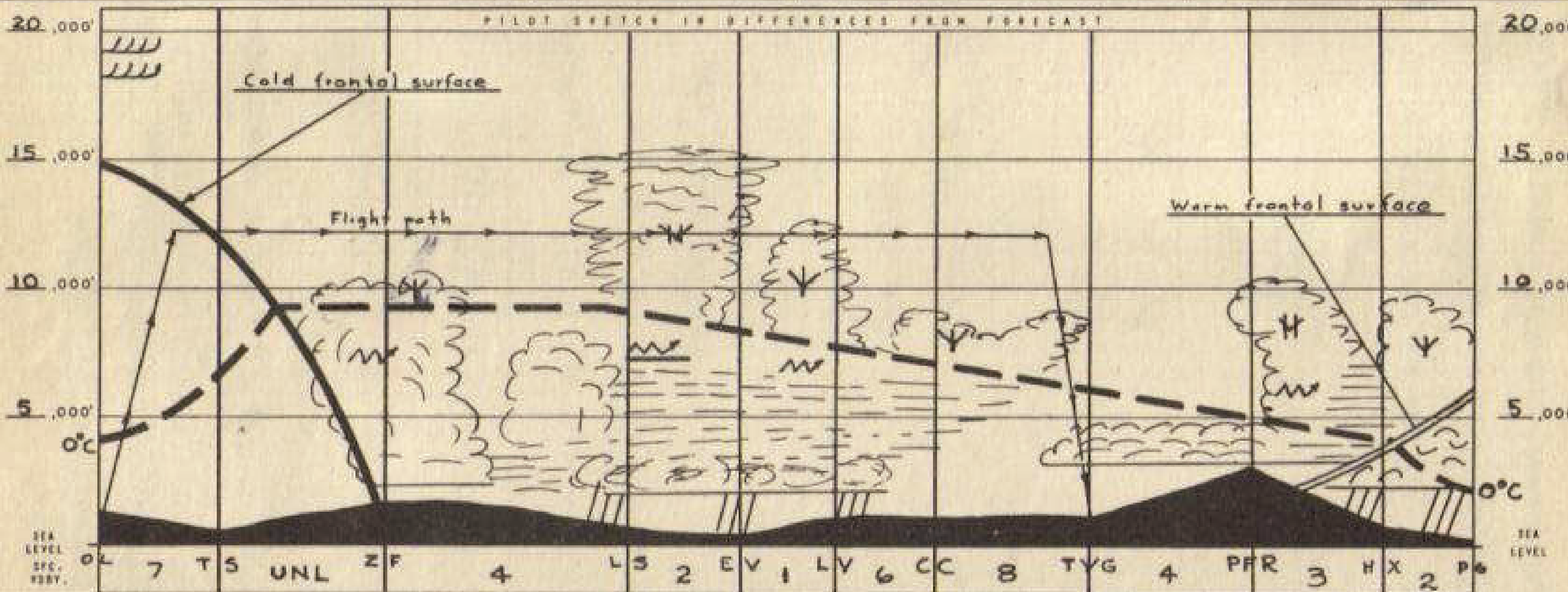
MAKE IN DUPLICATE.
WEATHER STATION RETAIN COPY.

ARMY AIR FORCES

VERTICAL CROSS-SECTION FORECAST

(TO BE TURNED IN TO WEATHER FORECASTER ON ARRIVAL)

FROM	TO	FORECAST GOOD UNTIL	FORECASTER	DATE	TIME



EXPLANATION OF SYMBOLS

RAIN	SNOW	SHOWERS	LIGHT ICING	LIGHT TURBULENCE	BLUE LINE - COLD FRONT
HAIL	FOG		MODERATE ICING	MODERATE TBC.	RED LINE - WARM FRONT
THUNDERSTORM			HEAVY ICING	HEAVY TURBULENCE	GREEN LINE - FREEZING LEVEL

WINDS ALOFT FORECAST

PORTION OF ROUTE	SURFACE TO 5,000'	5,000' TO 10,000'	10,000' TO 15,000'	15,000' TO 20,000'	ABOVE 20,000'	PILOT'S REMARKS (PILOT SHOW WIND IF DIFFERENT FROM FORECAST)
OL - ZF	320/45	300/40	270/35	220/40		
ZF - LV	240/40	270/20	240/31	220/40		
LV - HX	240/40	260/20	245/26	225/40		
HX - PG	150/20	260/25	250/30	240/36		

F - 1293

2-WX-3

U. S. GOVERNMENT PRINTING OFFICE: 1943

QUESTIONS

1. The vertical cross section forecast form is numbered FORM 23-A.

2. When does the forecaster make a vertical cross section? UPON REQUEST.

3. Fill in the following table with the appropriate symbols or description of coloring:

Weather	On Wea map	On Cross section
Turbulence	—	∧∧↗
Fog	YELLOW	≡
Icing	—	Ψ Ж Ж
Rain	GREEN	||| |||
Showers	∇ (GREEN)	∇
Cold front	BLUE	BLUE LINE
Warm front	RED	RED LINE
Snow	* (GREEN)	* *
Thunderstorm	Ꝁ (GREEN)	Ꝁ
Freezing level	—	BROKEN GREEN LINE

Answer the following questions by reference to WX 3 Fig. 1:

4. Where would it be most dangerous to try to fly under the clouds? ZF TO LU AND T~~V~~G TO PG.

5. How many degrees do the mean winds at flight altitude shift between zone 1 (OL-ZF) and zone 2 (ZF-LV)? 30°.

6. Why are no icing symbols below the 0°C line? ICING DOSE NOT OCCURE BELOW THIS LINE.

7. Where is the greatest turbulence? LS TO EU ~~AND [illegible]~~.

8. Does the forecaster think that breaks in the clouds will be found at or near TVG? YES —BECAUSE LANDING IS TO BE MADE THERE.

9. How high does the tallest cloud go? 15,000 FT.

10. Do the clouds obscure the mountain peaks near PFR? YES.

11. The freezing level is 5,000 feet higher at ZF than at OL, because the cold front has passed OL.

12. Rain is forecast for the zones LS TO LU AND HX TO PG.

NOTES

EXPLANATION OF PIBALS (WINDS ALOFT REPORTS)

ADD 0 TO GET DIRECTION

DHH16 02609 43058 8103

Station	Time	Level	Direction	Velocity	Level	Direction	Velocity	Direction	Velocity
Lubbock Texas	1600 GCT	Surface	260°	9 mph	4000 ft MSL	300°	58 mph	310°	103 mph
Two or three letters identify the station. A list of call letters is posted in the weather station. Lubbock is 3241 feet above sea level.	This is the time of the observation in zero meridian time. In weather this time zone is denoted by "Z".	The second group of the message always gives surface data and always has a zero as its first digit. 5 DIGITS The surface in this report is 3241 ft. MSL.	Two figures give the direction in tens of degrees. Always add a zero to get the direction from which the wind blows. Calm is coded 00. If the velocity of the wind is over 99 mph, 50 is added to the direction code number.	These two digits give the actual velocity of the wind except when the velocity is 100 mph or over, only the last two digits are sent in this position.	The first digit of each 5-digit group indicates the level. "4" is also used to mark the 14,000-foot level. All levels above the surface are MSL.	The third and fourth digits from the right in any group give the direction in tens of degrees. Always add a zero to get the direction in degrees. A plane flying a true course of 300° at this level would have a direct head wind.	The last two digits in any group, except the identification group, give the actual velocity of the wind in miles per hour unless it is over 99 mph.	50 was added to the direction number because the wind was over 99 mph. Whenever adding a zero gives more than 360°, subtract 500° to get the true direction and add 100 mph to get the true velocity.	Velocity digits show 03 and the big direction number adds 100 mph--total 103 mph at 5000 ft. MSL. The level of 4-digit groups is determined by preceding or following 5-digit groups.

The first thousand-foot level MSL, 200 feet or more above the surface, is reported in the third group. All thousand-foot levels MSL reached by the balloon observation are reported in order, up to and including 15,000 feet MSL; above this only 5000-foot levels MSL are reported. In five-digit groups, the 1st digit marks the level as follows:

- 0 surface, 10,000 ft., 20,000 ft., 30,000 ft., ...
- 2 2000 ft. or 12,000 ft.
- 4 4000 ft. or 14,000 ft.
- 6 6000 ft.
- 8 8000 ft.
- 5 25,000 ft., 35,000 ft., 45,000 ft., ...

When no observation can be taken, the identification group will appear as in a regular message, followed by a 4-letter group indicating the reason:

PIBA	no balloons	PIKO	smoky
PICO	low clouds	PIRA	raining
PIDU	thick dust	PISE	unfavorable sea conditions
PIFI	not filed		
PIFO	foggy	PISO	snowing
PIHE	no gas	PIWI	high or gusty surface wind
PIIO	instrument trouble		

Pibals are run at approximately 0400, 1000, 1600 and 2200 GCT, and the reports are available in most weather stations about an hour and a half later.

WX 27 P. 123 is a Winds Aloft Chart. The original was 20" by 30".

Winds aloft charts show the general flow of air over the country for nine different levels. Even though it may be marked for clouds, the last map is used for the 20,000 foot level. These charts are drawn every six hours from the pibal reports.

The arrows fly with the wind and the numbers give the velocity of the wind in miles per hour.

WX 4-106

E016 01410 1822 62127 2130 82130 2229 02237 2241 22247 2253 42264 2285 07306
DL10 03220 3436 23331 3130 42929 2831 62732 2533 82432
TR04 01916 1917 22017
LS22 PIRA
RP 21 02708 2816 62922 3016 83016 3410 03316 3332 23250 3278 43282 3174 03190 53198
PDR03 00905 21113 0710 43608 3314 63222
N004 01704 1919 22026 2318 42610 2614 62716
ZF04 PICO

WX 4-106 DECODED

	EL PASO 1100 CWT		DALLAS 0500 CWT		TEXARKANA 2300 CWT		RENO 1600 CWT		DEL RIO 2200 CWT		NEW ORLEANS 2300 CWT	
ALTITUDE	DIRECT	SPEED	DIRECT	SPEED	DIRECT	SPEED	DIRECT	SPEED	DIRECT	SPEED	DIRECT	SPEED
SURFACE	140°	10MPH	320°	20MPH	190°	16MPH	270°	8 MPH	090°	5 MPH	170°	4 MPH
1000' MSL			340	36	190	17					190	19
2000			330	31	200	17			110	13	200	26
3000			310	30					070	10	230	18
4000			290	29					360	8	260	10
5000	180	22	280	31			280	16	330	14	260	14
6000	210	27	270	32			290	22	320	22	270	16
7000	210	30	250	33			300	16				
8000	210	30	240	32			300	16				
9000	220	29					340	10				
10000	220	37					330	16				
11000	220	41					330	32				
12000	220	47					320	50				
13000	220	53					320	78				
14000	220	64					320	82				
15000	220	85					310	74				
20000	230	106					310	90				
25000							310	98				

St. Louis, 1700 CWT, Raining.

Springfield, Mo., 2300 CWT, Low Clouds.

NOTES

PIBALS — WINDS ALOFT REPORTS

TAKEN 4 TIMES EVERY DAY

TRANSMITTED EVERY 6 HR. 0500, 1100, 1700, 2300, G.M.T. (Z TIME)

USUALLY BEGINS WITH 4 DIDGET NO.— 2 LETTERS — 2 NUMBERS (INDICATES TIME)

DHH 16 0 26 09

STATION TIME LEVEL ALTITUDE DIRECTION 260° SPEED 9

ADD 0 TO SECOND GROUP TO GET WIND DIRECTION

IF WIND VELOCITY IS MORE THEN 100 MPH 50 IS ADDED TO DIRECTION

4 DIDGET GROUP — ODD LEVEL JUST DIRECTION AND SPEED

QUESTIONS

(Use WX-27 P. 123 to answer questions 2, 6, 7, 8, 9, 10.)

1. At 0730 CWT a navigator receives a Pibal report marked 1000 Z. His plane attains an altitude of 6000 ft. at 0900 CWT. How old is the wind observation? 7½ HR.

2. On the Winds Aloft Chart, does the arrow fly with the wind or into the wind? WITH WIND

3. Is the wind velocity reported in statute miles or knots? STATUTE MILES.

4. Decode the following by completing the charts on the following pages:

ZH DBY04 01916 1917 22017

HU04 01917 2025 21944 2346 42642

WC03 01915 1928 22042 2340 42732

DL04 02408 2521 22632 2635 42736 2636 62739

ZF05 PICO

N004 01704 1919 22026 2318 42610 2614 62716

LS05 PIRA

PDR03 00905 21113 2710 43608 3314 63222

DXW22 00000 0104 20000 0408

L121 02820 2722 22724 2626 42623 2731 62758 2764 87701

F016 00000 20803 0805 40608 0208 60107 0211 80214 3316 02615 2810 22510 3424 43426 3425 03423

AB16 02404 62811 3016 83225 3228 02737 3137 23040 3047 42957 3058 03195 58133

SM17 01614 1622 41733 1836 61837 1930 81926 1930 02024 2028 22126

MN15 03106 3410 83612 3311 03512

TZ816 00903 0301 60303 3602 83305

AQ16 01313 41425 1424 61522 1524 81209 1512 02208 2207 22306

PS16 PICO

MM15 00715 0730 21040 0832 41130 0830 60529 0428 80425

END

5. What is the best altitude to fly a true course of 338° from HU to DL according to the above pibals?____________________.

6. What is the wind at 12,000 ft. MSL at Houston, Texas (Station 243; 30N-95W)?____________________.

7. Why do the Colorado stations appear on the 6000-foot chart but not on the 2000 and 4000-foot charts?____________________.

8. By how many degrees does the wind change between 2000' and 6000' at Del Rio, Texas (station 261; 29N, 101W)?____________________.

9. What is the general air flow at 2000' to 4000' over Texas?____________________.

10. What is the general air flow at 6000' to 14000' over Texas?____________________.

WINDS ALOFT

STATION	DBY		HO		WC		OL					
TIME	0400		0400		0300		0400					
SURFACE	190°	16MPH	190°	17MPH	190°	15MPH	240°	09MPH				
1000' MSL	190°	17	200°	25	190°	28MPH	250°	21				
2000' MSL	200	17	190°	44	204°	42	260°	32				
3000' MSL			230°	46	220°	40	260°	35				
4000' MSL			260°	42	270°	32	270°	36				
5000' MSL							260°	36				
6000' MSL							270°	39				
7000' MSL												
8000' MSL												
9000' MSL												
10,000' MSL												
11,000' MSL												
12,000' MSL												
13,000' MSL												
14,000' MSL												
15,000' MSL												
20,000' MSL												
25,000' MSL												
30,000' MSL												
35,000' MSL												
40,000' MSL												

WINDS ALOFT

STATION												
TIME												
SURFACE												
1000' MSL												
2000' MSL												
3000' MSL												
4000' MSL												
5000' MSL												
6000' MSL												
7000' MSL												
8000' MSL												
9000' MSL												
10,000' MSL												
11,000' MSL												
12,000' MSL												
13,000' MSL												
14,000' MSL												
15,000' MSL												
20,000' MSL												
25,000' MSL												
30,000' MSL												
35,000' MSL												
40,000' MSL												

WINDS ALOFT

STATION												
TIME												
SURFACE												
1000' MSL												
2000' MSL												
3000' MSL												
4000' MSL												
5000' MSL												
6000' MSL												
7000' MSL												
8000' MSL												
9000' MSL												
10,000' MSL												
11,000' MSL												
12,000' MSL												
13,000' MSL												
14,000' MSL												
15,000' MSL												
20,000' MSL												
25,000' MSL												
30,000' MSL												
35,000' MSL												
40,000' MSL												

EXPLANATION OF HOURLY WEATHER SEQUENCE CODE

WA N SPL 121624E E30⊕15⦶2VTRW-BD- 152/68/60→↘22+↑1618E/996/+⊕NW OCNL LTNG IN CLDS

STATION	CLASSIFICATION OF REPORT	TYPE OF REPORT	DATE-TIME	CEILING	SKY CONDITION	VISIBILITY	WEATHER	OBSTRUCTIONS TO VISION	BAROMETRIC PRESSURE	TEMPERATURE	DEW POINT	WIND	ALTIMETER SETTING	REMARKS	SPECIAL DATA
Lists of station identification letters are posted in weather stations.	If no classification letter is used, the station is not located at an airport designated as a controlled airport. C: satisfactory for contact flight. Usually this requires the ceiling to be 1000 feet or better, and visibility 3 mi. or better. N: requiring observance of instrument flight rules. Usually, ceiling 500 ft. or better and visibility one mile or better. X: take-off and landing suspended.	"SPL", meaning Special Report, appears when crucial changes have occurred in weather conditions since the last report. When this item is missing no crucial change has occurred since the last report.	The first 2 digits give the date of the month and the last four the time on the 24 hour clock. The letter indicates the time zone: E: Eastern war time, C: Central war time, M: Mountain war time, P: Pacific war time. This element is sent only when the report comes at other than the scheduled time.	This item is the height in hundreds of feet of the lowest level below 10,000 feet above the station at which the total cloudiness from the surface up covers more than 1/2 the sky. If the clouds below 10,000 feet cover less than 1/2 the sky, this item is omitted. One of five letters precedes the ceiling figures: A Airplane report, E Estimated, M Measured by balloon or light, P Precipitation causes ceiling, W Indefinite base of clouds is ragged.	If no symbol appears in this position, the ceiling is zero or else the sky cannot be observed due to some obstruction to visibility. The sky condition is indicated by the following symbols: ○ Clear. Clouds, if any, cover less than 1/10 of the sky. ⦶ Scattered. Clouds cover 1/10 to 5/10 of the sky. ⦷ Broken. Clouds cover 6/10 to 9/10 of the sky. ⊕ Overcast. Clouds cover more than 9/10 of the sky. ⊕⦷ Overcast, lower broken. ⊕⦶ Overcast, lower scattered. ⦷⦷ Broken, lower broken. ⦷⦶ Broken, lower scattered. ⦶⦷ Scattered, lower broken. ⦶⦶ Scattered, lower scattered. The word "high" is used to mean 10,000 ft. or higher. ⦶/ High scattered. ⦷/ High broken. ⊕/ High overcast. ⊕/⦷ High overcast, lower broken. ⊕/⦶ High overcast, lower scattered. ⦷/⦷ High broken, lower broken. ⦷/⦶ High broken, lower scattered. ⦶/⦷ High scattered, lower broken. ⦶/⦶ High scattered, lower scattered. If a plus sign (+) precedes a cloud symbol, the cloud is dark. If a minus sign (-) precedes a cloud symbol, the cloud is thin. Estimated height of lower scattered clouds is given by a figure representing hundreds of feet, immediately preceding the symbol(⦶). This height need not be confused with the ceiling because no letter accompanies it.	The value of visibility below ten miles is given in miles. The absence of a figure for visibility indicates that the visibility is ten miles or more. The letter "V" immediately following the figure for visibility indicates a fluctuating visibility which does not vary by more than 1/4 mile to either side of the reported value. If the visibility varies more than 1/4 mile, it will be explained in remarks.	When appropriate the weather is indicated by one or more of the following: A Hail AP Small hail E Sleet L Drizzle R Rain RQ Rain squall RW Rain showers S Snow SP Snow pellets SQ Snow squall SW Snow showers T Thunderstorm ZL Freezing drizzle ZR Freezing rain + Heavy - Light Weather not modified by either + or - is called moderate.	When they apply, the following are used in this element: BD Blowing dust BN Blowing sand BS Blowing snow D Dust F Fog GF Ground fog GS Drifting snow H Haze IF Ice fog K Smoke + Thick or heavy - Light Obstructions not modified by either + or - are called moderate.	Barometric pressure reduced to sea level is given by a group of three digits: tens, units, and tenths of millibars involved. Thus 152 means 1015.2 mb. 979 means 997.9 mb. etc. This element is omitted by stations not equipped with mercurial barometers.	Temperature is given to the nearest degree Fahrenheit. A minus sign(-) indicates a reading below zero.	Dew point is given to the nearest degree Fahrenheit. A minus sign(-) indicates a reading below zero.	Arrows indicate the wind direction: ↓ North ↓↙ North northeast ↙ Northeast ←↙ East northeast ← East ←↖ East southeast ↖ Southeast ↑↖ South southeast ↑ South ↑↗ South southwest ↗ Southwest →↗ West southwest → West →↘ West northwest ↘ Northwest ↓↘ North northwest The velocity of the wind is given in miles per hour. "C" is used for calm. If the velocity is estimated, the letter E will follow the velocity figures. When appropriate, the character of the wind is indicated by a minus (-) for fresh gusts, and a plus (+) for strong gusts. Otherwise the wind varies less than ten miles per hour in 15 seconds. Wind shifts at the reporting station are given, immediately following the other wind data, by an arrow showing the wind direction prior to the shift, followed by the time at which the shift occurred. The intensity of the shift is given by a minus (-) for mild, no sign for moderate, and the plus (+) for severe immediately following the time zone letter.	The setting to make the altimeter read true altitude is given by three digits representing units, tenths, and hundredths of inches. Thus 108 means 31.08 000 means 30.00 996 means 29.96 etc. Sent only by stations equipped with mercurial barometers.	Remarks are transmitted in English, authorized abbreviations, and symbols. Lists of abbreviations are available for inspection at the weather station. The symbols are shown on this chart. Examples: ⦶V⦷ Sky scattered varying to broken. ⦷V⊕ Sky broken varying to overcast.	Special data comprising pressure change and characteristic, clouds in three levels by type, cloud direction, maximum or minimum temperature, 5000-foot pressure at selected stations, and other data, are coded at certain times and sent immediately following the report proper, by designated stations. These data are intended primarily for forecasting.

V - VARIABLE

The report given above is deciphered as follows: Washington, Field on instruments, special report, 12th day of the month, 1624 Eastern War Time, ceiling estimated 3000', overcast, lower scattered clouds at 1500', visibility two miles variable, thunderstorm, light rain showers, light blowing dust, barometric pressure 1015.2 millibars, temperature 68°F, dew point 60°F, wind west northwest at 22 mph, strong gusts, moderate wind shift from the south at 1618 EWT, altimeter setting 29.96", the overcast is dark to the northwest, occasional lightning in clouds.

ABBREVIATIONS

Extensive use of abbreviations, as well as symbols, is characteristic of weather work. Care is needed in interpreting some of these, especially adjectives and adverbs formed of directions. SERN means "southeastern", not "southern". Some common word endings are:

LY	ally, erly, or ly
NG	ening
RN	ern
NS	iness or ness
G	ing (add NG if word ends in G)
WD	ward

Following is a partial list of abbreviations and phrase contractions:

ABV	above
ACTV	active
ALF	aloft
ALG	along
ALSTG	altimeter setting
ALT	altitude
AMS	air mass
APCNO	approach control transmitting facilities not operative until further notice
APOBS	airplane weather observations
ARPT	airport
AVG	average
BCM	become
BCTOVC	broken clouds to overcast
*BEBNR	beacon light burning but not revolving until further notice
*BEBOK	beacon resumed normal operation
*BENBU	beacon light not burning until further notice
*BINOVC	breaks in overcast
BLK	black
BLO	below
BNTH	beneath
BRGT	bright
BRK	break
BRKN	broken
BRM	barometer
*BRONO	broadcast not operating until further notice
*BROOK	broadcast resumed operation
BTR	better
BTWN	between
BYD	beyond
*CAVU	ceiling and visibility unlimited (ceiling, if any, 10,000' or higher and visibility 10 miles or greater
CFR	contact flight rule
CHG	change
*CIG	ceiling
CIGUN	ceiling unrestricted
CLD	cloud
CLR	clear
CM	cumulonimbus mammatus (mammatocumulus)
CND	condition
CNVCTN	convection
CONIC	restricted in clear
CQN	correction
CTN	caution
CTSCLDS	clear to scattered clouds
CVR	cover
DCRS	decrease
DGR	danger
DGRE	degree
DMSH	diminish
DNS	dense
DRK	dark
DRZL	drizzle
DSIPT	dissipate
DSNT	distant
DUPE	duplicate
DURG	during
DWPNT	dew point
ETD	estimated
FA	airway and terminal forecasts
*FANOT	fan type marker not operative until further notice
*FAROK	fan type marker resumed operation
FC	fractocumulus
FCST	forecast
FILLI	field and lighting facilities
FINO	hourly sequence weather report not filed
FLD	field
FLG	falling
FLRY	flurry
FQT	frequent
FRMG	forming
FROPA	frontal passage
FRSH	fresh
FRST	frost
FRZ	freeze
FS	fractostratus
GND	ground
GNDFG	ground fog
GNRL	general
GRDL	gradual
GST	gust
HIR	higher
HND	hundred
HRZN	horizon
HURCN	hurricane
HVY	heavy
HZY	hazy
*ICG	icing
*ICGIC	icing in clouds
*ICGIP	icing in precipitation
IFR	instrument flight rule
ILSNO	instrument landing system not operative until further notice
INCR	increase
INDFNT	indefinite
INSTMT	instrument
INTMT	intermittent
INTS	intense
IOVC	in the overcast
IPV	improve
IREG	irregular
KAFMXD	smoke and fog mixed
LFT	lift
LGT	light
LMT	limit
*LTNG	lightning
LVL	level
LWR	lower
LYR	layer
MAX	maximum
MDT	moderate
MIM	minimum
MISG	missing
MOV	move
*MSL	mean sea level
MTN	mountain
MXD	mixed
NMRS	numerous
*NOOPV	not operative
*NOTAM	notice to airmen
OBS	observe
*OBSC	obscure
OBST	obstruct
OCLD	occlude
OTP	on top
OTR	other
*OVC	overcast
OVHD	overhead
OVR	over
PB	pilot balloon sequence reports
PBL	probable
PCPN	precipitation
PDW	priority delayed weather
*PIREPS	pilot reports
PRES	pressure
PSBL	possible
PSG	passing
PTCH	patch
PTLY	partly
PTN	portion
PVLT	prevalent
QTR	quarter
QUAD	quadrant
*RABNO	radio range and voice communication facilities not operative until further notice
*RACFI	radio and communication facilities not operative until further notice
*RACFO	radio and communication facilities operative
*RACOM	radio and communication facilities
*RAFRZ	radiosonde observation lowest freezing level at
*RAGOK	radio range resumed operation
*RAICG	radiosonde observation icing at
*RANDI	radio range has probably shifted from published bearing
*RANOT	radio range not operating until further notice
RAOBS	radiosonde observations
*RARAU	radio range appears unreliable
RCV	receive
*RCVNO	radio receiving facilities not operative until further notice
*RCVOK	radio receiving facilities resumed operation
REDIS	reference dispatch
RENOA	reference notice to airmen
RGD	ragged
RH	relative humidity
RNG	range
RNWY	runway
*RONLY	receiving only
RPD	rapid
RS	radiosonde reports
RSG	rising
*RSOPN	resumed operation
RUF	rough
SBSD	subside
SC	sequence collection reports
SCT	scatter
SFC	surface
SHFT	shift
SHLW	shallow
SHWR	shower
SLGT	slight
SLT	sleet
SLW	slow
SNW	snow
SQAL	squall
STG	strong
STM	storm
STN	station
SVR	severe
*THD	thunderhead
THDR	thunder
THK	thick
THN	thin
*THSD	thousand
THTN	threaten
TLTP	teletype
TMP	temperature
*TOVC	top of overcast
*TPG	topping
TSHWR	thundershower
*TSTM	thunderstorm
*TURBC	turbulence
TURBT	turbulent
UNL	unlimited
UNRSTD	unrestricted
UNSTDY	unsteady
VLNT	violent
VRBL	variable
VRG	veering
VSB	visible
*VSBY	visibility
VSRDBK	visibility reduced by smoke
*VSRSTD	visibility restricted
WEA	weather
WENOA	weekly notice to airmen
WK	weak
*WND	wind
WRM	warm
WRS	worse
XCP	except
XLNT	excellent
XST	exist
*ZOHOK	station location marker, ultra high frequency, resumed operation
*ZONOT	station location marker, ultra high frequency, not operating until further notice.

Teletype reports are sent every hour. In bad weather, extra reports called "specials" are sent in the interim between scheduled reports. All these reports are posted as received, in code, and are the only source of really fresh weather information. Navigators and pilots read them before taking off. The table where these reports are posted is where flying men "sweat out" the weather.

NOTES

EVERY HOUR TO CHECK ON FORCASTS

LATEST CHECK ON WEATHER BEFORE FLIGHT

CLASSIFICATION - DETERMINED BY CEILING AND VISIBILITY

C (CONTACT) CEILING 1000 OR MORE VISIBILITY 3 MILES

N (INSTURMENT) " 500 - 1000 " 1 AND 3 MILES

X " BELOW 500 FT. " LESS THEN 1 MILE

CEILING - LOWEST LAYER OF CLOUDS THAT COVERS 5 OR MORE TENTHS OF THE SKY

IF VISIBILITY IS FARTHER THEN 10 MI. NO REPORT GIVEN / IF VISIBILITY IS LESS THEN 6 MILES THE REASON MUST BE GIVEN

IF CEILING IS HIGHER THEN 10,000 NO "CEILING" IS INDICATED

○ — SKY CLEAR, NO CLOUDS (CANNOT FORM CEILING)

◑ — SCATTERED (CANNOT FORM CEILING)

◍ — BROKEN (FORM CEILING)

⊕ — OVERCAST (FORM CEILING)

ABOVE 10,000 FT. DIAGONAL LINE IS ADDED BESIDE SYMBLE I.E. O/ (SKY CLEAR ABOVE 10,000)

\+ - HEAVY

\- - LIGHT

NO SIGN - MODERATE

NOTES

QUESTIONS

Decode the following reports and complete the chart provided. If the report is not classified, decide on the correct classification and enclose the classification letter in parentheses. The first report has been entered in the chart as an illustration.

1. LN 70⦶ 227/17/9→↘10/014/SNW CVR 1
2. AQ C ○9 254/20/14→11/017/K SW
3. NAS SPL 290650C E10⊕⦶3H 105/70/69↑↗16/983/E70⦶ SCUD 3 HND
4. LK ○3/8GF 38/38C
5. TUT E15⊕⦶R- 041/50/48↙5/963/CLDS TPG RDGS E40⊖6⦶
6. AF E45-⊕11/2SW- 129/24/14↘26+/985/ 803 5007
7. TTV SPL E35⦶/⦶21/2K- 058/56/54↖11/972/CM OVHD CLRG W
8. AF P10⊕11/2RF- 125/56/54↓6/989
9. LI N E15⊕/⦶11/2K- 122/55/52C/988
10. NAS SPL 240800C E15⊕/⦶7 145/67/63↘14/995/6⦶ FROPA 240750C
11. CG C E12⊕8⦶7R- 980/51/45↑↗15/947/CIG RGD

8-HH

1307

	STN	CLASSIFICATION	CEILING CIG	HEIGHT AND AMOUNT: CLDS ABV CIG	CLDS FRMG CIG	CLDS BLO CIG	VSBY	WEA	OBSTN TO VSN	TMP-DWPNT SPRD	WND: DRCTN	VEL	ALSTG	RMRKS
1-	Lebo, Kans.	(C)	Unl	None	None	7000 feet sctd	Over 10 mi.	None	None	8°F	WNW	10 mph	30.14	Snow cover one inch
2-	AMARILLO, TEX.	C	UNL	NONE	NONE	NONE	9MI.	NONE	NONE	6°F	W	11 MPH	30.17	SMOKE AND SNOW SHOWERS
3-	NAS -		1000				3 MI		HASE	1°F	SSW	16 MPH	29.83	ESTIMATED, BROKEN CLOUDS AT 7000
4-	LK	—	—	NONE	NONE	NONE	3/8 MI	NONE	GROUND FOG	0°	—	CALM	—	—
5-	TUT	—	1500	OVERCAST AT 1500			OVER 10 MI.	LIGHT RAIN	—	2°	NW	5MPH	996.3	CLOUDS TOPING RIDGES ESTIMATED AT 4000 FT. SCATTERED CLOUDS AT 600?
6-	AF	—	4500 OR LESS	OVERCAST	—	—	1 1/2	LIGHT SNOW SHOWERS	LIGHT SNOW SHOWERS	10°	NE	26 GUST)	998.5	
7-														
8-														
9-														
10-														
11-														

F - 1307

5-WX-5

NOTES

QUESTIONS

		SYMBOL	NAME
1.	More than nine tenths of the sky covered with clouds.	⊕	OVERCAST
2.	Clouds cover six tenths to nine tenths of the sky.	⦷	BROKEN
3.	Clouds cover one tenth to five tenths of the sky.	⦶	SCATTERED
4.	Clouds, if any, cover less than one tenth of the sky.	○	CLEAR
5.	Which cloud deck is the lower? ⦶⦷	⦷	

6. Check the cloud decks which would make a ceiling: ○ __ ; ⦶ __ ; ⦷ ✓ ; ⊕ ✓ .

7. When clouds are reported as ⦷/, what is the height of their bases above the surface? OVER 10,000 FT.

8. When AQ (see "Partial List of Station Identification Letters") reports "M14⊕", what is the height of the base of the clouds above mean sea level? 17,604 FT.

9. What is the difference between (a) −⦶/ and (b) ⦶/ ? "A" LESS THEN 10,000 FT.

10. What is the difference between (a) E20⊕ and (b) E20+⊕ ? OVERCAST IS HIGHER IN "B"

11. What is the meaning of the remark "TSTM DSIPTD"? THUNDERSTORM DISSIPATED.

12. TS X 01/16GF+ 125/36/36↗3/990/BROOK
   (a) Why is Tulsa closed? VISIBILITY IS 1/16 MILE
   (b) What is the meaning of "BROOK"? BROADCAST RESUMED OPERATION

13. PDW CQN NO N 291130E M7⊕ 132/61/56↓↘29+/991/CIG RGD/ 315 5001
   (a) What is the name of the station? ______
   (b) What is the time of the report? ______
   (c) Why is the field on instruments? ______
   (d) How was the ceiling obtained? ______
   (e) What is the character of the wind? ______
   (f) Translate the remark. ______

14. DV N W5⊕⊕3R-F-K- 173/44/42←7/002/E8⊕ CLDS OBSCG MTNS
   (a) What is the meaning of the W? ______
   (b) What is the classification? ______
   (c) Why is the field so classified? ______
   (d) What is the height of the ceiling? ______
   (e) What is the height of the broken clouds? ______
   (f) What is the height of the overcast? ______
   (g) What does the "K-" mean? ______
   (h) Decode the remark. ______

15. AG C ⦶/ 196/73/69↓↘14/016/FQT LTNG CLD TO GND W AND SW PIREPS LARGE TSTM RABNO ZONOT
   (a) What is the ceiling? ______
   (b) What is the visibility? ______
   (c) Write out the remarks in full. ______

16. TUT W12⊕4⦶R- 112/59/56←↖9/989/R INTMT ⦶ TPG MTNS T MOVD SW
   (a) What should be the classification of this field? ______
   (b) Write the remarks in full. ______

17. WD X SPL 131519C W15+⊕1VSQ+E 063/18/15↓↘26↗1514C+/971/WND OCNLY 45 ONE 10755 5005 RAGOK BRM RSG RPDLY
   (a) What is the time of the report? ______ CWT
   (b) What is the meaning of the plus sign in "W15+⊕" ? ______
   (c) What weather is reported first? ______
   (d) What weather is then reported? ______
   (e) What is the wind direction at the time of the report? ______
   (f) What velocity does the wind occasionally attain? ______
   (g) What is the average velocity of the wind? ______
   (h) RAGOK means ______
   (i) BRM RSG RPDLY means ______

18. DGM ○ 098/58/55C/981/SHLW TRACES GNDFG LOW PLACES N AND NE
    (a) What is the ceiling?______________________________
    (b) What is the sky condition?______________________________
    (c) What is the visibility?______________________________
    (d) Write the remarks in full.______________________________
    ____
    ____

19. WD N W5⊕2VTRW+ 023/65/65↙14-/945/FEW SCUD E3 RANDI
    (a) What is the visibility?______________________________
    (b) What weather is reported first?______________________________
    (c) What other weather is reported?______________________________
    (d) What is the height of the lowest clouds reported?______________________________
    (e) What is the barometric pressure?______________________________
    (f) What is the character of the wind?______________________________
    (g) What does "RANDI" mean?______________________________

20. DWX SPL 291440C A5⊕3R-F- 122/62/60→25+/989/BRONO VSBY 4 N PIREPS TOVC 150 MSL
    (a) What is the time of the report?______________________________ CWT
    (b) What should be the classification of the field?______________________________
    (c) Approximately how thick is the cloud?______________________________
    (d) How was the height of the cloud determined?______________________________
    (e) What is the visibility looking north?______________________________
    (f) What is the character of the wind?______________________________
    (g) What is the average velocity of the wind?______________________________
    (h) What item of equipment is not operating?______________________________

21. GC N SPL 240952E E6⊕⊕11/2TRW+ 129/64/62↗16/992/E15⊕ THDS ALL QUADS
    (a) What is the time of the report?______________________________ CWT
    (b) What is the height of the ceiling?______________________________
    (c) What is the height of the overcast?______________________________
    (d) What is the height of the broken deck?______________________________
    (e) What is the visibility?______________________________
    (f) What weather is reported first?______________________________
    (g) What other weather is reported?______________________________
    (h) Write the remark "THDS ALL QUADS" in full.______________________________
    ____

22. UM C SPL M23⊕7⦶ 108/58/58↗5/984/DSNT LTNG NE ⦶V⦶ RANOT
    (a) What is the visibility?______________________________
    (b) What is the pressure?______________________________
    (c) What is the ceiling?______________________________
    (d) Explain the indication that the ceiling may change.______________________________
    ____
    ____
    (e) What is the meaning of RANOT?______________________________
    (f) Write in full the rest of the remarks.______________________________
    ____

23. NAS SPL 290800C E7⊕4T 997/63/60↓↙17-↑↗0745C/952/T NW DSNT RW OCNL LTNG CLD TO GND CIG VRBL 7 TO 10

(a) What was the time of the wind shift?________________CWT
(b) What is the barometric pressure?________________
(c) How should the field be classified?________________
(d) What is the character of the wind?________________
(e) What is the direction of the wind now?________________
(f) What was the direction before the shift?________________
(g) Write the remarks in full.________________

24. PC X SPL P8+⊕1/2VE+SW 983/24/20↘25+↑1612C+/936/OCNL SNW SQAL RARAU

(a) There are four plus signs in this report. Clearly state the meaning of each, taking them in order, and name the weather to which each applies.________________
(b) What is the present wind direction?________________
(c) What does "RARAU" mean?________________

25. DKX SPL P8⊖⁝2A-ZL-F- 135/30/27→↘22/991/E40⊕ WND SHFTG GRDLY/ 31914 6006

(a) Give the height and coverage of the higher deck of clouds.________________
(b) Give the height and coverage of the lower deck of clouds.________________
(c) What is the weather reported first?________________
(d) What is the weather next reported?________________

26. DON C O 058/44/21→↗5E/975/FEW HI THN CLDS K LYR ALF SW

(a) What is the meaning of the "5E"?________________
(b) If there are clouds as it says in "Remarks", why is the sky reported clear?________________
(c) Write in full the meaning of "K LYR ALF SW".________________

27. CG C E40⊕/⊕8 976/53/44↑↗13/944/BINOVC OCNL THDR LTNG NE DRK N THRU E

(a) What is the barometric pressure?________________
(b) Which deck of clouds is the ceiling?________________
(c) What is the height of the other deck?________________
(d) Write the remarks in full.________________

28. CG X WOO1F+ 201/-15/-15↗7/053
   (a) What is the ceiling?________
   (b) What is the visibility?________
   (c) How many degrees below freezing is the temperature?________
   (d) What is the altimeter setting?________

29. CG N E10⊕2SQ+ 203/-9/-10←35+/012/VSBY SW1 1/4 NW2 NE1 3/4 SE 4
   (a) What weather is reported?________
   (b) How many degrees below freezing is the dew point?________
   (c) Write the remarks in full.________

   ____

30. BH N SPL 291209C E8+⊕3R-F- 122/60/50↘19-↗1205C-/989/VSBY NE2 -⊕SE RANOT
   (a) In general, is the overcast dark or thin?________
   (b) What was the wind direction 5 minutes before the time of the report?________
   (c) There are five elements modified by minus signs. Give their meanings. Give them in order.________

   ____

   ____

   ____
   (d) What is the meaning of "RANOT"?________

31. JX C SPL E30⦶/⊕7R- 152/66/62↓↘12/997/RW SW SE AND N
   (a) Write the remarks in full.________

   ____

32. LC C SPL 291105C E70⦶100⊕ 200/46/35↓↘15-/011/RAFRZ 127 MSL RH 51
   (a) What is the date of the month?________
   (b) What does the minus sign mean?________
   (c) Translate the remarks.________

33. AG N SPL A5⦶/⊕2R- 125/63/62↑↗11/993/CIG RGD TOP LWR CLDS 40 MSL RAINING FROM HIR CLDS
   (a) How was the height of the ceiling determined?________
   (b) Which is the ceiling, the overcast or the broken deck?________
   (c) At what level is the top of the lower deck of clouds?________

34. CO C E33⦶⊕8 058/53/46↑↗18/969/RW- E50⦶ ⊕V⦶
   (a) What is the meaning of "RW-"?________
   (b) Why is this reported in remarks instead of the regular position for weather?________
   (c) What is the meaning of ⊕V⦶?________

   ____

8-44

1313

35. DV SPL 291204M PIREPS 10N DV BASE ⊕ 85 MSL MDT RIME ICGIC
    Write in full.

36. NA SPL 231544C PIREPS ICG- TO ICG DKX TO NA 30 MSL TMP 27
    LOST ICG BLO 30 MSL
    Write in full.

37. PS SPL 071012C PIREPS TMP 2C 60 MSL 3C 70MSL
    Write in full.

38. KC SPL 011021C PIREPS TOVC 20 W DM 55 MSL
    Write in full.

Decode the following reports and complete the chart provided. If the report is not classified, decide what the correct classification should be and enclose the classification letter in parentheses. Report number 39 has been entered in the chart as a model.

39. BH C SPL 291106C W14⊕⊕3R-K- 115/59/57↑↗11/988/PCPN INTMT E70⊕
40. TJ C SPL E12+⊖ 146/78/70↓↘25+↗1225E-/995/PIREPS HVY TURBC
41. GD C SPL E10⊖6K- 159/46/41↘27+/999/DRK CLD E RANDI
42. UO SPL 231013C A25⊕10⊕7 203/42/35↘20/012/BINOVC PIREPS TOVC
    37 MSL ANOTHER LYR ABV VSBY UNRSTD BTWN LYRS
43. LG N E9⊕3R- 081/46/44←17/976/SCUD 4 HND HIR ⊕ VSBL THRU BRKS
44. CG C E30⊕/⊕ 976/52/44↑↗13/946/5K S/ 100 5709 52
45. TS C ○ 237/25/20↘10/020/CU FRMG WSW
46. KX C E25⊖5R- 172/57/56→↘4/005/FOG FRMG IN VLYS E-NE
47. DOX SPL A3⊖1-⊕1L- 129/64/63→↗9/990/PIREPS TOVC 30 TWRG CU ALL QUADS
48. UM E85⊖/⊕6F-K- 163/67/64↑↗11/000/FEW SC 3 THSD BINOVC
49. UO A30⊕⊕1/4TBD+ 132/85/81↗22+/998/THDS SW E70⊕

7-WX-6

F-1313

STN	CLASSIFICATION	CIG	GIVE HEIGHT AND AMOUNT			VSBY	WEA	OBSTN TO VSN	TMP-DWPNT SPRD	WND		ALSTG	RMRKS
			CLDS ABV CIG	CLDS FRMG CIG	CLDS BLO CIG					DRCTN	VEL		
Birmingham, Ala.	C	Indefinite 1400'	7000' OVC	1400' Brkn	None	3	Light rain	Light smoke	$2^{0}F$	SSW	11 mph	29.88	Precipitation intermittent

The accuracy and value of a forecast given to airmen depend on the accuracy and completeness of the information available to the weather officer. Even in the United States and in England, where hundreds of stations make regular reports of observations from the ground, reports from planes in flight are often necessary to accurately locate fronts, cloud layers, and other phenomena that affect flying. In some theaters of war, the weather officer has little information except the reports of returning airmen. Therefore it is extremely important that navigators learn to make accurate, legible, and intelligible observations in flight. To attain this end, the student will make weather observations during training flights and supplement these by practice on the ground.

Navigation weather observations should include the following, in order: (1) Place, date, time; (2) Clouds; (3) Visibility; (4) Weather and obstructions to vision; (5) Special phenomena.

In the first group, when recording a surface observation, give the call letters of the station, the date of the month, and the time of day. While in flight give the time of all observations and the location when practicable. The time of observation made in flight will be in GCT, as are all entries in the log. With permission of the instructor, observations from the ground may be marked in CWT. Thus IV 061430C would mean Ellington Field, sixth day of the month, 1430 CWT; 15E DHN 2015 would mean 15 miles east of Hondo, 2015 GCT.

Second, all layers of clouds will be reported, giving amounts, tops and bases. After clouds are studied, the names of the clouds observed will be noted, using the approved abbreviations. If there are no clouds, CLR or ○ will be entered. The amount of each cloud layer will be reported by SCTD or ⦶ BRKN or ⦷, OVC or ⊕ . The top and base of each layer will be recorded in hundreds of feet MSL, with the top as the numerator and the base as the denominator of a fraction. The letters M, E, and U will indicate whether the level is measured, estimated or unknown. Examples: SCTD $\frac{M40}{E25}$, OVC $\frac{U}{E80}$, BRKN $\frac{M48}{M15}$, ⦷ $\frac{U}{E70}$, ⦶ $\frac{U}{M30}$.

Third, visibility (VSBY) will be estimated and recorded in miles. The word "unlimited" will not be used. Visibility will be defined as the length of the radius of the circle of objects on the earth that can be recognized from the place of the observer.

Fourth, the abbreviation for the existing weather and obstruction to visibility should follow the visibility, e.g. VSBY 15H, VSBY 5RW, VSBY OF.

Finally, any phenomenon occuring at the time and in sight should be recorded. For example: moderate turbulence (TURBC), heavy turbulence (TURBC +), light icing (ICG -), heavy icing (ICG +), thunderstorm 15 miles to the south (TSTM 15S), thunderheads to the west (THDS W), fog bank 10 miles south of Atlanta (F BNK 10 S AG), distant lightning to the southeast (DSNT LTNG SE), thick smoke layer at 3500' (THK K LYR 35 MSL), clouds obscuring mountains (CLDS OBSCG MTNS), freezing level at 14,000' (FRZG LVL 140 MSL).

During flight, weather observations should be recorded whenever any change takes place in the weather or when any special phenomenon is encountered or noticed for the first time. Routine observations should be made so that not more than 30 minutes elapse between observations.

NOTES

QUESTIONS

CLOUD NAME	*ABBREVIATION*
Altocumulus	AC
Cirrus	CI
Cumulonimbus	CB
Cumulus	CU
Stratus	ST

Read the observations:

1. DHN 130600C ⦶ AC $\frac{E145}{E140}$ VSBY 2GF

2. DMS 070900C ⦷ CU $\frac{E200}{E40}$ VSBY 10H

3. UO 091600C ⦶ CB $\frac{E250}{E30}$ ⦷ CI $\frac{U}{U}$ VSBY 15 TRW 10 E

Record the following observations:

4. Ellington, 18th day, 1100 CWT, scattered cumulus with estimated bases and tops at 2500' and 4000', scattered altocumulus with estimated bases and tops at 14,000' and 15,000', Vsby 15 miles, thunderheads visible to the southwest.

5. Hondo, 26th day, 2300 CWT, scattered altocumulus, Vsby 20 miles, distant lightning to the east.

Read the following in flight observations:

6. 1900 ⦷ CU $\frac{M100}{M\ 30}$ VSBY 20H LGT TURBC BLO CLDS

7. 15 SE JA 1100 ○ VSBY 8K F BNK S AND E

8. (35-50N; 83-40W) 1800 ⦷ ST $\frac{E55}{M40}$ VSBY 20 CLDS OBSCG MTNS 10E

Record the following in flight observations:

9. At 1200, stratus bank to the south and east; scattered altocumulus with bases measured at 14,000 feet, tops estimated at 15,500 feet; Vsby 10 miles with light smoke layers at 500 feet.

10. 10 miles E of Tyler, Texas at 2000, an undercast of stratus clouds with tops estimated at 4000 feet, an overcast of altocumulus with base measured at 10,000 feet, light drizzle, freezing level at 9000 feet.

The purpose of this period is to acquaint the student with the facilities of the weather station. Before the trip, the student should have some idea of what he is expected to see and learn. Notice how various observations are measured.

(1) Barometric pressure.
(2) Wind velocity and direction.
(3) Base of clouds with ceiling light and clinometer at night.
(4) Base of clouds with ceiling balloon.
(5) Temperature and dew point.
(6) Pibals.

Learn when and in what form the following reports are received:

(1) 6-hourly synoptic map data.
(2) Pibal.
(3) Radiosonde.
(4) Weather Bureau forecasts.

Become acquainted with the various charts by which the weather station attempts to put its teletype data into usable form.

(1) Synoptic weather map.
(2) Cross section.
(3) Adiabatic chart.
(4) Winds aloft chart.
(5) Pressure charts for upper levels.

Understand the scheme used for reporting hourly weather observations.

(1) When observations are taken.
(2) How the region is divided into circuits.
(3) Procedure followed when sending.
(4) When special observations are sent.

NOTES

40% OF SUNS RAYS ABSORBED BY EARTH —INSULATION
1- CLEAR AIR DOSE NOT ADSORB AS MUCH OF SUNS ENERGY

2- MAX. TEMPERATURE IS INCREASED BY CLOUD LAYER

THE HOTTER THE SHORTER
THE COLDER THE LONGER

CONVECTION — WHEN AIR MOVES VERTICALLY
ADVECTION — " " " HORIZONTALLY

The amount of solar heat received at the surface of the earth depends on the inclination of the sun's rays and on the amount of cloudiness. Even places receiving the same amount of heat will vary in temperature if they have different types of surface. Water heats slowly, especially if deep, vegetated areas more rapidly and bare regions most rapidly of all.

Good absorbers of heat are also good radiators, and the bare regions that are heated most rapidly will also cool most rapidly after sunset. Deep water scarcely changes temperature and well vegetated areas have a moderate variation in temperature between day and night. Also a cover of clouds will retard cooling at night just as it reduces insolation during the day. Deserts have extreme variation in temperature between day and night not only because the surface is bare, but also because they are so situated that they have very few clouds.

Variations in surface temperature cause variations in air temperature, which in turn cause variations in air density. Warmer air is less dense and will float up like a balloon or like the draft in a chimney. The warm air that rises must be replaced by air subsiding to take its place and the resulting circulation is called convection.

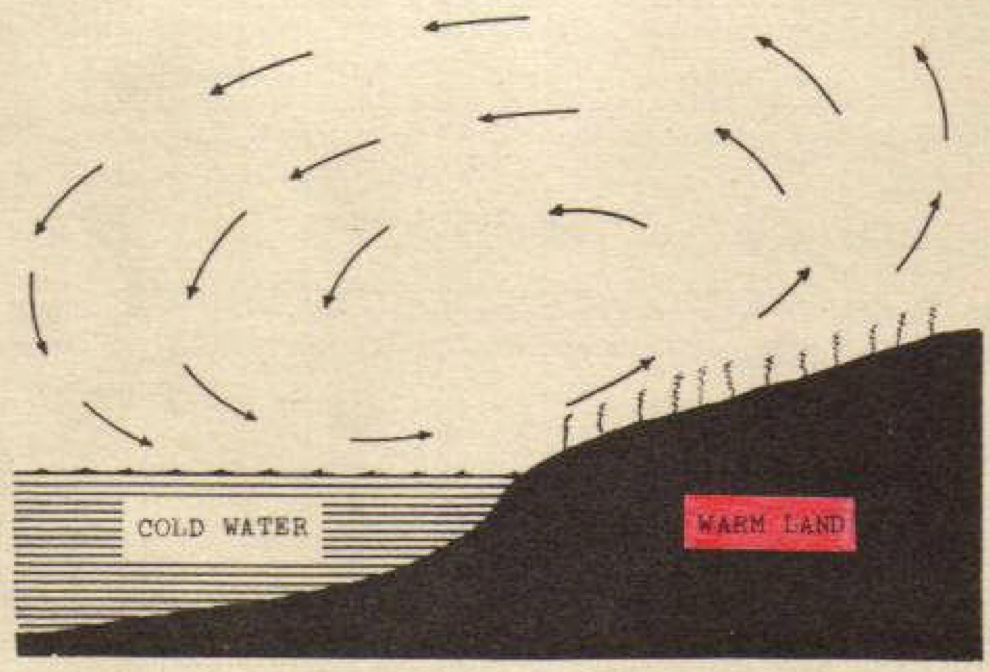


Figure 1. Sea Breeze Caused by Convection.

The horizontal movement, especially when it is on a large scale, is called advection. Advection also includes the movement from warm to cold surfaces, as for example, from the warm Gulf Stream to the cold Labrador Current.

The balloon-carried device for measuring the temperature, pressure, and humidity of air aloft is called a radiosonde. Reports of the observations made with it are called "raobs" for short.

The lapse rate of temperature with altitude varies greatly, especially in the lower levels, but averages about 2°C/1000'. Since warm air rises, heating is carried upward rather rapidly, while cooling is usually noticeable only near the surface.

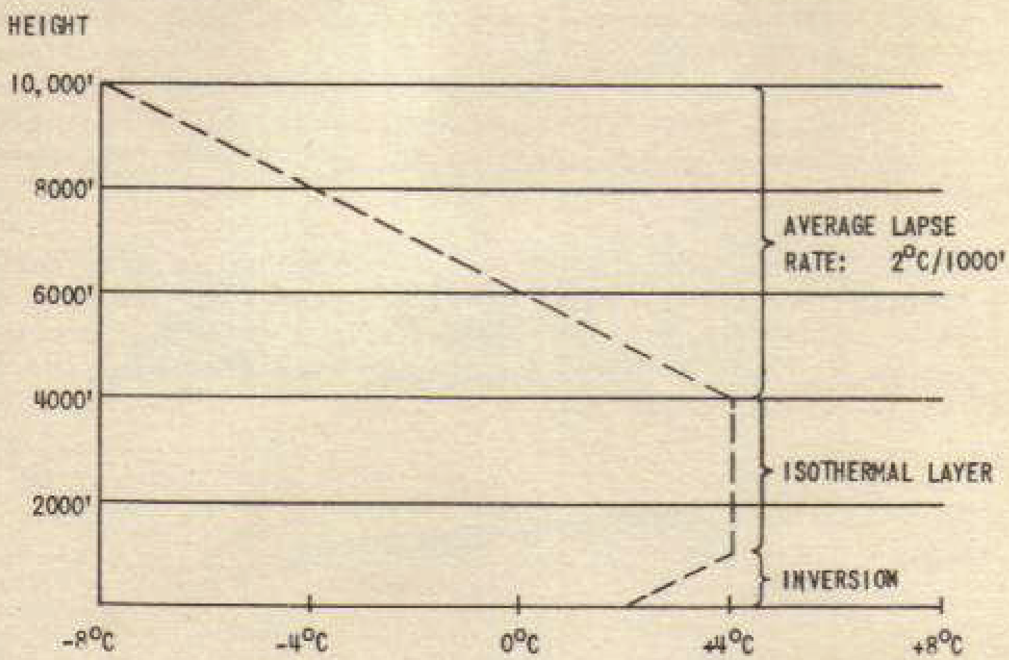


Figure 2. Night Sounding.

Surface inversions are caused by radiation or advection, upper inversions are caused by turbulence, subsidence or frontal surfaces.

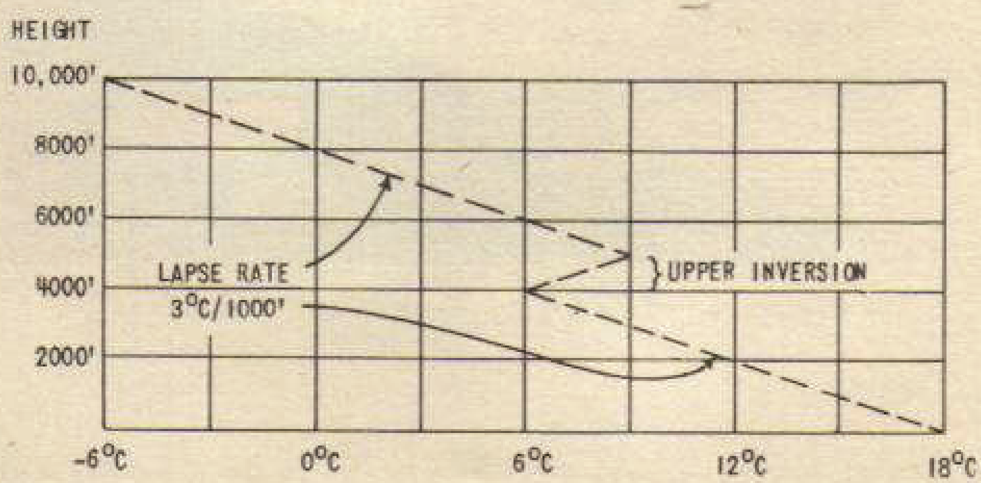


Figure 3.

Since inversions occur with frontal surfaces, they are important to navigators. The wind usually changes sharply when the temperature changes suddenly.

See WX-13 for further discussion of vertical currents.

NOTES

QUESTIONS

1. The term insolation means ______________________________

2. Upon what two factors does insolation depend? ______________
   (1) ______________________ (2) ______________________

3. Which type of surface, land or water, heats more rapidly? ______________

4. Which heats and cools faster, open fields or heavily vegetated tracts?
____

5. Are winter minimum temperatures experienced on clear or cloudy nights?
____

6. Why are desert temperatures so cool in the early morning? Give two reasons.
(1)_______________
(2)_______________

7. Which holds heat better, a surface that heats rapidly or one that heats slowly?_______________

8. Which is more effective in heating the atmosphere, the direct rays of the sun or a warm surface?_______________

9. Due to unequal heating during the day, would up-currents be normally expected over a barren field or over an adjacent water surface?_______________
____

10. On a hot summer afternoon will there be advection currents from water to adjacent land areas or vice-versa?_______________

11. Do convection currents stop as soon as the sun sets?_______________

12. At what period in the day are convection currents usually strongest?
____

13. Would convection currents be expected over the Gulf Stream at night?
____

14. What is the average lapse rate?_______________

15. When is the lapse rate usually greatest, 0001 to 0600; 0600 to 1200; 1200 to 1800; 1800 to 2400?_______________

16. When is the lapse rate usually least?_______________

17. The temperatures of the upper atmosphere are obtained by an instrument called a RAIDOSONDE. The report of the observation itself is spoken of as a RAOBS report.

18. A layer of the atmosphere in which temperature increases with altitude is called an INVERSION.

19. What layer of the atmosphere has the greatest variation in temperature?
LOWER

20. Give one reason for an upper air inversion._______________
____

Although atmospheric pressure cannot be directly and simply associated with air temperatures, it is agreed that temperatures over the earth's surface in a large measure account for differences in air densities - hence differences in atmospheric pressure. Wind is a horizontal motion of air caused by pressure differences. Air tends to flow from higher to lower pressure just as water tends to flow down hill. The speed with which this air flows depends upon the change in pressure per unit of distance (pressure gradient). The steeper the gradient the stronger the wind. This force which tends to move air along the pressure gradient is called the pressure gradient force.

If pressure gradient force were the only force involved in wind direction, winds would blow perpendicular to isobars directly from higher to lower pressure. However, due to the rotation of the earth, winds are deflected to the right of pressure gradient in the northern hemisphere and to the left in the southern hemisphere. This deflection, called Coriolis effect, is proportional to the wind velocity.

Frictional effects of the earth's surface slow down the air flow and hence reduce the Coriolis effect in the lower atmosphere. Resultant surface winds will diverge from highs and converge toward lows, spiraling across the isobars at an angle depending upon the terrain and the amount of friction: 10-30° is common. The circulation will be clockwise about highs and counterclockwise about lows in the northern hemisphere. The circulation is reversed south of the equator. Gradient winds are winds apparently free from surface friction, which are parallel to isobars. The gradient level (the lowest level at which the wind is free from frictional effects) is normally found about 2000 feet above the surface. This level varies a great deal depending on terrain.

Buys Ballot's law states that if one is in the northern hemisphere and places his back to the wind, lower pressure will lie to his left and higher pressure to his right. These directions are reversed south of the equator.

Winds are reported by the direction from which the winds are blowing. Barbs on the wind arrow on surface maps indicate the wind velocity by means of the Beaufort scale. Each full barb counts two, and a half barb counts one. A conversion from Beaufort numbers to mph can be approximated by multiplying the next two Beaufort numbers above the wind in question and dividing their product by 2, e.g. Beaufort 3 = $\frac{4 \times 5}{2}$ = 10 mph.

Whenever the hemisphere is not specified, assume northern hemisphere.

NOTES

PRESSURE GRADIENT change of pressure with distance

NOTES

QUESTIONS

1. What causes winds to blow? pressure (unequal temp.) differences

2. What deflects winds from the direction of the pressure gradient? Rotation of earth.

3. Upper winds blow parallel to isobars but surface winds do not. Why? Surface friction

4. Why are winds aloft nearly always stronger than surface winds? Frictional effect of the earth's surface

5. What is a gradient wind? High enough so surface friction does not affect it

6. What determines the velocity of a gradient wind? Pressure gradient

7. What gradient wind is expected on the east side of a high? North

8. Navigators often judge wind by waves on the ocean. Will the difference between surface and gradient winds be greater or less than over land, and why? Less because there is less surface friction

9. Surface winds diverge from High centers.

10. Surface winds converge toward Low centers.

11. In the Northern Hemisphere, the air circulates around highs in a Clockwise direction.

12. In the Northern Hemisphere, the air circulates around lows in a Counterclockwise direction.

13. If a low pressure cell is centered to the west, the wind will be from the South

14. In the southern hemisphere, surface winds spiral Clockwise into a low.

15. On the average, the gradient level may be considered as 2000 feet above the surface.

16. Flying with a heading of 360° and a wind of 270° places low pressure ahead of plane's position.

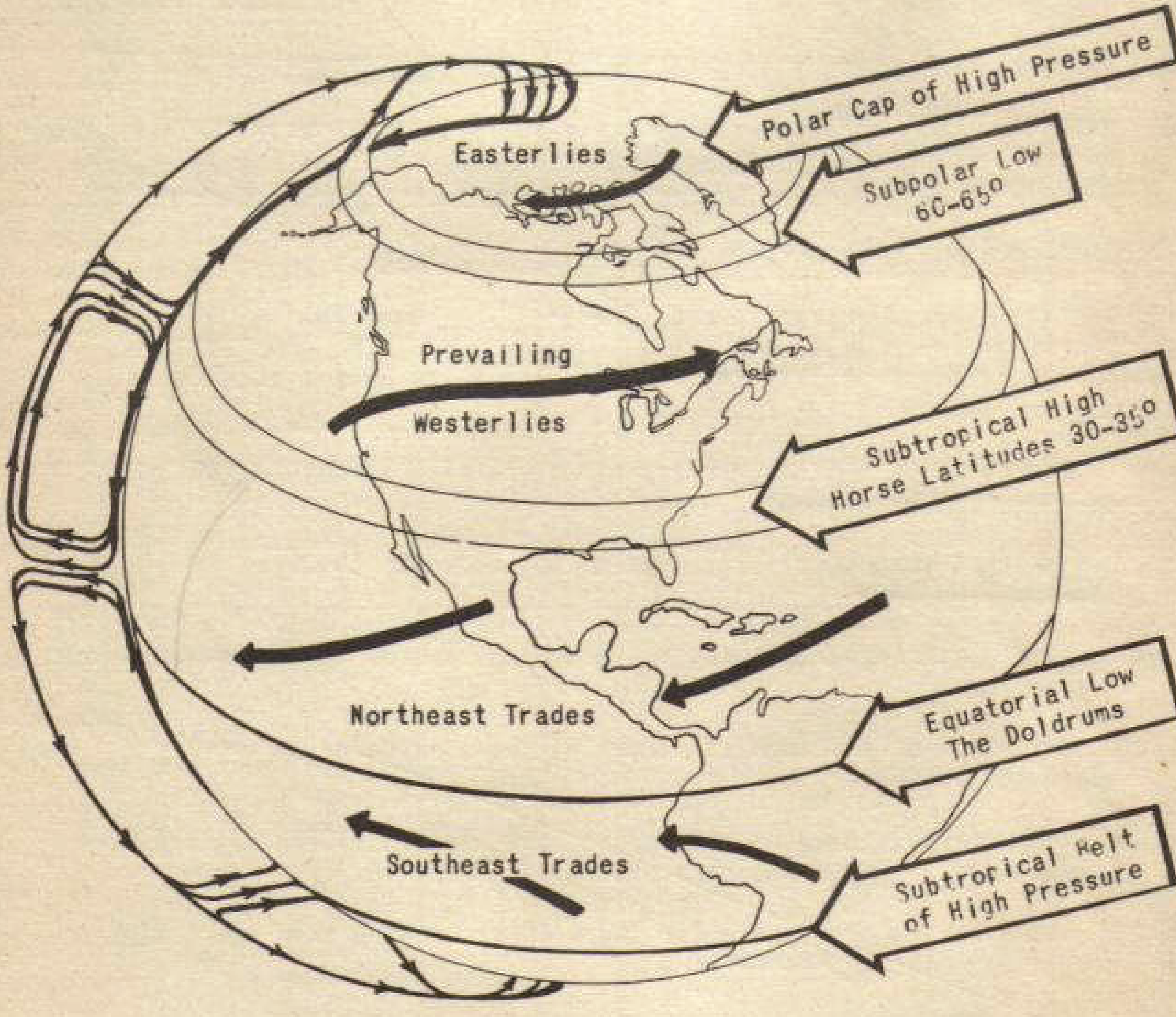
17. In the southern hemisphere, if the wind is blowing from 090°, high pressure lies to the North

18.  The wind is from 80 ° at 3 mph.

19.  The wind is from 340 ° at 23 mph.

20. Give the wind direction and velocity for . 270 °, 36 mph.

Due to unequal heating in different latitudes, air from the polar regions is heavy and cold as compared to air at the equator. At the earth's surface there is a constant tendency for surface air to move from the polar regions toward the equator and equatorial air to rise and flow back toward the polar regions at high levels. Due to the rotational effects of the earth this circulation is not a simple unicellular circulation but breaks down into different cells causing high and low pressure belts and wind zones as indicated on the accompanying diagram. This circulation assumes an earth of the same uniform surface throughout.



The pressure belts and the wind belts migrate with the seasons, but this migration covers only a few degrees. For example, the northern hemisphere sub-tropical high lies south of the Mediterranean Sea in the winter and north of it in the summer.

QUESTIONS

1. In which hemisphere are the prevailing westerlies better developed?______

2. What winds prevail over the North Atlantic?______

3. Why does the west coast of the United States have milder winters than the east coast?______

4. Where are the high pressure belts of the world located?______

5. Where are low pressure belts of the world located?______

6. According to the primary circulation pattern, what are the prevailing winds at the following places?

Hawaii	20°N, 156°W	______
Fiji Islands	18°S, 178°W	______
Canary Islands	28°N, 15°W	______
Falkland Islands	52°S, 58°W	______
San Francisco	38°N, 122°W	______

7. Describe the winds in the doldrums belt.______

8. Where do prevailing easterly winds occur?______

9. In July and August, where are the pressure and wind belts as compared to their average position?______

10. Why are the prevailing winds stronger and more dependable in the southern hemisphere?______

Many of the high and low pressure cells which appear on world pressure maps are a direct outgrowth of primary circulation. These cells may move north and south with the seasons but throughout the year will be found in the same general latitudes - lows 55-65° and highs 25-35°, north and south. Also these cells are found, on the whole, over the oceans rather than over continents because the temperature of water varies less.

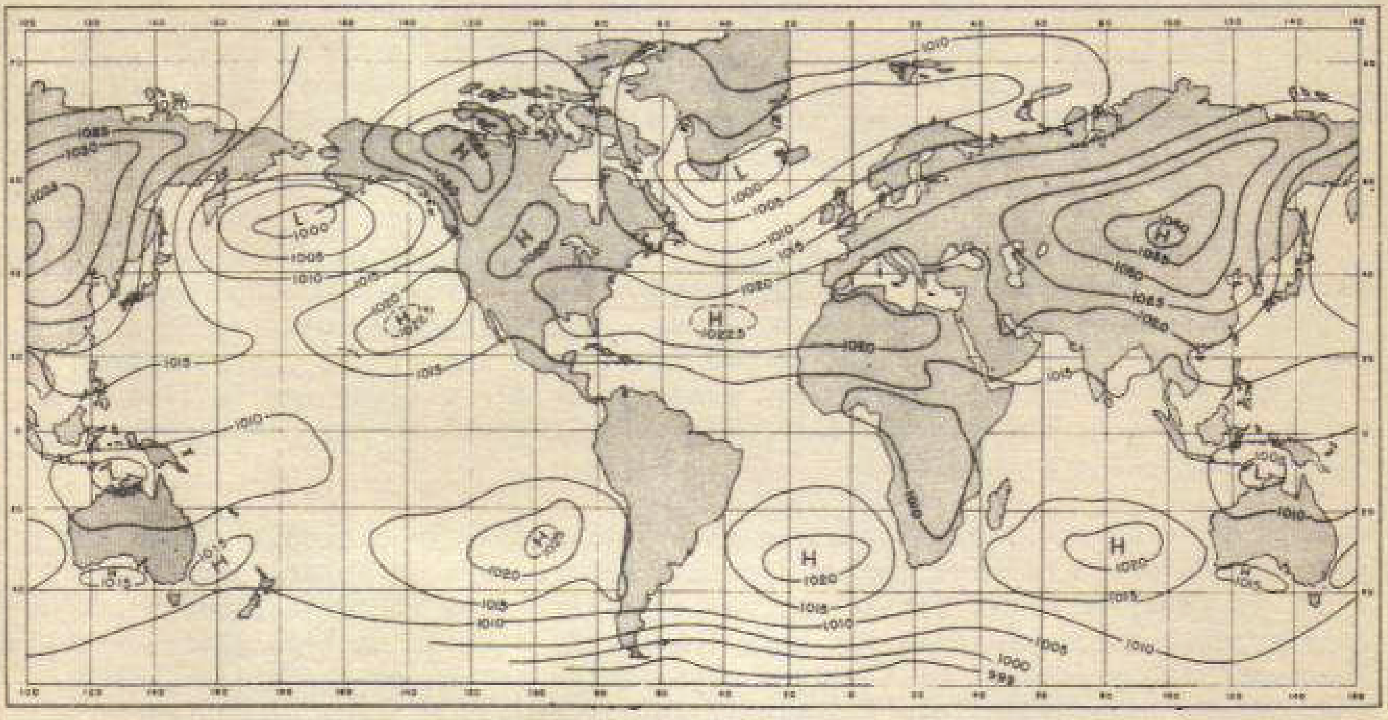


Figure I. Prevailing pressure systems of the world in winter.

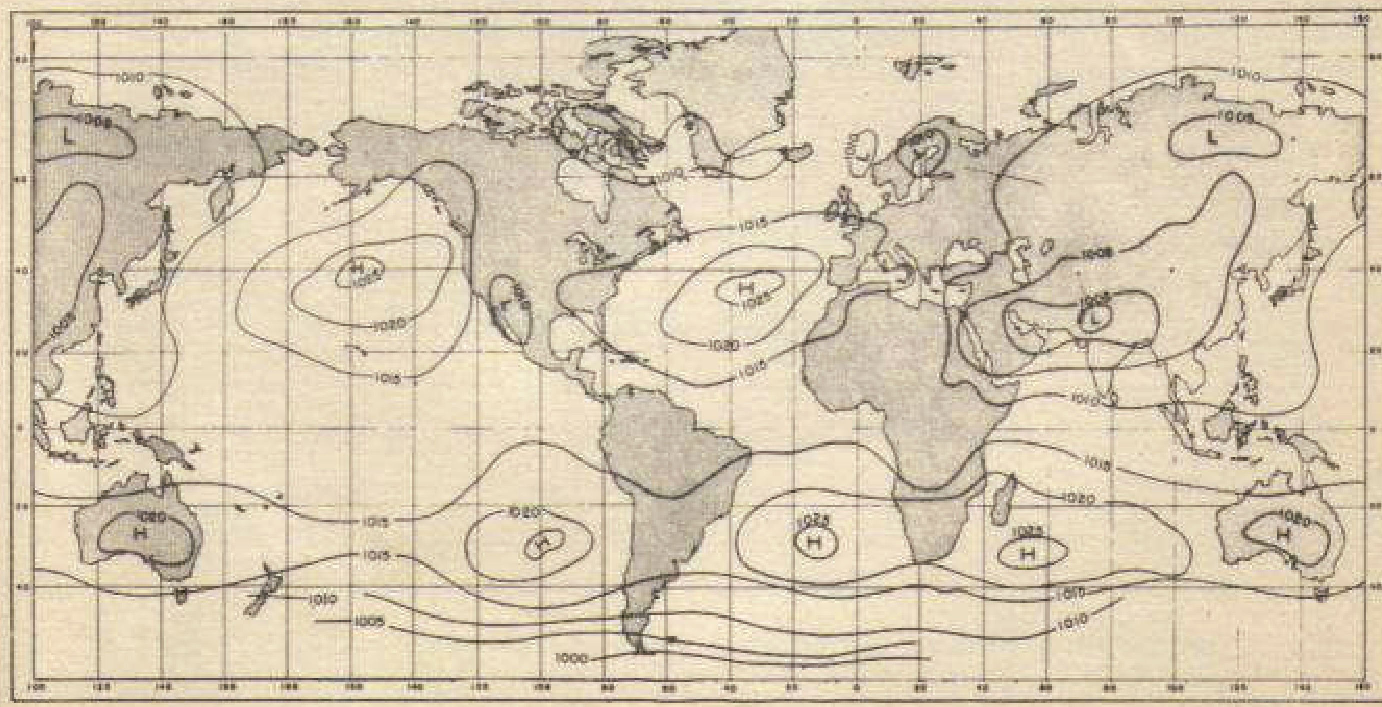


Figure 2. Prevailing pressure systems of the world in summer.

The high and low pressure areas that build up over large continental areas are semi-permanent. High pressures are common over land during the winter seasons and lows develop over hot arid lands during the summer.

Local land and sea breezes are a result of temporary differences in pressure due to differences in temperature. Other things being equal, winds will blow from cool land to relatively warm sea at night, a land breeze, and reverse themselves during the day by blowing from the sea to a relatively warm land, a sea breeze. When land and sea temperature differences build up relative high and low pressures that are reversed with the season, cold, dry offshore winds blow during winter and warm moist onshore winds blow during summer months. This type of wind and pressure control is called a monsoon. Asia has a true monsoon climate.

Mountains also have a modifying influence on pressures and winds. Breezes from the mountains, mountain breezes, are frequent during summer nights and breezes up the mountain slopes, valley breezes, occur during the day. These are due to the heating and cooling of the air in close contact with the earth's surface. Mountain breezes, or air sliding and falling down mountain sides, sometimes build to high velocities if terrain and general weather conditions are favorable. BORA WINDS — COME DOWN MOUNTAINS DUE TO GRAVITY HIGH VELOCITY COLD

Primary circulation as studied in WX-II results in a gradual depletion of air in equatorial regions and an increase of pressure in Polar regions. In order to equalize these pressures, masses of air from polar regions break out at irregular intervals and flow back toward the equator in high pressure cells. These are the migratory or fleeting highs which appear on the daily synoptic map. These highs move into the middle latitudes and are pushed eastward by prevailing westerly winds. Occasionally they are even deflected back north before dissipating. Conflicting circulation between two migrating highs sets up convergence along their borders and frequently develops low pressure troughs and centers. These lows move along with the highs and are usually the focal regions of bad weather.

NOTES

CHINOOK OR FOEHN WINDS — DOWNWARD PRESURE GRADIENT HEATED BY COMPRESSION

WHAT MAKES THE WIND BLOW?

QUESTIONS

1. Where are the so-called permanent lows of the world?____________________

2. Where are the so-called permanent highs of the world?____________________

3. What causes the Canadian high pressure area during the winter months?_____

4. During what time of year will India and Burma have onshore winds?________

5. What causes a reversal of winds from night to day along the coast lines?

6. What is the origin of the migrating highs which show day to day movements on current synoptic maps?

7. How do migrating lows develop?

8. Which direction do migrating highs generally move?

9. How do the permanent high and low pressure centers of the world shift with the season?

10. What is a Bora or Williwaw wind?

11. Are the pressure cells due to primary circulation evident over land or over water?

12. What kind of pressure do large continents develop in winter?

13. How far do land and sea breezes extend from shore?

14. Where is the most effective monsoon and why?

15. Do polar outbreaks occur in cells or as a steady outflow?

16. How do the winds of a migrating high blow?

17. If the controlling high is centered to the east, what is the direction of the gradient wind?

18. Which way will highs and lows in the tropics tend to move? Why?

19. Which have better weather, lows or highs?

20. At Midway Island, 28°N, 177°W, will the trade winds be more dependable in January or in July?

Air converges at the surface in a low pressure area thus causing a rising current of air. At high levels, this current of air spreads out. This air then subsides to take the place of the outflowing air from the high pressure areas at the surface. The rising air and the subsiding air are the large scale vertical currents of the atmosphere.

Vertical currents may also be formed as a result of terrain, fronts, and thermal heating. These vertical currents are on a relatively small scale. These are the vertical currents that cause the turbulence in the air, so noticeable to navigators.

Air, when it is lifted, cools at the rate of 3°C per thousand feet, provided clouds do not form. Upon the formation of clouds, the air cools at the slower rate of 1.5°C per thousand feet. When air subsides, it warms according to the same principles.

If air is warmed to a temperature higher than that surrounding it (e.g., a barren field surrounded by woodlands), it will rise. It will continue to rise until its temperature is the same as that around it. While it is rising the layer of air through which it is passing is referred to as unstable air. When the air reaches a level where it is as cold or colder than the air around it, then that layer of air is referred to as stable air.

If the plotted "raob" shows a lapse rate greater than 3°C per thousand feet, the air is unstable since any air that is lifted will not cool faster than 3°C per thousand feet and thus will continue to rise. Such air will be very choppy or turbulent.

If, on the other hand, the "raob" shows a lapse rate less than 1.5°C per thousand feet, then it is stable, since any air that is lifted will cool at a faster rate and will tend to sink back. Such air will be smooth.

Thus by picking out a layer on the "raob" where the lapse rate is less than 1.5°C per thousand feet, one generally may be sure of smooth flying.

NOTES

NOTES

FREE CONVECTION — WARM AIR RISING OF ITS OWN ACCORD

LAPSE RATE — MORE THEN 3°/1000FT — ROUGH AIR
LESS " " — SMOTHE "

QUESTIONS

1. Name three causes of vertical currents.
   1. TERRAIN ______ 2. FRONTS ______ 3. THERMAL ______
2. What is dry air? ______
3. What is moist air? ______
4. May air which is originally dry become moist by forced lift? ______
5. What causes air to cool on being lifted? ______

6. What causes air to warm on subsiding?______________________

7. At what rate does dry air cool on being lifted?______________________

8. At what rate does moist air cool on being lifted?______________________

9. What are the flying conditions in stable air?______________________

10. How is flying in unstable air?______________________

RAOB LC 1500Z	
SFC	20°C
2000' MSL	13
4000	10
6000	11
8000	10
10000	7
12000	3

11. Is the layer of air between the surface and 2000' stable or unstable?
____

12. Is the layer of air between 4000' and 6000' stable or unstable?
____

13. What can you say about the air between 10,000 and 12,000'?
____

14. According to the LC raob, what altitude would be the most favorable for flying?______________________

15. If rolled, turbulent clouds were present in the atmosphere, where would the smoothest air be: underneath, in, or on top of the clouds?____________

RAOB JA 0300Z	
SFC	27°C
500'MSL	31
2000	28
5000	19
10000	7
12000	7
18000	-2

16. Between which two levels will the air be the roughest?______________

17. Between which two levels above 1000' MSL will the air be the smoothest?
____

18. What name is given to a temperature distribution like that shown for JA from the surface to 500 ft?______________________

19. If the surface temperature increases by mid-afternoon to 99°F at JA and if the air is quite dry, what will be the condition of the air up to 10,000'?______________________

SUMMARIZATION PERIOD

This period is designed to give the student an opportunity to get a connected view of what has been studied and to clarify points that may be hazy in his mind if adequate time has not been available for discussion. It is the responsibility of the student to look over the previous discussions and questions, noting in the margin of his workbook any material not clear to him so that he may know what misunderstandings to have cleared up by discussion.

NOTES

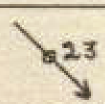
QUESTIONS

1. What weather data should the navigator obtain from the weather station? ______________________________

____

2. What is meant by "standard atmosphere"? ______________________________

____

3. What is meant by 

on a winds aloft chart? ______________________________

4. What features of a weather map are in color? ______________________________

____

5. What information may be obtained by the navigator from the isobaric pattern of the surface weather map? ______________________________

____

6. What data are placed on a vertical cross section and how are these data obtained? ______________________________

____

____

7. At what times during the day are pibal data obtained? ______________

8. What determines the height to which pibal data are obtained? ______________

____

9. Is the wind direction expressed to the nearest degree in the pibal code?

____

For questions 10 to 14.

TUT M15⊕⦶6R- 047/86/83↑7/965/CLDS TPG RDGS NE E60⊕
MS E10⦶/⦶3RW- 100/60/52→16/981/FROPA 0810C
MP 70⦶ 230/15/9→↘12/013/SNW CVR 2
OL ⦶/3/4GF 122/50/50C/988

10. The classification of the reports above has been omitted. Classify the reports on the basis of CAA minima. TUT_____, MS _____, MP _____, OL _____.

11. Be able to read the remarks. ______________________________

____

____

12. Give the ceiling heights in the examples above. TUT_____, MS_____, MP_____, OL_____.

13. Give the height of each layer of clouds at TUT. ______________________________

____

14. What is the temperature-dew point spread in each case? TUT_____, MS_____, MP_____, OL _____.

15. Explain the difference between advection and convection. ______________

____

____

____

16. What is the lapse rate of temperature with altitude for
   (a) the average or standard atmosphere? ______________
   (b) ascending clear air? ______________
   (c) ascending currents within a cloud? ______________

17. How can a navigator use the temperature aloft data to determine levels which will provide smooth flying?____________________

18. Under what conditions existing in late afternoon would one expect a fairly large drop of temperature during the night?____________________

19. By knowing the wind at any given place, what deduction can one make concerning the isobaric pattern? ____________________

20. While flying at 4000 feet from WC to JA, a double drift shows the wind to be 170° 20K. If the altimeter setting at WC was 29.96, what reasonable conclusion can one make about the altimeter setting at JA?____________________

21. What is the circulation around highs and lows in the northern and southern hemispheres? Northern hemisphere ____________________
Southern hemisphere ____________________

22. What and where are the prevailing westerlies?____________________

23. What and where is the doldrums belt? ____________________

24. Describe the weather and flying conditions in the doldrums belt.____________________

25. Where are the trade wind belts usually found?____________________

26. At which of the following latitudes are vertical currents most common? (a) Equatorial belt, (b) 20-40°N, (c) 50-65°N, (d) Polar area. __________

27. What are the principle causes of vertical currents?____________________

28. What types of clouds give evidence of fairly strong vertical currents?

29. State Buys Ballot's Law. ____________________

30. What wind is denoted by  ?____________________

31. Be able to analyze hourly weather sequences and pibals in light of their effect on the route, flight altitude, etc.

The capacity of air to hold water depends upon its temperature - the warmer the air, the more moisture it can hold. 1000 gm of dry air at 1013 mb pressure and 86°F temperature will contain 27 gm of water vapor (moisture) when it is 100% saturated, whereas if the temperature of this air is reduced to 66°F only 13 1/2 gm of this moisture can be held. In example C, the air holds only 50% as much moisture as it can, hence its relative humidity is 50%. The temperature at which a parcel of air reaches condensation when it is cooled (without being lifted) is the dew point. The dew point of parcel A is 86°F, B is 66°F, C is 66°F. The dew point of a parcel of air indicates the amount of moisture in the air, while the difference between temperature and dew point, called the "temperature-dew point spread", indicates how near saturation the air is or the relative humidity of the air. The dew point can be increased by evaporation of water from water surfaces, falling rain, moist ground, or vegetation.

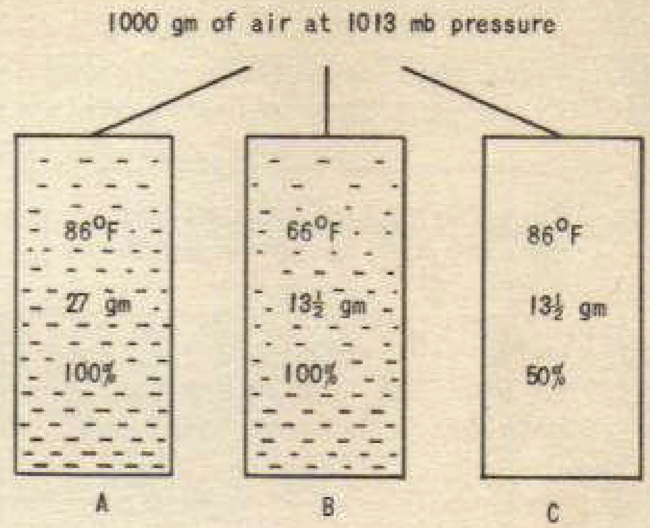


Figure I

Although, as seen from the diagram above, the amount of water vapor in the air is rather small, most bad flying weather is associated with moisture in the atmosphere. Clouds and fog are indications of layers of air saturated with water vapor. All air operations are affected by them. Clouds and fog are formed by the condensation of water vapor onto minute water absorbing particles. These particles are generally too small to be discerned by the most powerful conventional microscope. This condensation occurs when the air is almost or quite saturated. In other words, clouds and fog are formed when air is cooled so that the relative humidity is almost, if not quite, 100%.

Air may be cooled by (1) contact with colder surfaces, (2) evaporation of falling rain, (3) mixing with colder air, (4) radiation of heat into space and (5) expansional cooling caused by lifting. While fog may be produced by any of the above methods, clouds are usually produced by expansional cooling as the result of lifting. This lifting may occur when air moves up a slope of the terrain, moves up a frontal slope, moves upward due to thermal convection, or moves upward when air converges into a low pressure area from several directions. Assume a parcel of air at sea level to have a temperature (T) of 86°F, dew point (DP) of 78°F, and relative humidity (RH) of 78%. When this air moves up the slope to B, assuming no heat to be added or taken from the air, the T will be 81°F, DP 77°F, and RH 88%. At 2000' above A the air will be cooled so that saturation will be reached and clouds or fog will begin to form. It is dangerous to attempt to fly under clouds formed in this way because the terrain often projects into the clouds. Warm moist air may also form clouds in the same manner when it moves up the slope of a wedge of colder air.

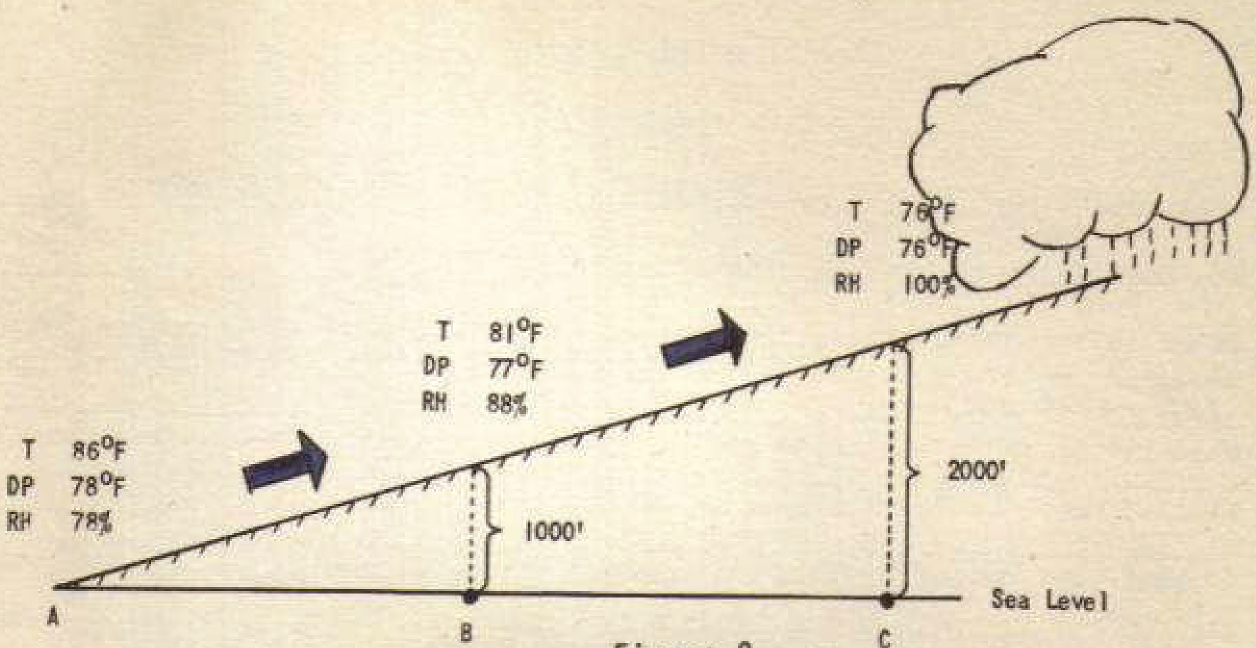


Figure 2

Most rain comes from clouds that contain both ice crystals and water droplets. Water tends to form on the ice crystals increasing their weight until they fall as rain, snow, sleet or hail depending upon air temperatures and vertical currents. The size of a drop of rain or hail is often used to estimate the strength of vertical currents within the clouds. If the air has only small vertical currents, the rain will be of small size and rather continuous in nature. The clouds associated with this type will generally be stratiform. If vertical currents are stronger, as in cumuliform clouds, the rain will fall in larger drops and be showery in nature.

NOTES

MAX. H_2O VAPOR – 4%
MIN. " " – 1%

WATER ADDED TO ATMOSPHERE BY ——
1-EVAPORATION OF WATER IN LAKES ETC.
2-FALLING RAIN OR SNOW

DEW POINT – TEMP. AT WHICH WATER VAPOR IN AIR CONDENCES

3 CONDITIONS FOR FOG OR CLOUDS IN SUMMER
1- MOISTURE
2- CONDEN. NEUCLI
3- REDUCE TEMP DEW POINT SPREAD TO NEAR 0

CLOUDS IN LOW PRESSURE AREAS
HIGH PRES. AREAS ARE CLEAR (GOOD WEATHER)

NOTES

THE STRONGER THE VERTICAL CURRENTS THE LARGER THE RAIN DROPS

QUESTIONS

1. What constituent of the air causes bad weather? WATER VAPOR
2. How does moisture get into the atmosphere?
3. Other things being equal, how does the temperature of the air affect the amount of moisture it can hold? THE HIGHER THE TEMP. THE MORE MOISTURE THE AIR CAN HOLD
4. What serves as an indicator of the amount of moisture in the atmosphere?
5. What is meant by the statement that the dew point is 74?
6. In what ways can saturation be reached?
7. Name five means by which air can be cooled. (1) (2) (3) (4) (5)
8. Name two sources for increasing the dew point of the air by evaporation. (1) (2)
9. Are all impurities in the air condensation nuclei?
10. What would be the effect if the air were free of condensation nuclei?
11. Which is of more importance to navigators, the temperature, the dew point, or the temperature-dew point spread? TEMP.-DEW POINT SPREAD
12. What is the effect of an unusual abundance of condensation nuclei in the air?
13. Does condensation mean rain? NO
14. Will the temperature-dew point spread at the surface ordinarily be greater in afternoon or early morning? AFTERNOON
15. Rain which is showery in nature indicates what degree of turbulence? HIGH
16. Name four ways air can be lifted. (1) SURFACE HEATING (2) HITTING MOUNTAIN (3) HITTING FRONT (4)
17. To give heavy or even moderate rain, how high will the top of the cloud extend? ABOVE FREEZING LEVEL

Clouds differ from fogs only in location. Both result from either the cooling of air close to or below its dew point, or the moistening of air until the dew point is close to the temperature. If the condensation occurs more than fifty feet above the surface of the earth, weather men call the resulting formation a cloud. So a formation called a cloud by a man in a valley may well be called fog by a man on the hilltop.

The classification of clouds is based upon their form and appearance. However, there is a general relationship between the form of clouds and their height, as shown by actual measurements, so that a classification according to form and appearance is also, in effect, one according to height. Note that this relationship is general, for actually the height of any particular type or form of cloud will vary with the latitude and with the season, chiefly due to the variation in temperature.

FAMILY A: HIGH CLOUDS 20,000

Bases average above 20,000 feet.
Composition: Ice crystals.

1. Cirrus
2. Cirrostratus
3. Cirrocumulus

Ci

Cirrus, plates 1, 2, 3, 4, 8, detached clouds of delicate and fibrous appearance, without shading, generally white in color, often of a silky appearance. Before sunrise and after sunset cirrus is often colored bright yellow or bright red. These clouds are lit up long before other clouds and fade out much later; some time after sunset they become gray. At all hours of the day, cirrus near the horizon is often of a yellowish color, due to the distance and to the great thickness of air traversed by the rays of light.

Cirrus appears in the most varied forms, such as isolated tufts, lines drawn across a blue sky, branching feather-like plumes, curved lines ending in tufts, etc.; they are often arranged in bands which cross the sky like meridian lines, and which, owing to the effects of perspective, converge to a point on the horizon.

As a rule, when these clouds cross the sun's disk, they hardly diminish its brightness, and celestial observations on the sun or the moon are quite feasible. But when they are exceptionally thick, they may veil the sun's light and obliterate its contour. This would also be the case with patches of altostratus, but cirrus is distinguished by the dazzling and silky whiteness of its edges.

Cs

Cirrostratus, plates 4, 5, 6, 7, a thin whitish veil, which does not blur the outlines of the sun or moon, but gives rise to halos. Sometimes it is quite diffuse and merely gives the sky a milky look; sometimes it more or less distinctly shows a fibrous structure with disordered filaments. During the day, when the sun is sufficiently high above the horizon, the sheet is never thick enough to prevent shadows of objects on the ground.

A milky veil of fog (thin stratus) is distinguished from a veil of cirrostratus of a similar appearance by the halo phenomena, which the sun and moon nearly always produce in a layer of cirrostratus.

Cc

Cirrocumulus, plates 7, 8, is a cirriform layer, or patch, composed of small white flakes or of very small globular masses, without shadows, which are arranged in groups or lines, or more often, in ripples resembling those of the sand on the seashore. Real cirrocumulus is uncommon. It should not be confused with small altocumulus patches on the edges of altocumulus sheets as in plate 16. Instead it is associated with cirrus or cirrostratus.

General: Cirrus clouds are always composed of ice crystals and their transparent character depends upon the degree of separation of the crystals. Often it is impossible to tell just when a plane enters or leaves these clouds.

If they increase and lower, high clouds may be a good indication that a warm front is approaching.

NOTES

HIGH CLOUDS ARE MADE UP OF ICE CRYSTALS

Cs-NO ICEING HAZARD

Cc—NO PROTECTION —NO TURBULANCE OR ICEING

Ci—THICK —) THIN —) NO PROTECTION OR TURBULANCE OR ICEING

Cloud Photographs Furnished By The Ground Training Technical Advisory Unit, Randolph Field, Texas

Plate 1. Ci Cirrus

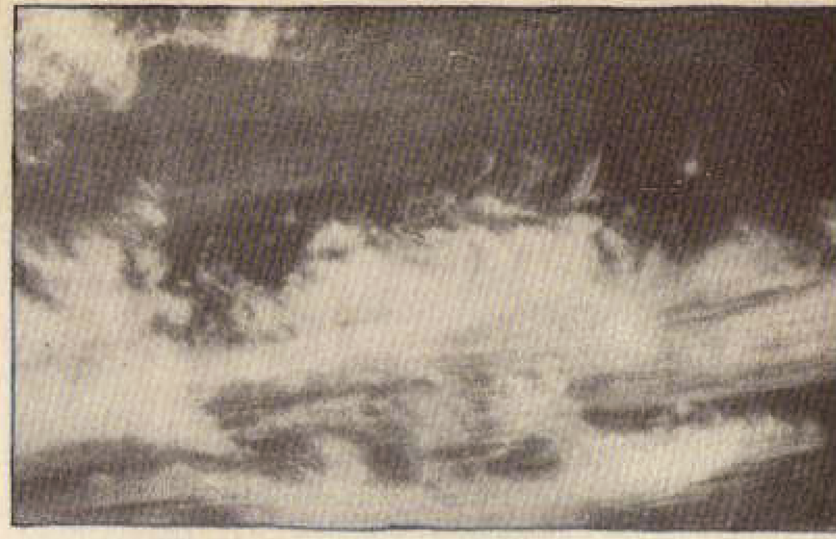


Plate 2. Ci Cirrus

Plate 3. Ci Dense cirrus of the type that is derived from thunderstorms

Plate 4. Ci Cirrus

Plate 5. Cs Cirrostratus

Plate 6. Cs Cirrostratus

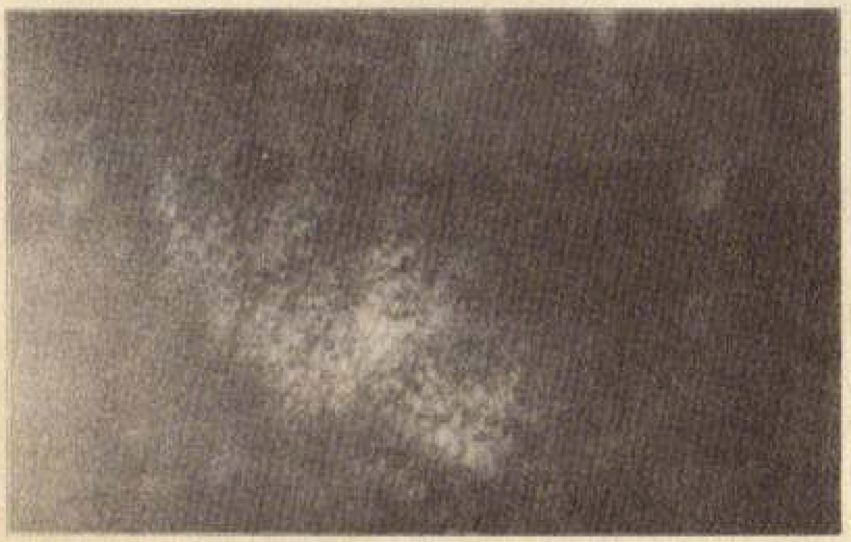


Plate 7. Cc Cirrocumulus associated with cirrostratus

Plate 8. Cc Cirrocumulus associated with cirrostratus

1. What is the composition of the high clouds? ICE CRYSTALS

2. What is the average height of the base of high clouds? 20,000

3. Which one of the high cloud types is rather rare in occurrence? ______

4. Will high clouds yield precipitation? Ci

5. What significance has a thickening veil of cirrostratus? APPROACH OF WARM FRONT

6. How will cirrus and cirrostratus affect navigation by celestial aids? ______

7. What is the characteristic appearance of high clouds that distinguish them from others? ______

8. With what type cloud do you associate a halo? CIRROSTRATUS

9. What appearance do high clouds have at sunrise and sunset? ______

10. Which cloud shows instability at high levels? CIRROCUMULUS

11. On what two things is the cloud classification based? (1) HEIGHT (2) TYPE

12. What is the difference between cloud and fog? NONE

13. In what season do high clouds occur at the lowest elevations? WINTER

14. In what latitudes do high clouds occur at the lowest elevations? NORTH

15. What is the abbreviation for -
    Cirrus Ci
    Cirrocumulus Cc
    Cirrostratus Cs

16. Practice identification by covering the name and symbol on the picture, and identifying the image.

FAMILY B: MIDDLE CLOUDS

Average levels 6,500 to 20,000 feet.
Composition: Water droplets or water droplets and ice crystals.

4. Altocumulus Ac
5. Altostratus As L (THIN) LL THICK
6. Nimbostratus Ns

VISIBILITY APP. 25 YD.

Altocumulus, plates 9, 10, 11, 12, 13, 14, 15, 16, is composed of a layer or patch of flakes or rather flattened globular masses. The layer is comparatively regularly arranged and the smallest elements are fairly small and thin, with or without shadows. These elements are arranged in groups, in lines, or waves, following one or two directions, and are sometimes so close together that their edges join. The thin and translucent edges of the elements often show color, which is rather characteristic of this class of cloud.

At the lower levels, where altocumulus may be derived from a spreading out of the tops of cumulus clouds, it may easily be mistaken for stratocumulus. The rule usually adopted is that the cloud is altocumulus if the smallest well-defined and regularly arranged elements are not greater than ten solar diameters in their smallest diameters. In applying this rule, leave out the detached elements which are generally seen on the edges, and count ten solar diameters as the width of three fingers when the arm is held extended.

Near the upper limits of middle clouds, altocumulus resembles cirrocumulus. It may be distinguished in the following way: (1) It has no connection with cirrus or cirrostratus; (2) It does not evolve from cirrus or cirrostratus; (3) It is composed of water droplets or water droplets and ice crystals.

Altostratus, plates 17, 18, 19, 23, is a fairly uniform veil, gray or bluish in color. Through this cloud, the sun or moon shows vaguely, with a faint gleam, as though through ground glass, unless the cloud is very thick and dark, in which case the sun may be entirely hidden.

Rain or snow may fall from altostratus, but when the rain is heavy, the cloud is so thick and low that it is called nimbostratus. However, heavy snow may fall from a layer that is definitely altostratus.

When altostratus is high and thin, it resembles cirrostratus but halo phenomena do not occur in altostratus. When a warm front is approaching, altostratus usually follows, and looks as if it were formed from cirrostratus.

Altostratus is the best cloud for concealment because it is usually continuous, extensive, sufficiently dense and smooth. VISIBILITY — 100 - 200 YD.

[ICE AND WATER CLOUD]

Nimbostratus (Ns) is a low, shapeless, rainy layer of a dark gray color and nearly uniform. It is the type of thing that cannot be photographed. When it gives precipitation, it is in the form of continuous rain or snow. Even when it does not give precipitation, it looks as if it were going to do so. There is often precipitation which does not reach the ground. In this case the base of the cloud is always diffuse and looks wet so that it is not possible to determine the limit of its lower surface.

The usual evolution is as follows: A layer of altostratus grows thicker and lower until it becomes a layer of nimbostratus. Beneath the latter there is generally a progressive development of very low, ragged clouds caused by the evaporation of rain falling from the altostratus. These are isolated at first, then fuse together into an almost continuous layer. Nimbostratus can generally be seen through the breaks of this layer. These very low clouds are called *Scud*.

A sheet of low altostratus may be distinguished from a somewhat similar sheet of nimbostratus by the following characteristics: nimbostratus is of a much darker and more uniform gray and shows nowhere any whitish gleam or fibrous structure; one cannot definitely see the limit of its undersurface, which has a wet look, due to the rain which may or may not reach the ground. Nimbostratus hides the sun and moon in every part of it, while altostratus only hides them in places behind its darker portions, they reappear through the lighter parts. A cloud layer, even a continuous one, which has no fibrous structure, and in which rounded cloud masses may be seen, is classed as altocumulus or nimbostratus rather than altostratus. Flying in nimbostratus is unpleasant due to icing, turbulence, and extremely poor visibility.

NOTES

VAIL LIKE PERCIPITATION FALLING OUT OF A NIMBOSTRATUS IS CALLED "VIRGA" (WHEN PER. DOSE NOT REACH EARTH)

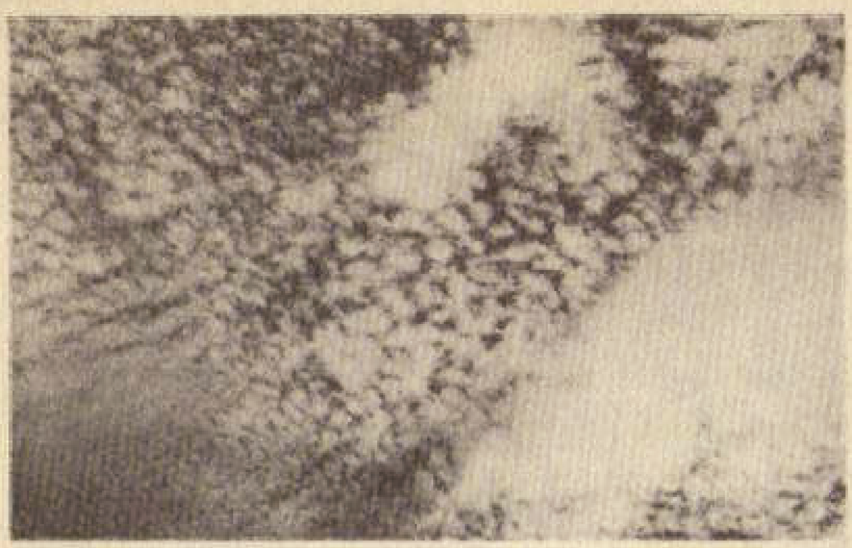


Plate 9. Ac Altocumulus, high. Note resemblance to cirrocumulus at top of picture

Plate 10. Ac Altocumulus at 7000', cumulus at 3000'. Taken from 5000'

Plate 11. Ac Altocumulus

Plate 12. Ac Altocumulus

Plate 13. Ac Altocumulus, height 9000'.
Taken from 7000'

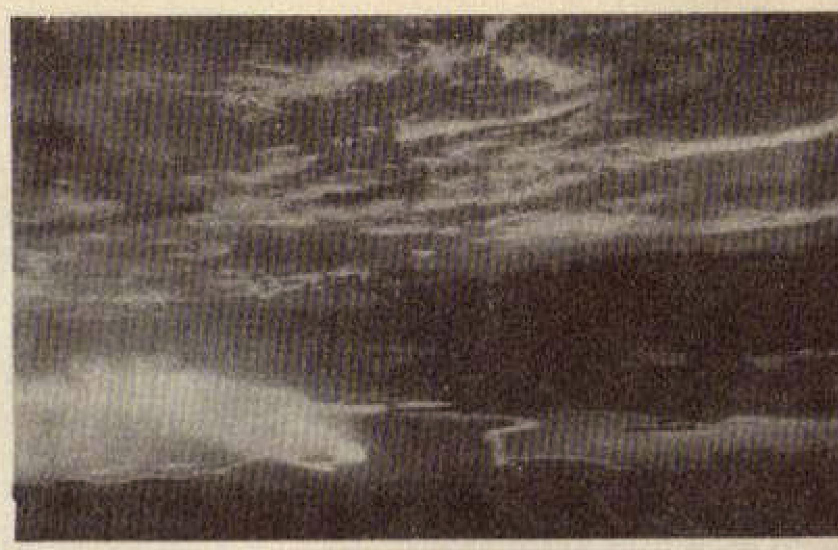


Plate 14. Ac Altocumulus dissipating
at sunset

Plate 15. Ac Altocumulus with ground fog
in early morning

Plate 16. Ac Altocumulus merging
into altostratus

Plate 17. As
Thin altostratus
with scud below

Plate 18. As
Complete veil
of altostratus
becoming thicker
in places

3. How is cirrostratus distinguished from high altostratus? ________

4. What significance is attached to a thickening altostratus? ________

5. Which of the middle clouds is least likely to yield precipitation? ________

6. Which middle cloud is best for evasive flying? ALTO STRATUS

7. How is nimbostratus distinguished from altostratus? ________

8. Can celestial work in navigation be done through an overcast of altostratus? ________

9. What does altocumulus indicate concerning the stability of the atmosphere? ________

10. Which of the middle clouds will give the lowest ceilings? NIMBO STRATUS

11. With what cloud is altocumulus easily confused? ________

12. Which cloud, so far studied, has the most turbulence? ________

13. Which cloud, so far studied, has the most icing danger? ________

14. Why do clouds form under nimbostratus? ________

15. The cloud in the upper right of plate 16 might be confused with ________

16. Complete this table:

Name	Abbreviation	Class
Altostratus		
Cirrocumulus		
Cirrus		
Nimbostratus		
Altocumulus		
Cirrostratus		

17. Practice identification by covering the legends of the pictures and naming the clouds.

18. Record the observation of plate 14 made at 1600 GCT from a F/A of 20,000'. The bases of the clouds below were measured as 15,000' and the tops as 15,500'. ________

BELOW 50 FT. — FOG

 50 – 6500

FAMILY C: LOW CLOUDS

Bases average below 6500 feet.
Usual composition: Water.

7. Stratocumulus
8. Stratus

Stratocumulus, plates 20, 21, 22, 23, is a layer, or patches, of globular masses or rolls, more or less regularly arranged. Even the smallest of the elements are fairly large and are soft and gray, with darker parts. They are arranged in groups, lines, or waves, aligned in one or two directions. Very often the rolls are so close that their edges join together. When they cover the whole sky, as they often do on the continent, especially in winter, they have a wavy appearance.

The elements of thick stratocumulus often tend to fuse together completely, and in some cases this layer can change into nimbostratus. The cloud is called nimbostratus only when the cloud elements of stratocumulus have completely disappeared and when, owing to the trails of falling precipitation, the lower surface no longer has a clear-cut boundary.

Stratocumulus can change into stratus, and vice versa. The stratus being lower, the elements appear very large and very soft, so that the structure of regularly arranged globular masses and waves disappears as far as the observer can see. The cloud will be called stratocumulus as long as the structure remains visible.

Stratus, plates 25 and 26, is a uniform layer of cloud, resembling fog, but not resting on the ground. A veil of true stratus generally gives the sky a hazy appearance, which, though characteristic, may cause confusion with nimbostratus. When there is precipitation, the difference is manifest—nimbostratus gives continuous rain or snow, precipitation composed of drops which may be small and sparse, or else large and close together, while stratus gives only drizzle, that is to say, small drops, very close together. When there is no precipitation, the distinction must be made on the appearance of the base of the cloud. Nimbostratus has a wet appearance, is quite uniform and without definite detail; stratus appears drier and, however uniform it may be, it shows some contrasts and some lighter transparent parts.

When stratus is broken into irregular shreds, the pieces are called scud. These low broken clouds of bad weather may also originate from broken stratocumulus. Sometimes they form independently and develop until they form a layer below nimbostratus, which may be seen through the breaks. They may be distinguished from the nimbostratus by their darker appearance and more definite detail. See plates 19, 27, and 28.

high clouds - CIRRIUS -!
low clouds - alto. - ?

Clouds of vertical development are low clouds

~~St.~~ St. (stratus) type clouds have very little vertical development. Level and smooth, gray looking from below. Show stable air. Dangerous to fly under. No icing or turbulence danger.

Sc. - Combination of stratus and cumulus and appear in soft gray rolls. Regularly arranged and fairly large. Holes appear between different elements. Moderate turbulence and some icing danger. Visibility between 15 - 20 yd.

Low broken clouds of bad weather 5000
Fractostratus or Fractocumulus (unstable air)
(stable air)

Found below cumulonimbus or Nimbostratus clouds
Continuous rain beneath ~~[illegible]~~ fall until scud clouds ~~[illegible]~~ have formed. No tactical value

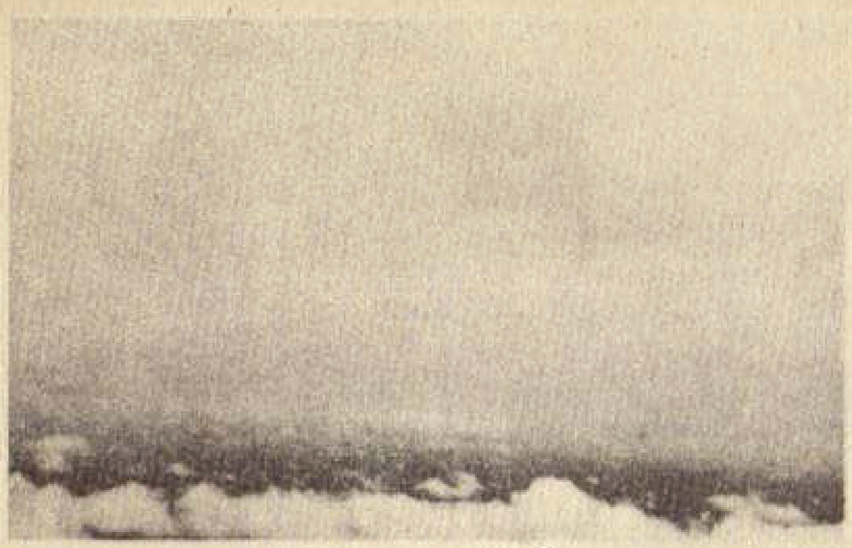


Plate 19. As Altostratus with scud below

Plate 20. Sc Stratocumulus

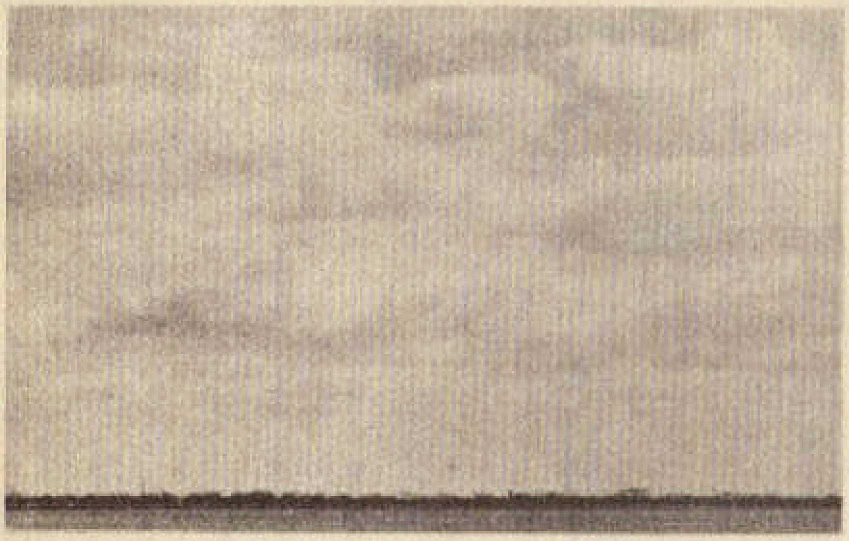


Plate 21. Sc Stratocumulus

Plate 22. Sc Stratocumulus

Plate 23. Sc Stratocumulus at 3500', Ac As at 8000'. Taken from 4500'

Plate 24. Sc Stratocumulus formed by stratus breaking

Plate 25. St Stratus

Plate 26. St Stratus

Plate 27.
Scud

Plate 28.
Roll cloud associated with cumulonimbus.

QUESTIONS

1. What is the usual composition of low clouds? ______________________

2. At what heights are stratus and stratocumulus found? ______________

3. What is the difference in appearance of stratus and stratocumulus? ______

____

____

4. How can stratus be distinguished from altostratus? ______

5. What is the chief hazard connected with stratus? ______

6. How can stratocumulus be distinguished from altocumulus? ______

7. What kind of precipitation is common from stratus? ______

8. What is the average thickness of stratus and stratocumulus? ______

9. Which type of low cloud, stratus or stratocumulus, would offer the most turbulence? ______

10. How does scud develop? ______

11. Why is stratus not suitable for evasive action? ______

12. Do clouds ever change from one type into another? ______

13. If one were on the ground looking up, would the cloud in plate 26 appear smoother or rougher than it does on top? ______

14. Write out the names for which the following abbreviations stand.

Ac ______	Cs ______
St ______	Sc ______
Cc ______	Ci ______
Ns ______	As ______

15. Practice identification using the pictures as before.

16. Flying at 3000' 20 miles east of AG at 1800 GCT, a navigator observes scattered cumulus with bases measured at 4000' and tops estimated at 6000', light turbulence below bases of clouds, visibility estimated at 15 miles and dense haze layer at 4000'. How should this observation be recorded? ______

17. In plate 26, the navigator at 0600 GCT is flying 40 miles east of Knoxville at 6000' MSL. Record the observation. ______

18. In plate 23, the navigator is flying with heading of 140° 50 miles north of Saint Louis, Mo. F/A is 5000'. The navigator 10 minutes previously noted that the tops of the lower layer of clouds was 3200' MSL. Record the observation. ______

FAMILY D: CLOUDS WITH VERTICAL DEVELOPMENT

Tops vary from low cloud level to high cloud level.
Bases are usually at low cloud level.
Composition: Water or water and ice.

9. Cumulus
10. Cumulonimbus

Cumulus, plates 10, 29, 30, 31, 32. Thick clouds with vertical development; the upper surface is dome shaped and exhibits rounded protuberances, while the base is nearly horizontal.

The parts of the cloud on which the sun shines appear a beautiful white, while other parts show definite shadow. The base is generally of a gray color. This indicates that the cloud is quite dense.

True cumulus is definitely limited above and below; its surface often appears hard and clear cut. But one may also observe a cloud resembling ragged cumulus in which the different parts show constant change. This cloud is desinated fractocumulus, plates 27 and 28.

Cumulus has a uniform structure; that is to say, it is composed of rounded parts right up to its summit with no fibrous structure. See plate 30. Even when highly developed, cumulus can produce only light precipitation.

Towering cumulus, or cumulus congestus (), is just what its name implies, a tall cumulus cloud. See plates 31 and 32.

Cumulonimbus, plates 32, 33, 34, 35, 36. Heavy masses of cloud, with great vertical development, whose cumuliform summits rise in the form of mountains or towers, the upper parts having a fibrous texture and often spreading out in the shape of an anvil.

The base resembles nimbostratus, and one generally notices streamers of precipitation falling from the cloud which may reach the ground. This base often has a layer of very low ragged clouds below it.

Cumulonimbus clouds generally produce showers of rain or snow and sometimes of hail or soft hail, and often thunderstorms as well. If the whole of the cloud cannot be seen, the fall of a real shower is enough to characterize the cloud as a cumulonimbus.

Even if a cumulonimbus were not distinguished by its shape from a strongly developed cumulus, its essential character is evident in the difference of structure of the upper parts, when these are visible. A fibrous structure identifies the cumulonimbus, while hard outlines indicate the cloud is still cumulus.

Cumulus, no matter how tall or massive, should never be classified as cumulonimbus until at least a portion of its top becomes "cirrus-like".

When a cumulonimbus covers nearly all the sky, the base alone is visible and resembles nimbostratus. The difference between the base of a cumulonimbus and a nimbostratus is often rather difficult to make out. If the cloud mass does not cover all the sky, and if even small portions of the upper parts of the cumulonimbus appear, the difference is evident. If not, it can only be made out if the preceding evolution of the clouds has been followed, or if precipitation occurs. The precipitation from cumulonimbus is characterized by showers of large drops, whereas precipitation from nimbostratus is characterized by relatively gentle and continuous rain.

The front of a thundercloud of great extent is sometimes accompanied by a roll cloud of a dark color in the shape of an arch, of a frayed-out appearance, and circumscribing a part of the sky of a lighter gray. This cloud is illustrated in plate 28.

Cumulonimbus mammatus is illustrated in plate 35. This cloud type is one of the surest indications that cumulonimbus clouds are present or in the immediate vicinity. These clouds are generally found at the base of the cumulonimbus.

While small cumulus clouds are only a nuisance, there is some turbulence in and under even the smallest. The taller the cloud, the greater the turbulence and well developed towering cumulus clouds are dangerous. The hazards of cumulonimbus in their probable order of importance are: heavy turbulence, heavy icing, hail, poor visibility, and lightning. Circumstances vary greatly but, in general, if one can neither circumnavigate a cumulonimbus nor turn back, he should next consider flying over the cloud, then below it, and fly through it as a last and desperate resort. In this last case, his chances are better if he can enter the cloud at a height where the temperature is below $-12^{\circ}C$, or in the upper third of the cloud.

NOTES:

Never fly into a bulging cumulus or cumulonimbus when the tuffs appear to be boiling

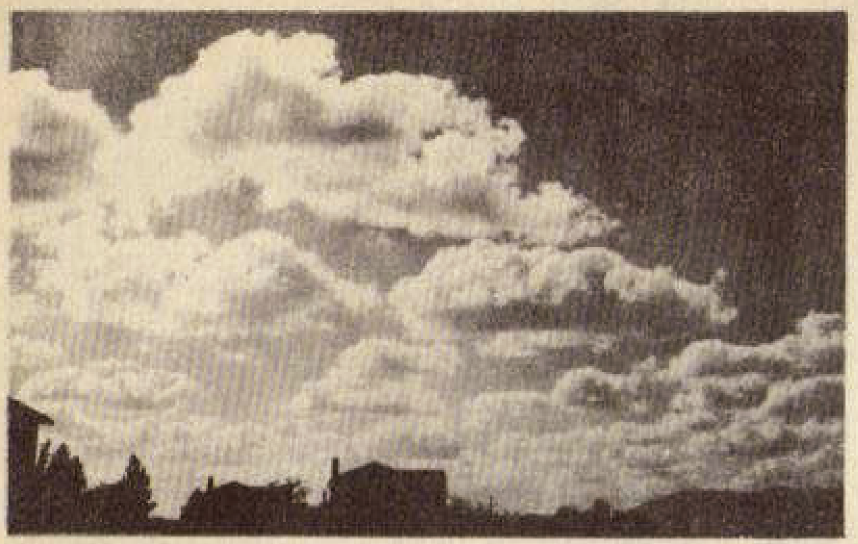


Plate 29. Cu Cumulus of fair weather

Plate 30. Cu Bulging cumulus

Plate 31. Cu Bulging cumulus

Plate 32. Cu Bulging cumulus note anvil of Cb in background

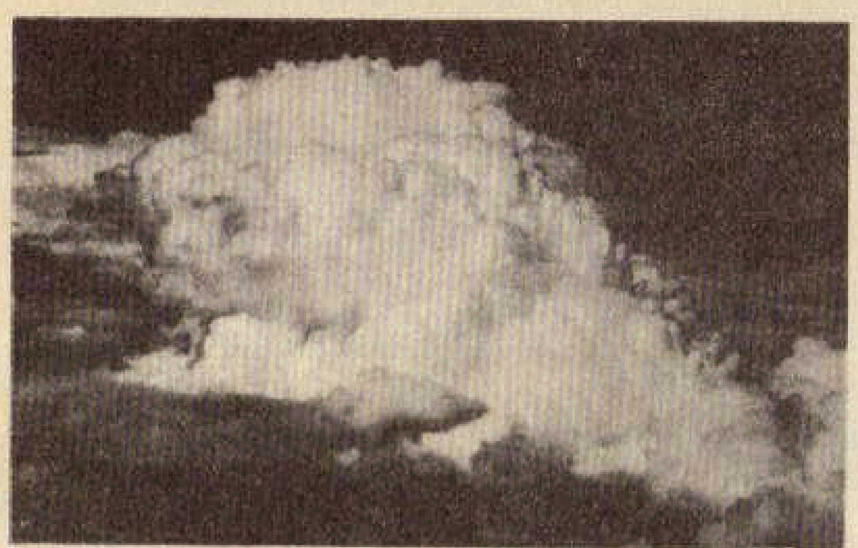


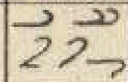
Plate 33. Cb Bulging cumulus becoming cumulonimbus

Plate 34. Cb Cumulonimbus, note the shower

Plate 35. Cb Cumulonimbus with mammatus structure

Plate 36. Cb Cumulonimbus, a tornado developed from this cloud

CHARACTERISTICS AND SUGGESTED TACTICAL USES OF CLOUDS

TYPE	ABBREV.	MAP SYMBOL	HT. OF BASE	THICK-NESS	DESCRIPTION	CON-TIN-UITY	VSBY IN YDS.	WING ICG	TURBC	TACTICAL USE
Cirrus	Ci		Above 15,000'		White streaks	Poor	500-1000	None	Lgt	Indicate probability of contrails.
Cirrocumulus	Cc		Above 15,000'		White pebbles	Poor	500-1000	None	Lgt-Mdt	Indicate probability of contrails.
Cirrostratus	Cs		Above 15,000'		White veil	Good	500-1000	None	None	Indicate probability of contrails.
Altostratus	As		Above 8000'	1000' to 4000'	Soft gray blanket	Good	100-200	Lgt	Lgt or None	Best for concealment yet can be used for formation flying and high enough to fly under when desirable.
Nimbostratus	Ns		0-4000'	5000' - 10,000'	Dark, wet blanket	Good	0-15	Mdt-Hvy	Mdt	Continuity is good for concealment in emergency. May keep fighters grounded.
Altocumulus	Ac		Above 8000'	2000' - 4000'	Lumpy layer of cotton	Poor	20-25	Lgt-Mdt	Lgt-Mdt	Can be used for temporary evasion. Good if elements are tightly packed.
Stratocumulus	Sc		1000' - 6000'	500' - 4000'	Low, dark, and lumpy	Fair	20-25	Mdt if any	Lgt-Mdt	Most used due to frequency and altitude.
Stratus	St		0-2000'	500-4000'	High fog	Variable	10-50	Lgt-Mdt	Lgt if any	Continuity is usually good. Know terrain and watch altitude.
Cumulus	Cu		800' - 4000'	500' - 15,000'	Piles of white cotton	Poor if any	10-20	Mdt-Hvy	Mdt-Hvy	All factors unfavorable. In the daytime, may help locate land.
Cumulonimbus	Cb		500' - 5000'	10,000' to 50,000'	Fuzzy topped mountain	Poor if any	0-10	Hvy	Hvy	Dangerous. May be entered in Ci at top where temperature is below $-12^{\circ}C$ for evasion from fighters.

Breaks in radiation fog may indicate bodies of water.
Sea fog at night looks very much like a mass of land and may deceive the navigator.
The winds above stratiform clouds are usually quite different from those below.
Shadows of Cu and Cb clouds frequently look like islands.
If clouds are lined up in either a straight line or an arc across the sky, watch for a wind shift.

1. What is the most likely composition of small cumulus? H_2O
2. What is the composition of a cumulonimbus cloud? ______
3. How can one tell when a cumulus is building into a cumulonimbus? ______
4. What are the hazards connected with a cumulonimbus? Heavy icing and turbulence
5. When precipitation falls from clouds of vertical development, it is of a shower type.
6. Name 3 distinguishing features of cumulonimbus clouds. (1) FUZZY MOUNTAIN SHAPED (2) HEAVY MASSES (3) ANVIL SHAPED AT THE TOP
7. How high may cumulus and cumulonimbus clouds build? To high cloud level
8. What is the principle cause of cumulus cloud development? Vertical development
9. Why do cumulus clouds generally disappear or break up during the night in the summer time? ______
10. Would it be smoother flying underneath a cumulus cloud or over the top? over the top
11. When a cumulonimbus lies ahead, what is the best procedure? ______
12. Is flying under a cumulonimbus safer over land or over water? Water
13. Is the visibility in cumuliform clouds good enough for formation flying? ______
14. Are all white clouds safe for flying? ______
15. Will cumulonimbus build higher in the tropics, the middle latitudes, or arctic regions? ______
16. During which seasons are thunderstorms most common in the middle latitudes? ______
17. Are thunderstorms as seasonal in the tropics as in the middle latitudes? ______

18. What cloud commonly has the heaviest icing? ____________________

19. Do the clouds in plate 29 make a ceiling? ____________________

20. Does it appear that the clouds in plate 30 make a ceiling? ____________________

21. Do the tops of the clouds in plate 31 show any fuzziness? ____________________

22. Flying at 9000' 25 miles east of Randolph Field, Texas at 1700 GCT, the clouds in plate 31 are seen. The bases were estimated at 3000' with tops measured at 8000'. Visibility was 30 miles. Record this observation.
____

23. Flying east 30 miles west of Selman Field at 1800 GCT, the view in plate 34 was observed. F/A was 1500'. Visibility was 20 miles. Record this observation. ____

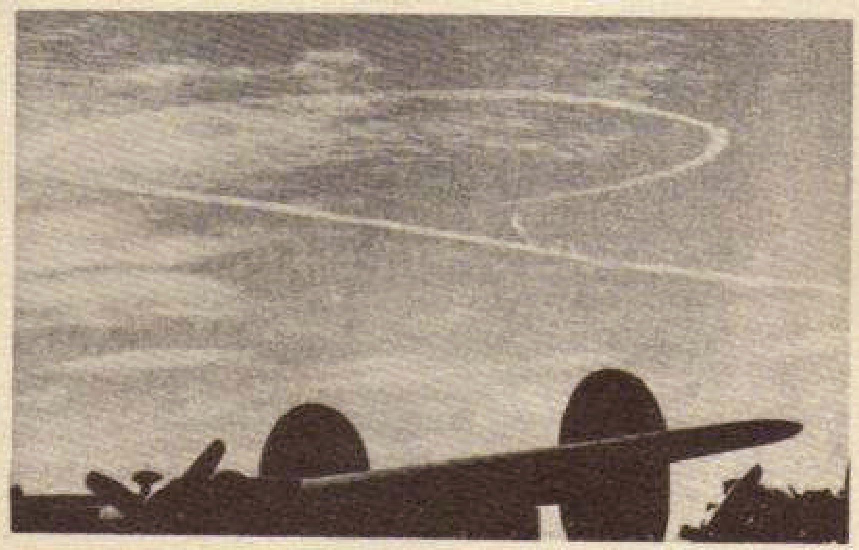


Plate 37. Condensation Trail

GENERAL

There are places in the world where large quantities of air tend to stagnate over land or water surfaces having uniform temperature, moisture and type of surface. During the time that a body of air lies over this uniform region, the air assumes properties which are characteristic of the area beneath it. Air which remains for some time over tropical deserts has very high temperature and low relative humidity. Air over the warm Gulf of Mexico will have high temperature and also high dew point, and air which stagnates over Siberia or Canada in winter is very cold and dry. A body of air that has generally uniform properties in a horizontal plane is called an *air mass*.

The area in which an air mass originates, that is, assumes uniform properties characteristic of that area, is called its source region. The formation of an air mass requires that the region be extensive and uniform as to type of surface and temperature and that a high pressure cell with the accompanying relatively weak winds and divergent air flow cover the region.

Air masses are classified according to the latitude and whether the source region has land or water surface. Four latitude zones are recognized: Arctic (A), Polar (P), Tropical (T) and Equatorial (E). Only two types of surfaces are distinguished: Maritime (m) and Continental (c). Air from Canada is continental polar or cP, while air from the Gulf of Mexico is called maritime tropical or mT. 45-60°N

All weather divides itself into two groups: (1) that weather that is characteristic of the air mass present because of the temperature and moisture properties of the air mass, and (2) that weather that is due to the mixing of two or more air masses of different properties. In tropical regions, where only one air mass predominates, the first classification is the only type of weather. On the other hand, the second group is important in the mid-latitudes (30^o-60^o) which serve as a region of mixing between pushes of large quantities of polar and tropical air.

As air masses move from their source regions in the general circulation flow pattern into the mid-latitude belt, they are modified by the surface over which they travel. Cold dry cP air flowing from Canada may be heated by the warmer earth's surface in the United States, and also have moisture added to lower levels by travel over the Great Lakes. Moist mP from the Pacific when travelling from west to east across the United States will lose much of its moisture on the western side of the Rockies and appear as a warmer and much drier air mass over the Central States. Because of the importance of temperature modifications, air masses are further classified as warm (w) or cold (k). A warm air mass is one that is warmer in its lower levels than the surface over which it is moving. A cold air mass is cold in comparison with the surface.

The characteristics of warm air masses are:

(1) smooth air in the lower layers due to the small lapse rate or surface inversion.

(2) low stratiform clouds.

(3) poor visibility especially in early morning.

(4) precipitation, if any, light, being generally drizzle, mist, or fine rain.

The characteristics of cold air masses are:

(1) turbulence in the lower layers with a steep lapse rate of approximately 3°C/1000'.

(2) cumuliform clouds.

(3) good visibility close to the surface.

(4) precipitation, if any, showery.

The designation of an air mass on the surface synoptic map consists of three letters, e.g.:

cPk - continental polar cold
mTw - maritime tropical warm
cAk - continental arctic cold
cPw - continental polar warm
etc.

Air mass weather in any part of the world is determined by three factors: (1) the source region of the air mass present, (2) the trajectory of that air mass and (3) the age, or time spent over modifying surfaces. Cold air masses are modified rapidly by convective currents, warm air masses are modified only slowly since surface cooling dampens vertical currents.

NOTES

SHOW CHANGE OF AIR MASS - CP + MP

WARM AIR OVER COLD $\frac{MT}{CP}$ or MT/CP

1- SOURCE REGION
2- PATH OVER WHICH AIR TRAVELS TRAJECTORY
3- AMOUNT OF TIME AWAY FROM SOURCE REGION
4- SEASON OF YEAR

QUESTIONS

1. Name two necessary characteristics of an air mass source region.
(1) uniform surface (2) large area
2. Name two prerequisites for an air mass to form over a source region.
(1) High pressure (2) ~~at least 500 miles across~~ gradual temperature change
3. What three properties change very little along a horizontal plane within an air mass? (1) temperature (2) moisture
(3) wind velocity

4. Name the two families of air masses of most importance in the middle latitudes. (1) ______ (2) ______

5. Why are Arctic air masses infrequent below 50° latitude? ______

6. Would an air mass from the Pacific be a warm or cold air mass on the North American coast during winter? ______

7. Would a tropical air mass moving inland from the Gulf in summer be warm or cold? warm

8. What direction will Polar air masses move? South

9. How can an air mass pick up more moisture as it moves along its trajectory? Traveling over bodies of water

10. Which air mass will offer greatest turbulence at 3000', a warm or cold? ______

11. Which air mass would be more likely to produce fog, a maritime warm or a maritime cold? ______

12. What makes winters in the middle latitudes so changeable? ______

13. What direction of winds should bring the coldest weather in the middle latitudes? ______

14. What is the meaning of mPw? ______

15. What type air mass would invade U.S. from Canada in the winter? ______

16. Why is high pressure essential for the formation of an air mass? ______

17. What cloud type predominates in warm air masses? ______

18. What type of precipitation is characteristic of cold air masses? ______

19. What three factors should be considered when anticipating the flying conditions in an air mass? (1) ______ (2) ______ (3) ______

20. What type of precipitation is characteristic of warm air masses? ______

21. The characteristic cloud of cold air masses is ______

Air masses may be divided into several classifications. Each has its own characteristics, which are often greatly modified by the terrain traversed by the air mass. For example, an outbreak of continental polar air is fundamentally considered as cPk, yet its western portion will be cPw and over certain regions, may strongly resemble mPw. The modifications that take place in any part of an air mass after it leaves its source region are due to the trajectory of that portion.

The most important air mass over the United States in winter is cP because the great mountain ranges in western United States prevent maritime influences from extending far onto the continent and also modify the mP air crossing them so that it becomes hardly distinguishable from cP. On the other hand, the east-to-west extension of the mountains in Europe offer no such barrier to the flow of mP air. Consequently, moist mP air with its abundance of clouds and winter fog penetrates far inland.

At its source, cP air is very stable, with low temperature and dew point. As the cP air moves southward, the lower layers are warmed, thus reducing their stability. However cP air moving southward over the United States still retains many of its original characteristics until it is well over the comparatively warm and moist Gulf of Mexico or Atlantic.

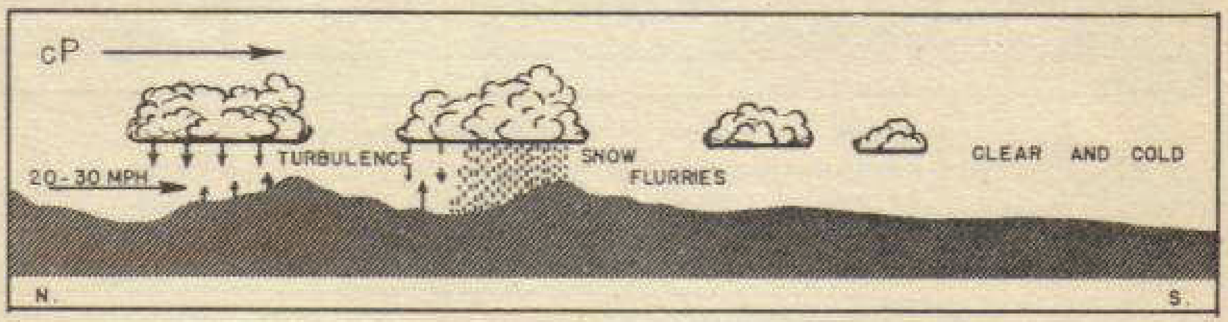


Figure 1. cP air moving southward.

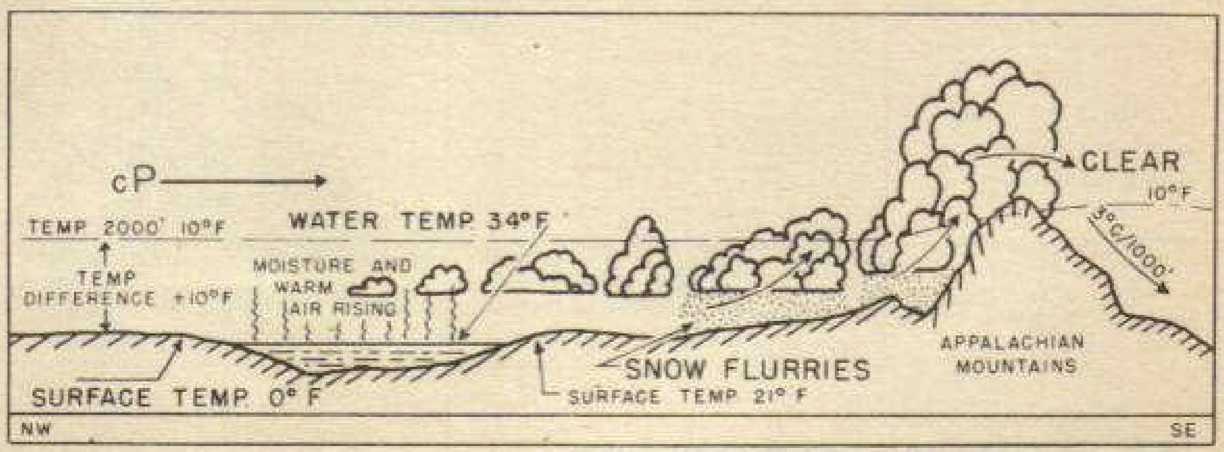


Figure 2. cP air moving over the Great Lakes.

 In Asia, the Himalayas in winter prevent cP air from reaching India until it has been greatly modified, losing its little moisture on the mountains. There northerly winds bring dry but not cold weather except at high elevations.

Moderate is the word that best describes mP air in winter. It is moderately unstable, has a moderately high dew point and a moderate temperature. In winter, mP air exerts its influence over that part of the United States west of the Great Divide, giving showers on the western side of the Rockies and extensive low clouds and fog in the valleys. Pronounced westerly flow carries mP air over the Rockies and brings clear skies, relatively warm temperatures and low dew points to the central states.

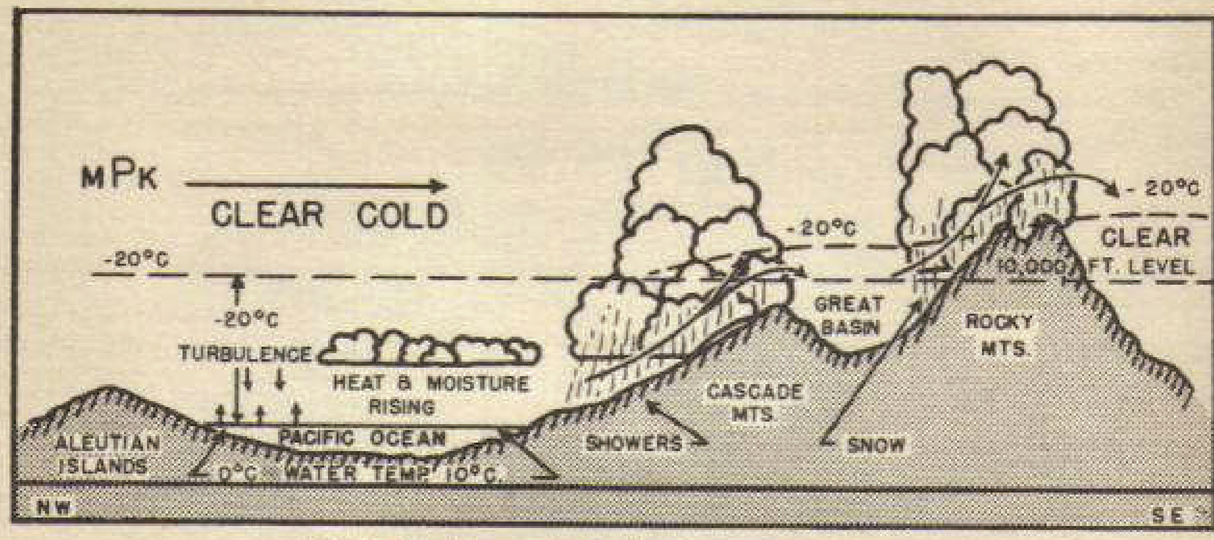


Figure 3. Movement of mPk air southeastward.

As mT air moves northward over the Gulf states, it often carries its characteristic low ceilings and fog as far north as the Great Lakes. This movement of mT air in the winter generally occurs east of a cold front in the Mississippi valley.

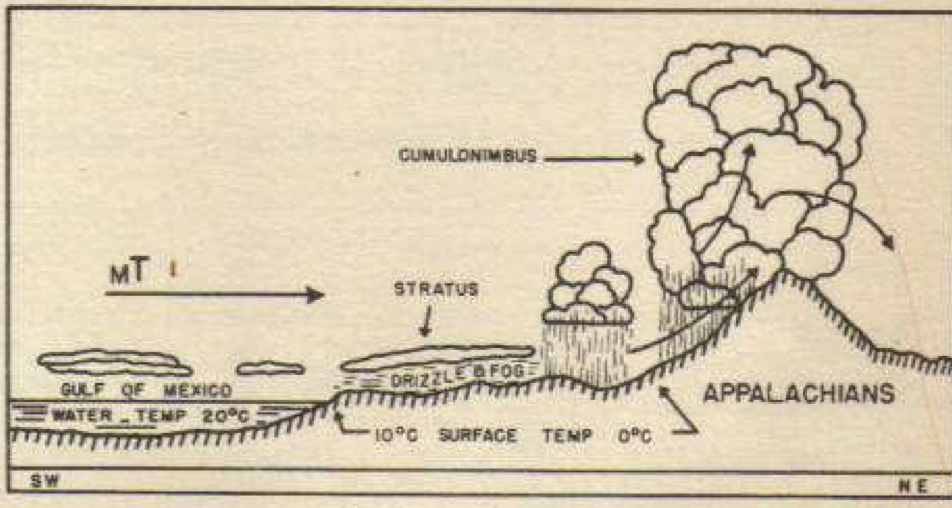


Figure 4
mT air moving northeastward.

No cT air is found in the United States in the winter, but cT is present in Africa and the Near East. Although unstable, it brings clear skies since its dew point is low and its temperature is high.

GENERAL CHARACTERISTICS OF NORTH AMERICAN AIR MASSES IN WINTER

AIR MASS	CLOUDS	CEILINGS	VSBY	TURBULENCE	SFC TMP
cP, Canada to Gulf of Mexico passing west of the Great Lakes.	Few except over rough terrain with strong winds.	Unlimited except 1000 feet to 2000 feet over rough terrain.	Excellent except in snow flurries over rough terrain.	Light to moderate in low levels.	-10° to -60°F in source region.
cP, over the Gulf of Mexico.	Cu and Cb.	1500 feet.	Good except for K and H in early morning over coasts.	Moderate to heavy in spots over Gulf.	30° to 50°F.
cP from Canada that has crossed the Great Lakes.	Sc and Cu with tops 7000 feet—10,000 feet.	800' to 1500', often zero in the Appalachian mountains.	4 to 10 miles, reduced to near zero in snow flurries.	Moderate to heavy according to terrain.	0° to 20°F.
mP from the Pacific over the North Pacific coast.	Cu and Cb, tops over 20,000 feet in coastal ranges.	1000 feet to 3000 feet, often zero in the mountains.	Good except in precipitation and where clouds touch mountains.	Moderate to heavy.	25° to 55°F, depending on direction of wind.
mP from the Pacific east of the mountains.	Few except when lifted higher by cold air.	Generally unlimited.	Excellent except occasionally in fog and near industrial areas.	Smooth.	30° to 40°F, except at high altitudes.
mP from the Atlantic.	Sc and St, tops 6000' to 8000'.	1000 feet or less.	Fair except in precipitation.	Rough in low levels.	25° to 40°F.
mT from the Pacific on the Pacific coast.	St and Sc with tops 4000 feet—8000 feet.	500 feet to 1500 feet.	Fair except in precipitation.	Smooth except in low levels with strong winds.	55° to 60°F.
mT from the Atlantic on the Atlantic coast.	St, Sc, Cu and Cb in the mountains.	100' to 1500'. Sometimes zero in the Appalachians.	Fair except in precipitation.	Smooth except in mountains or when winds are strong.	60° to 70°F.
mT from the Gulf in the Southern Plains States.	St, Sc.	100 feet to 1500 feet.	Fair except in precipitation and fog.	Light.	60° to 70°F.
mT from the Gulf east of the Mississippi.	Sc, Cu and Cb.	100 feet to 1500 feet, often zero in the mountains.	Fair except in precipitation and when clouds touch mountains and in fog.	Moderate.	50° to 70°F.
mT from Gulf on east coast on leeward side of mountains.	None.	Unlimited.	Good.	Smooth.	50° to 70°F.

NOTES

QUESTIONS

Remember it's winter.

1. What sky condition is to be expected in the Gulf states with fresh cP air? ____________________
2. What effect do the Great Lakes have on cPk air? ____________________
____
3. What is the reason for overcast skies and snow from cP air in the mid-west states of Montana, North and South Dakota and Minnesota? ____________________
____
4. Why does mPw air yield such heavy rains in the Pacific northwest during winter? ____________________
____
5. Where is mT air of Pacific source important in the United States? ____________________
____

6. Is air that flows on shore from the Gulf during winter "warm" or "cold"?
____

7. What is the most common hazard connected with mT over the Gulf states?
____

8. What causes mP air from the Atlantic to be sometimes drawn into New England against prevailing atmospheric circulation? _______________
____

9. What weather characteristics are associated with the "Nor'-easters" of New England? _______________

10. What effect do mountains have on weather? _______________
____

11. Name an air mass that will bring most favorable weather conditions to the South Central States. _______________

12. Name an air mass that will bring most adverse weather conditions to the South Central States. _______________

13. What is the difference between mP and cP air in the region of the Mississippi valley? _______________
____

14. What type of air is brought to Louisiana and eastern Texas by a southerly wind? _______________

15. What type of air will a strong north wind bring to Kansas? _______________

16. What is the most important air mass in the United States in the winter?
____

17. What is the most common air mass in northwest Europe? _______________

18. Why is the western side of an air mass the most strongly modified?
____
____

19. Complete the table using hi, mdt, lo.

AMS	TMP	DWPNT
cP	________	________
mP	________	________
mT	________	________
cT	________	________

20. Which is more stable, polar or tropical air? _______________

21. Why is it never cold in the lowlands of India? ____________________

____

22. Why does cP air bring clouds and precipitation to western Japan? __________

____

23. What kind of weather is brought to southwest British Isles by a southwest wind? ____________________

24. Which system will give the worse flying weather at ZH? Why? __________

____

____

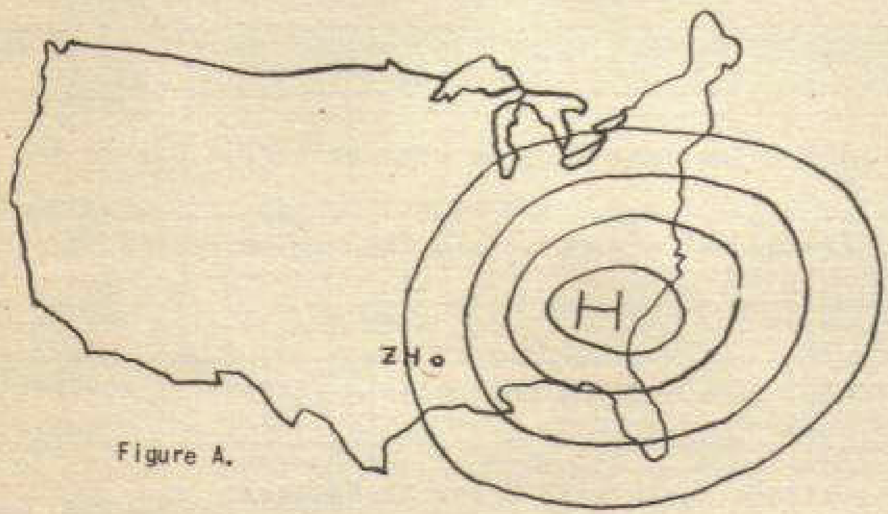


Figure A.

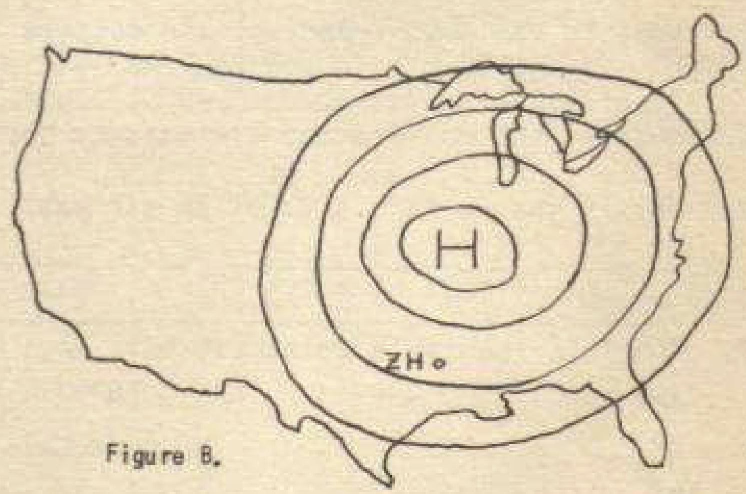


Figure B.

25. The maritime air from the high in the south Atlantic flows over lower south America and the Andes Mountains. What climate would you expect to find west of the Andes? ____________________

____

In the northern hemisphere, in summer, the influence of mT air extends farther north with the pressure centers and the polar front also displaced northward. The Azores and Pacific high pressure cells become stronger and are displaced northward while the Siberian High gives way to a deep low and the Canadian High becomes less intense.

In general, maritime air is cooler than adjoining land areas and assumes the characteristics of a "k" air mass when passing over the warmer land areas. Conversely, an air mass that has been over land for some time is usually cooled in the lower levels when passing over cooler water surfaces. Extensive areas of dense fog are produced in this season over cold ocean currents - the Aleutian Current, the Labrador Current and the California Current. These fogs are due to the movement of air on the western side of the large high pressure cells from the warm water across the cold currents.

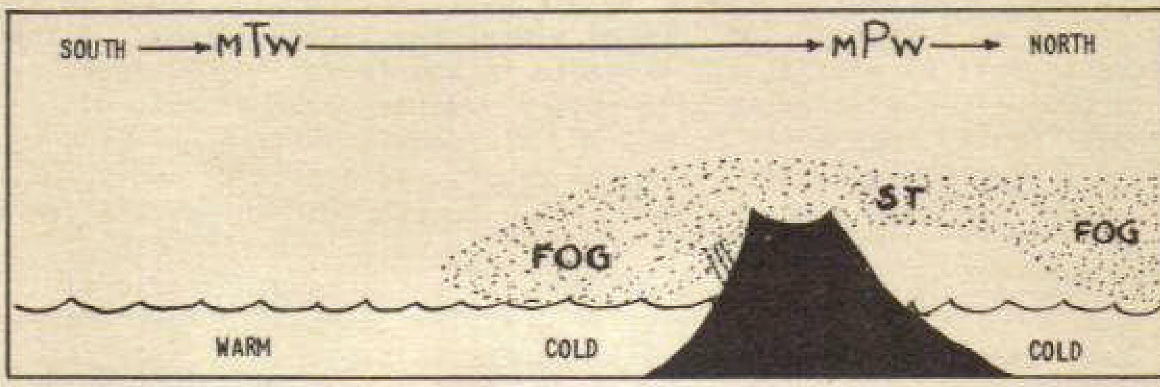


Figure 1. Summer.

In the summer, the eastern half of the United States is under the influence of mT air. In the other portions of the country, cT air covers the southwest; mP air, the west coast section; and outbreaks of cP air, the northern states.

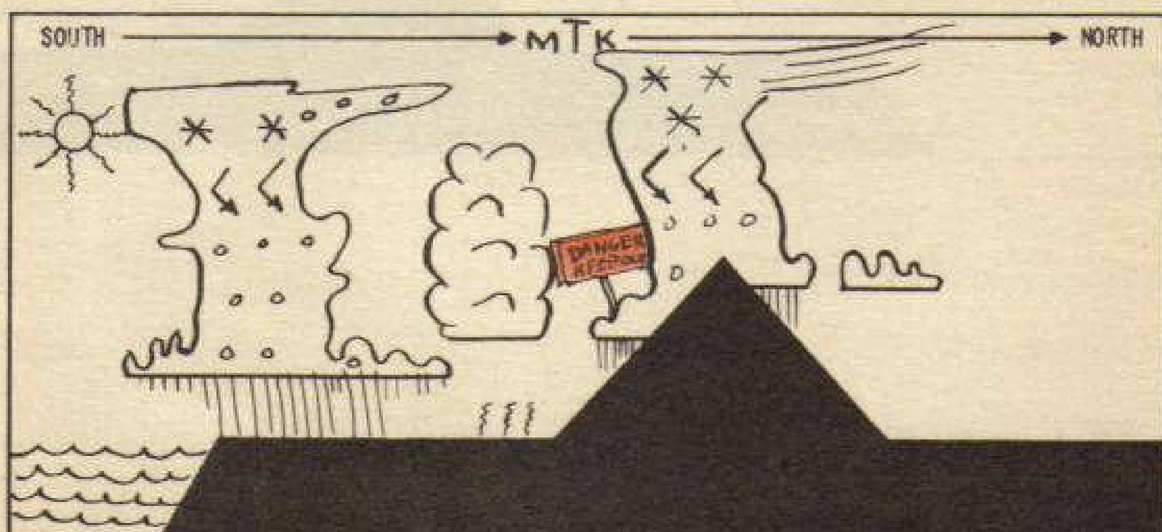


Figure 2. Summer.

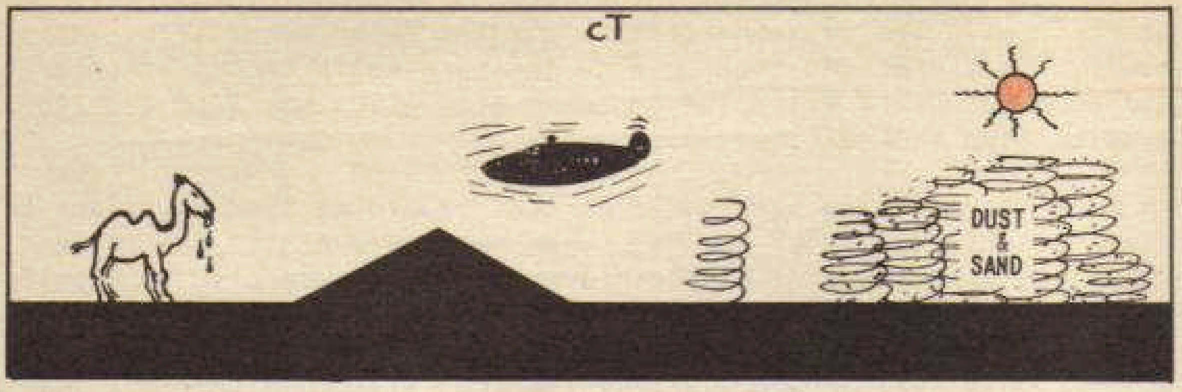


Figure 3. Summer.

More than any other air mass, mT air produces the rain areas in the United States in summer in the form of widespread thunderstorms. Although it is extremely dry, cT air is very unstable in the lowest 10,000 feet, causing heavy turbulence in afternoons with severe dust and sand storms. In mP air on the west coast, fogs often form over cold coastal waters and blow on shore, producing a bad flying hazard along the coast. As mentioned above, mP is usually a "k" air mass over the continent. However, mP enters the continent in summer farther north than in winter, giving rain in Washington and West Canada. Over the United States in summer, cP air produces little air mass cloudiness or rain because its relative humidity is usually low. Passage of cP air over bodies of water has little effect in summer.

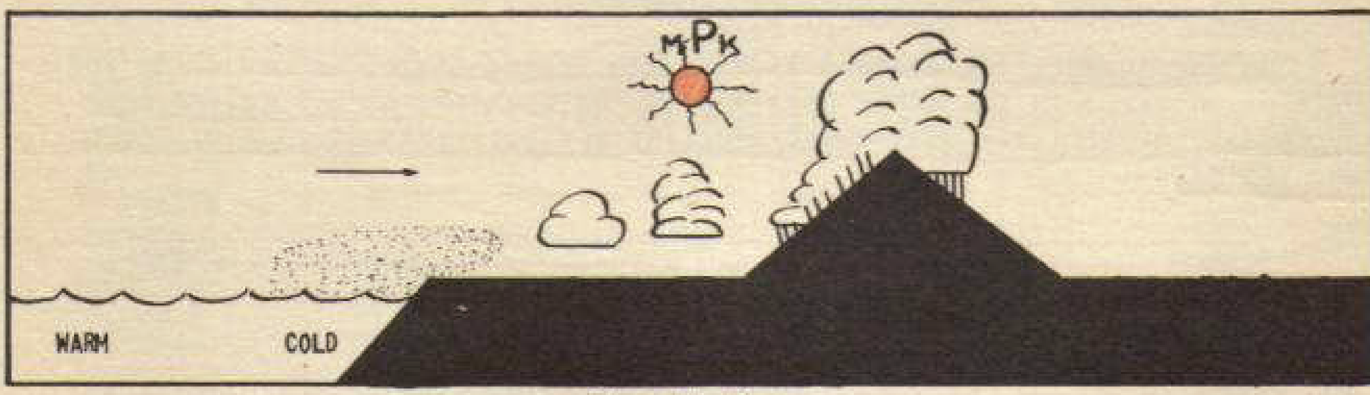


Figure 4. Summer.

NOTES

GENERAL CHARACTERISTICS OF NORTH AMERICAN AIR MASSES IN SUMMER

AIR MASS	CLOUDS	CEILINGS	VISIBILITY	TURBULENCE
cP, from Canada.	Scattered afternoon Cu.	Unlimited except in or before showers.	Good. A few patches of fog.	Moderate up to 10,000 feet in afternoon.
mP from the Pacific over the Pacific coast.	St, tops 2000' to 5000', frequent at night.	100' to 2500', unlimited during day.	Poor, especially at night.	Slightly rough below and in clouds, smooth above.
mP from the Pacific east of the mountains.	Scattered afternoon Cu.	Unlimited.	Excellent.	Generally smooth except in lowest layers in afternoon.
mP from the Atlantic (New England States).	Broken to overcast Sc.	800 feet to 2000 feet.	Good.	Light turbulence below clouds.
mT from the Gulf and Atlantic.	St or Sc in early morning, Cu and Cb in afternoon.	Morning 500' to 1500', frequently unlimited. Afternoon 2000' to 4000'.	Excellent except below clouds in early morning.	Smooth in early morning, rough in afternoon.
cT from Mexico and the Southwest States.	None.	Unlimited.	Excellent.	Smooth in early morning, rough in afternoon.

NOTES

NOTES

QUESTIONS

Remember it's summer.

1. What air mass is of most importance in explaining the summer weather east of the Rockies? ____________________

2. Why is the modification of cP air, due to passage over the Great Lakes, less in summer than in winter? ____________________

3. Why is the mP air of the Pacific more stable when it hits the coast line than it is in the winter? ____________________

4. What is the principle hazard connected with mTk air?____________

5. At what time of day would one expect the most cloudiness in mTk air?____________

6. What causes mTw air in winter to change to mTk air in summer?____________

7. Do mountains have equal effects on air mass weather during summer and winter?____________

8. Which air mass will normally be more favorable to airmen during summer? mTk or cPk?____________

9. Will flying in the afternoon in mT or cP air be smooth or bumpy below 8000'?____________

10. What can be said of average visibilities in mT and cP air?____________

11. What is the chief difference between mT and cT air?____________

12. What happens to the mT air mass source region in the Pacific during the summer?____________

13. What weather is caused by mTw blowing over cold ocean currents?____________

14. Why is cT air so rough at low altitudes?____________

15. What air mass brings most dust storms and sand storms?____________

16. What type of weather may be expected when mP air blows over a warm ocean current such as the Gulf Stream?____________

17. In which season, summer or winter, are most clouds stratiform?____________

18. Which air mass has the fewest clouds?____________

19. In which season, summer or winter, are air masses most easily distinguished?____________

20. What three factors are important in determining the weather to be expected in any air mass?____________

When two air masses of different densities move into the same area, the colder, heavier air mass displaces the warmer or lighter one, forcing it to rise. There will be a certain amount of mixing between the two air masses. However, this mixing will occur only along a narrow boundary known as a *front*.

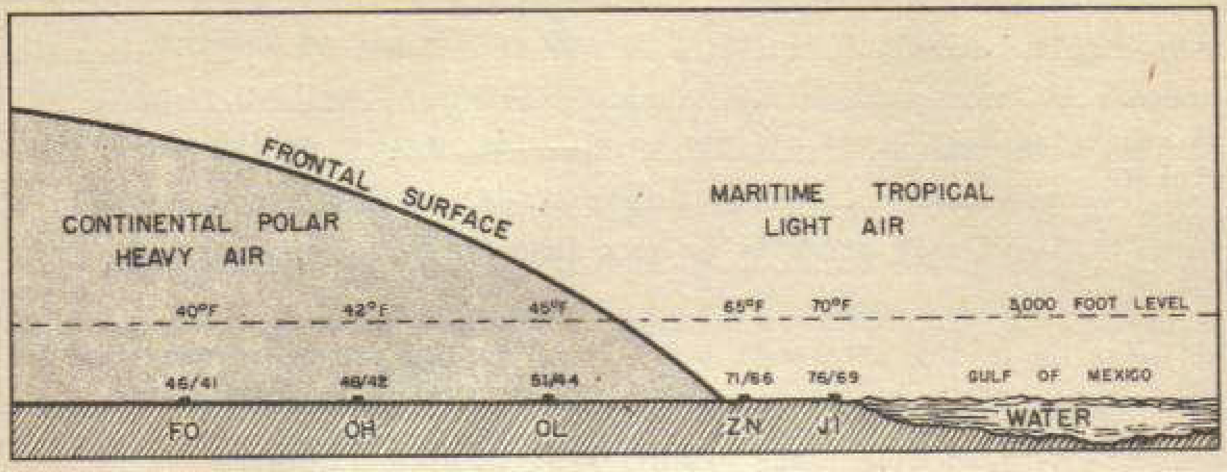


Figure 1.

A front is therefore a zone of discontinuity between two air masses, and its width and extent depend largely upon the densities of the two air masses and the speed with which they are traveling. This zone of discontinuity is not a vertical wall of air separating the two air masses but slopes over toward the colder, underlying air. This sloping surface or zone is called the *frontal surface* and the degree of slope depends upon the speed of the moving air masses. The intersection of the frontal surface with the earth's surface is the *front*. The term *front*, however, is often used for both the surface front and frontal surface.

A *cold front* is one in which cold air is replacing warm air at the surface, causing the warm air to rise over the underrunning cold wedge. On the other hand, when the colder mass of air is moving away and permitting the warmer air mass to take its place at the earth's surface the front between the air masses is a *warm front*.

There are certain characteristics common to all types of fronts:

1. Change in temperature.
2. Pressure dip with frontal passage. LOW PRESS
3. Wind shift.
4. Cloudiness and precipitation.
5. Turbulence.

Wind will veer with the passage of any front

A cold front has weather characteristics depending upon its speed. A so-called *fast moving cold front* moves along the earth's surface at a speed of 25 to 50 or more mph. One which moves slower than this is called a *slow moving cold front*.

The characteristics of a fast moving cold front are:

1. Speed - 25 to 50 mph.

2. Slope of frontal surface - 1/40 to 1/80.

3. Cloudiness.

    a. Stratocumulus and fast developing cumulus often extending ahead of the front 50 to 100 miles, with altocumulus and cirrocumulus above the lower clouds.

    b. Tall cumulus to cumulonimbus over the front.

    c. Altocumulus and cirrocumulus extend 50 to 75 miles in the warm air behind the front and stratocumulus and small cumulus in the cold air under the frontal surface.

    d. A squall line often occurs with frontal passage or precedes the front by 50 to 200 miles.

4. Precipitation - showery.

5. Turbulence - moderate to heavy.

6. Winds - gusty, shifting from south or southwest to a westerly or northerly wind.

7. Rapid clearing behind the front except when the cold air is exceptionally moist or unstable.

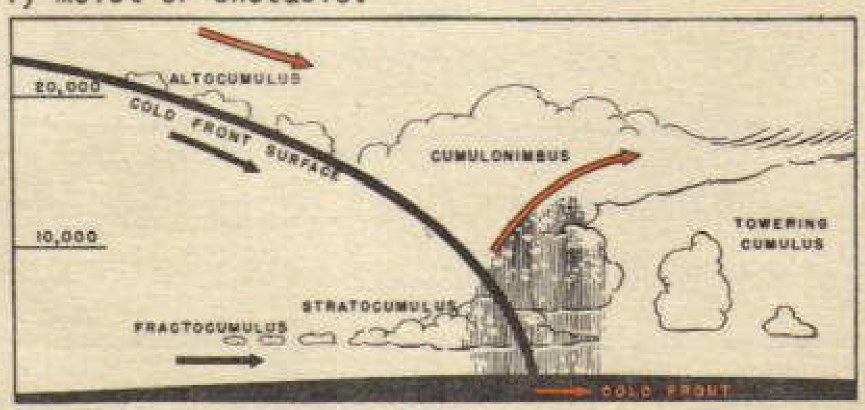


Figure 2.

Fast Moving Cold Front. Note: This illustration is generalized. In particular cases many of these elements may be greatly modified or missing.

Definitions:

Veer - change direction clockwise.

Back - change direction counterclockwise.

NOTES

Passage of a cold front

Increase southerly wind. High cumuliform clouds such as alto cu. On the horizon either the west or north. Pressure will fall. CB and rain when front passes. Wind will shift to a westerly or northern direction after front passes and it clears up.

QUESTIONS

1. What is a front? Narrow boundary between two different air masses
2. Which way does a frontal surface slope? toward the cold air
3. Which air (warm or cold) lies under the frontal surface? Cold
4. How is a warm front produced? Warm air replacing retreating cold air
5. Name five characteristics which are common to all types of fronts. Change in temp; low pressure; wind shift; cloudiness and precipitation; turbulence
6. Which front usually moves the faster, warm or cold? Cold

7. Which front usually has the steepest slope, warm or cold? cold

8. A fast moving cold front has what range of speeds? 25-50 MPH

9. How far ahead of a fast moving cold front may clouds build? 50 to 100 miles

10. How far back of a fast moving cold front will one usually find clearing skies? 50 to 75 miles

11. What type of clouds, stratiform or cumuliform, predominates along fast moving cold fronts? ~~[illegible]~~ cumuliform

12. Why is the air so turbulent with fast moving cold fronts? Because of vertical currents

13. Why are fast moving cold fronts hazardous to fly through? Because of the cumuliform clouds

14. What type of precipitation is characteristic of a fast moving cold front? showery

15. What type of wind shift usually accompanies a fast moving cold front? veering

16. In which air, warm or cold, will most of the clouds be found? warm

17. If a 090° wind veers 30°, what is its new direction? 120°

18. If a 300° wind backs 40°, what is its new direction? 260°

19. With a cold front, do the clouds increase gradually, or do they come rather abruptly with little warning? abruptly with little warning

20. After a cold frontal passage, do the clouds clear suddenly or gradually? They clear rapidly

21. Why is the first cold air that arrives after a cold frontal passage likely to have a higher dew point and a higher temperature than the air that comes 24 hours later?

22. What effect does the speed of a front have on its slope? the greater the speed the steeper the slope

23. What is the typical cloud sequence with a fast moving cold front? Ahead of the front Stratocumulus and cumulus
At the front Tall cumulus to cumulonimbus
Behind the front ~~[illegible]~~ Fractocumulus and altocumulus

SLOW MOVING COLD FRONTS

A slow moving cold front has the speed, slope and cloud system of a warm front. However, in the case of the slow moving cold front, the region of cloudiness and precipitation are above and behind the surface front.

Characteristics:

(1) Speed - less than 25 mph.

(2) Slope - 1/100 to 1/150.

(3) Cloud system - nimbostratus over the surface front, becoming strato-cumulus with higher altostratus changing into altocumulus at some distance behind the front.

(4) Ceilings - low at the time of frontal passage.

(5) Precipitation - varies from continuous light rain to light showers.

(6) Windshift - south or southwest to northwest, north or northeast.

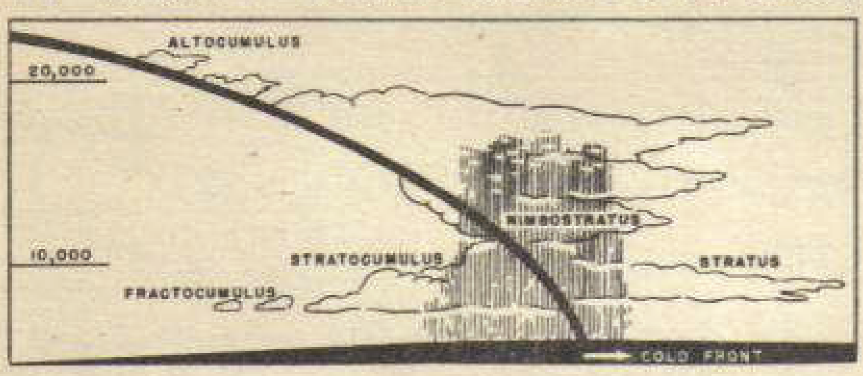


Figure I. Cross section of clouds on a slow moving cold front.

WARM FRONTS

A warm front is a front along which warm air is replacing retreating cold air. The associated cloud system covers a much larger area than either of the cold front types. The precipitation, too, is widespread. Poor visibility is the third general characteristic of this type of front.

Characteristics of a warm front with stable warm air:

(1) Speed - 5-25 mph.

(2) Slope - 1/100 to 1/300.

(3) Clouds -
   a. Extent: 400-1000 miles.
   b. System: cirrus merging into cirrostratus, then lowering, developing into nimbostratus as the front approaches. The vertical development may decrease at the front to give stratus at the time of frontal passage. Fog and low stratus often occur in the cold air ahead of the front if there is a prolonged period of precipitation.

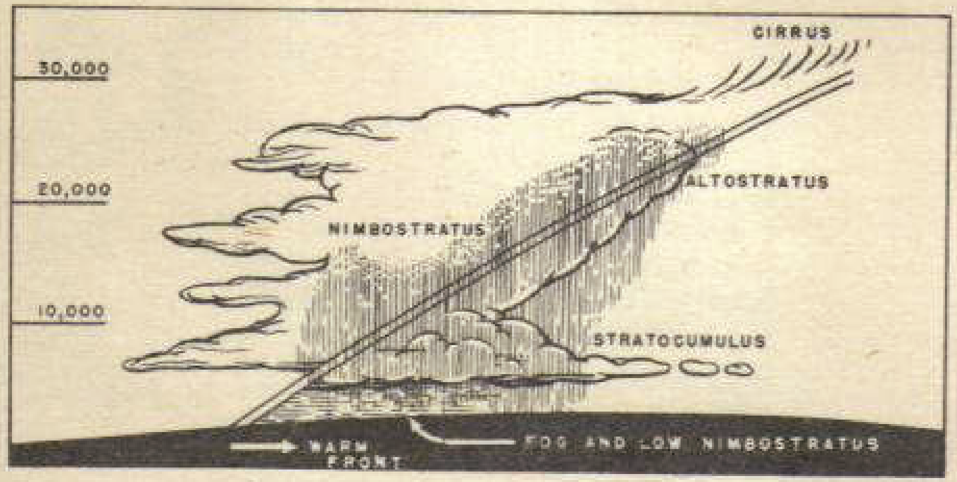


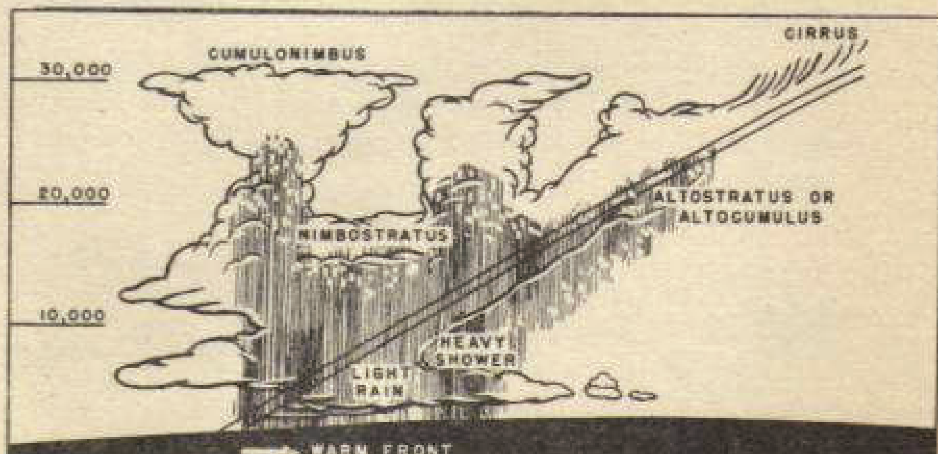
Figure 2.
Warm front with stable warm air.

Characteristics for a warm front with unstable warm air are different only in cloud characteristics and precipitation.

1. Cloud system: cirrus and cirrocumulus changing to altocumulus and altostratus, which lower, developing into nimbostratus with cumulus and cumulonimbus growing out of the tops. Decrease of vertical development may give stratocumulus and cumulus at the front.

2. Precipitation: intermittent to showery.

Figure 3.
Warm front with unstable warm air.



STATIONARY FRONTS

A stationary front is what the name implies. It is not, for the time, showing any movement. Its slope, cloud and precipitation characteristics are similar to those of a warm or slow moving cold front of the stratiform type.

NOTES

QUESTIONS

1. What is meant by a "secondary cold front"? Front formed behind a ~~[illegible]~~ cold front

2. Why is the formation of a secondary cold front more likely to occur with a fast moving cold front than with a slow moving one? Because a fast moving front ~~[illegible]~~ is tilted unequally while a slow moving front has a chance to maintain all of its ~~[illegible]~~ characteristics

3. Are stratiform clouds with drizzle or cumuliform clouds with showers characteristic of the secondary cold front? stratiform with drizzle

4. How does the region of cloudiness and precipitation differ between a fast and a slow moving cold front? The region of precipitation extends behind the slow moving front.

5. Are thunderstorms more likely to be found in front of a fast or slow moving cold front? fast moving cold front

6. What is the approximate slope of the following:
A fast moving cold front? 1/40 to 1/80
A slow moving cold front? 1/100 to 1/150
A warm front? 1/100 to 1/300

7. Describe the cloud sequence that is usually observed with the approach of a well defined warm front. Cirrus merging into cirrostratus then lowering & developing into altostratus

8. How far ahead of the surface position of a well-defined warm front is the beginning of the warm front cloud sequence observed? 400 to 1200 miles

9. What air mass is usually found overrunning the colder cP air of a warm front in the eastern states? MT Whether stratiform or cumuliform clouds are formed depends upon the Turbulence of this overrunning air.

10. Why do stratocumulus clouds often form in the cold air mass of a warm front? Rain falling from the higher clouds

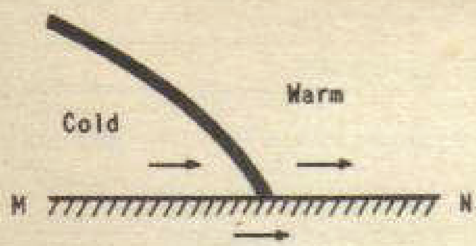
11. Are the cold front thunderstorms more likely to have lower or higher bases than those caused by the warm front? higher

12. Why is flying within clouds of stratiform appearance along a warm front a dangerous procedure? Low ceilings & rain

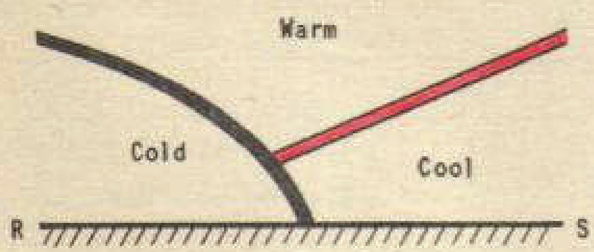
13. A stationary cold front will produce a wide area of clouds and precipitation if moist air is forced up the cold frontal slope by the wind flow. What is the main difference between a warm front and an active stationary cold front? ______

FRONTS

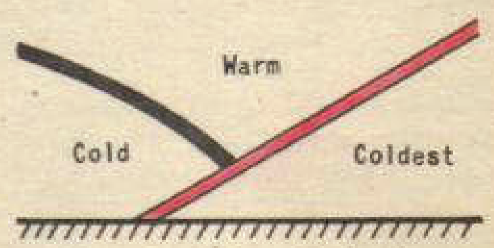
Cyclones (low pressure centers) in mid-latitudes are developed by waves forming on the polar front, causing a portion of the cold front to be retarded or actually reverse its direction of movement. Most warm fronts form when a part of a cold front reverses its direction and begins to move northeast. Diagrams A, B, C and D show the development of a wave on a polar front. In diagram A, a cold front is moving south. Something causes a part of it to be retarded, a low pressure area develops here and the circulation around the low causes a portion of the front to move northeast. If conditions favor the development of this low, the situation develops as in diagram C, with stronger circulation and more weather around the low. In C the cold front is moving faster than the warm front and will overtake it causing a part of the front in D to be occluded.



Section MN through the front in diagram A shows a wedge of cold air moving against and under warm air. In section PQ there are three air masses: the coldest air behind the cold front, warm air in front of the cold front and cool air in front of the warm front. The cold front moves faster than the warm front, overtaking it and forcing it aloft, producing the occluded front in section RS.

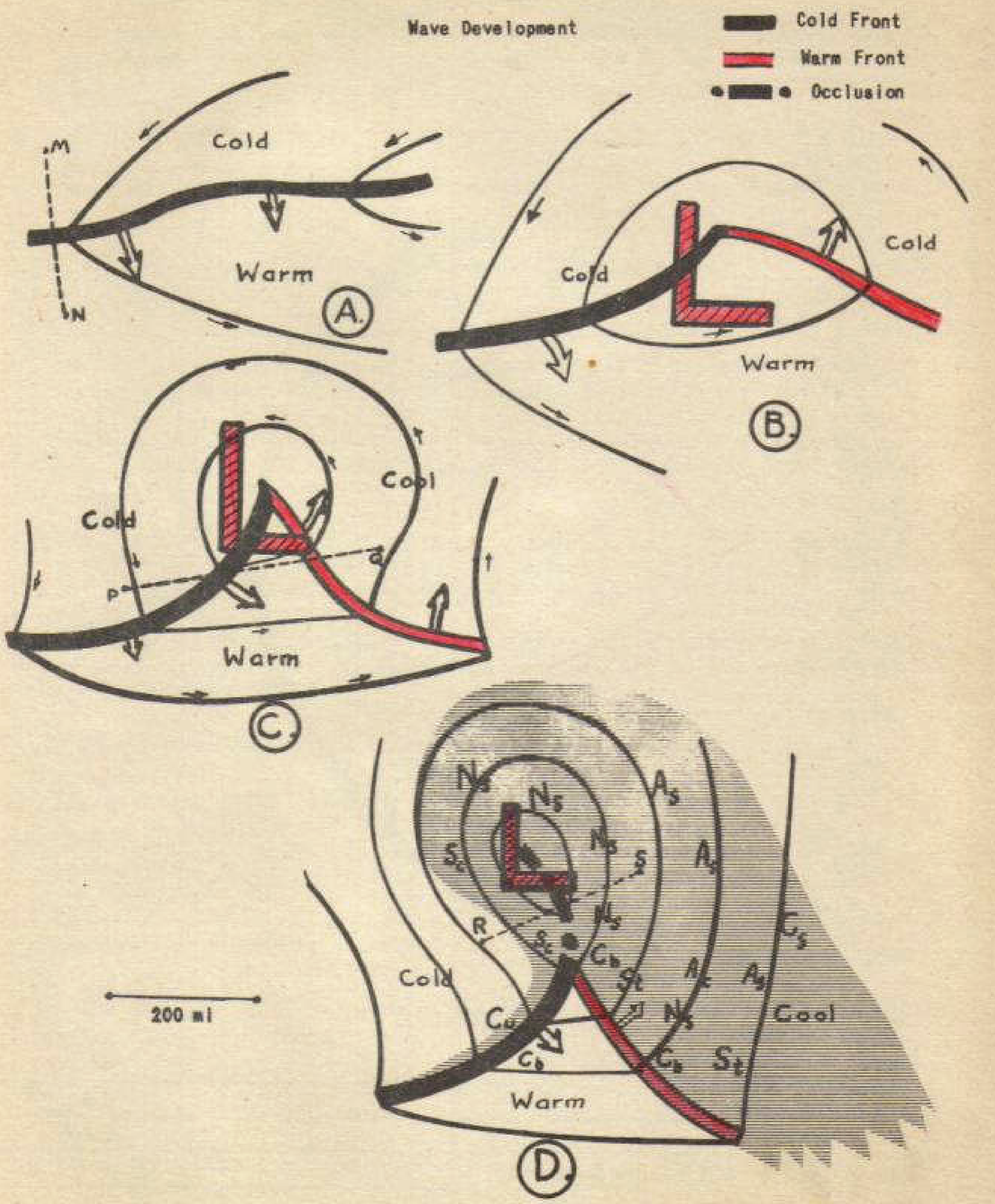


Cold Front Type Occlusion
Most Common



Warm Front Type Occlusion
Found Occasionally on
West Coast

The clouds accompanying the occlusion will be a combination of the usual warm front and cold front types. Diagram D is shaded to show areas with 7 to 10 tenths frontal cloud cover. Cloudiness extends farther back of the occluded part of the cold front than the unoccluded part when the low is well developed. The clouds in the warm sector of diagram D will usually be scattered cumulus and stratocumulus.


Wave Development
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Warm Front
Occlusion
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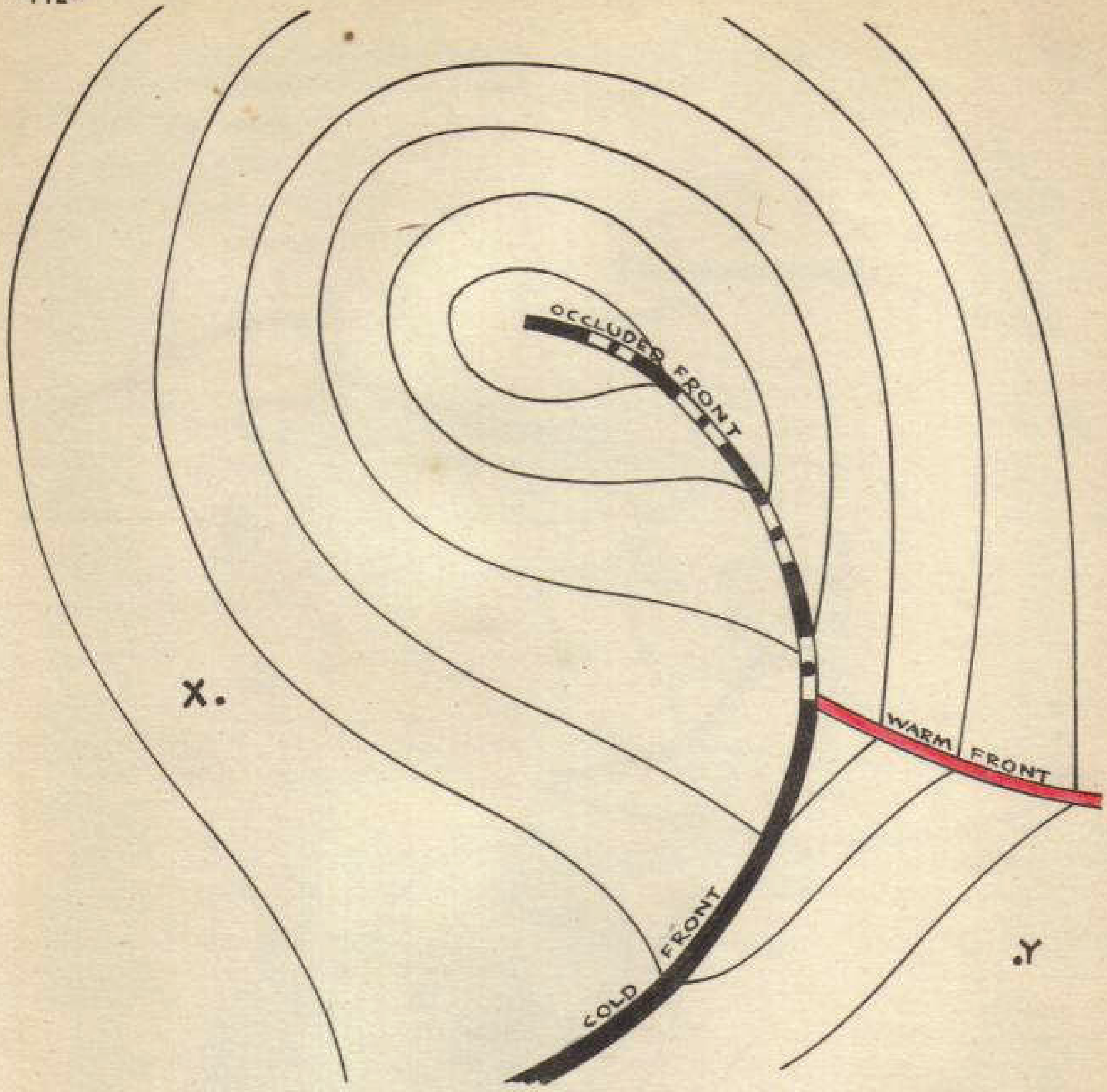


QUESTIONS

1. How are cyclones developed? ______________________________

____

____

2. How are most warm fronts developed? ______________________________

____

3. What type of front is on the eastern side of a wave? ____________

4. What type of front is on the western side of a wave? ____________

5. What type of clouds precede an occlusion? ____________

6. Whether or not thunderstorms accompany an occluded frontal passage depends primarily upon the moisture content and stability of which of the three air masses? ____________

7. What type of clouds usually follow the passage of an occlusion? ____________

8. What causes low clouds to form in the cold air underneath the frontal surfaces? ____________

9. Why is there so much turbulence below 4000 feet on the west side of a well-developed cyclone? ____________

____

10. In flying at 3000' MSL from P to Q in diagram C, what type of wind shifts will be encountered? ____________

11. In what way do the wind velocities in diagram D differ from those in diagram C? ____________

____

12. Which part of a wave moves faster, the warm or the cold front? ____________

13. An occluded front is produced when a ____________ overtakes a ____________

____

14. The weather of a cyclone may be described as a combination of ____________ weather and ____________ weather.

15. The clouds in the warm sector of a cyclone are usually ______ and ______.

16. On the accompanying chart, shade in the probable area with ceilings below 2000 feet. ____________

17. Along which portion of the front will there be the greatest shift in wind direction? ____________

18. Write Cb in the most likely spot for a thunderstorm. ____________

19. Write the proper letter in the center of the cyclone to indicate the type of pressure center. ____________

20. In flying from X to Y how will the free air temperature change? ____________

QUESTIONS

1. Which part of a wave has the most extensive cloudiness?________________

2. What is the wind shift with (a) the cold front?
(b) the warm front?________________ (c) the occluded front?__________

3. Describe the cloudiness in the warm sector.________________

4. What is the cloud system with (a) the cold front?________________
(b) the warm front?________________ (c) the occluded front?__________

NOTES

The purpose of this lesson period is to review the salient features of lessons 14 to 25. The following procedure is recommended for the student: Read the discussions and questions of lessons 14 to 25, think through the questions listed below, make note of ideas in the material which should be clarified, and attempt to clarify these ideas during class period.

NOTES

QUESTIONS

1. Much of your experience with the weather will be in identifying cloud types. Practice identifying clouds from actual observations and from pictures. Check with others.

2. How does the temperature affect the amount of moisture the atmosphere can hold?______________________________

3. In what ways is the air cooled?______________________________

4. Most clouds are formed and sustained by a lifting process which produces cooling and keeps the temperature lowered so that saturation persists. What are the means by which lifting occurs?____________________

5. The temperature of clear air is lowered $3^{o}C/1000'$ while the dew point is lowered about $\frac{1}{2}^{o}C/1000'$ when lifting takes place. At this rate how far must air having a temperature of $90^{o}F$ and dew point of $81^{o}F$ have been lifted before saturation is reached?____________________

6. What is the composition of clouds?______________________________

7. What features of cirrus clouds distinguishes them from middle clouds?__________

8. How does vertical motion differ in stratiform and cumuliform clouds?__________

9. Which clouds produce rain?

10. What is the source region of outbreaks of cP into the United States? What are the characteristics of this air in summer and winter?

11. In winter, mT air from the Gulf of Mexico presents what hazards to flying?

12. How do the characteristic clouds and weather in mT air over the southeastern states differ from winter to summer?

13. When mP air comes from west to east across the Rockies, what characteristic weather is found on the windward side of the mountain?

14. What hazards should be carefully watched when flying in a "w" air mass, especially in winter?

15. What type of cloud formation can be expected over the Gulf of Mexico in the winter when a cold cPk high pushes out over the Gulf?

16. What characteristic weather is expected in winter along the eastern side of Lake Michigan when cold air from northwestern Canada crosses the lake from the west northwest?

17. What air mass predominates over Eastern United States in summer?

18. Review mentally the structure of each type of front.

19. Without the aid of a weather map and with only local data, how can one tell when a cold front passes in winter?

20. How fast do cold fronts travel?

Be able to look at a surface map and visualize the slope of the cold air surface along each front.

If you are navigating in an area of bad weather and note a pronounced temperature change, you have probably passed through a front and the wind has shifted. This shift will be such that, if you continue to navigate on your last computed wind, you will be flying left of course. (If you don't believe it, consider several fronts, pick out various courses and work through the above!)

PROBLEM

Plan a mission from your field to 33-54N, 96-35W, thence to Lowry Field, 39-43N, 104-53W and return non-stop by the same route. Take-off is 0910 CWT, indicated air speed 200 mph.

Analysis of the weather depends on synoptic maps for 0030Z and 0630Z, temperature charts for 0400Z, winds aloft chart 1000Z, and some teletype hourly reports for 0730E and 0830E. From the study of these, develop a clear picture of the weather conditions to be expected on this mission. The following questions are designed to help you consider all significant details and the answers are to be placed in a navigator's log.

1. Write the date and name in the designated places. Zone 1 is from departure to 120 nm on route, covering the local area. Zone 2 is from 120 nm on route to 100° west longitude, covering the plains. Zone 3 is from 100°W to DV, the mountain and high wind belt. Fill in the Zone 1 winds for the 2, 4, 6, 8, 10, 12, 14 thousand feet levels.

2. Since the terrain in Zone 2 rises above 2000', fill in the winds for only 6, 8, 10, 12, 14 thousand feet.

3. Mountains up to about 8000' lie in Zone 3. Fill in the winds for 10, 12, 14 thousand feet.

4. After studying all the available information, write the expected temperatures for all zones and for each level for which a wind is recorded in the log.

5. Use the authorized abbreviations and symbols to record the cloud forecast for each zone.

6. Use the authorized abbreviations and symbols to record the visibility for each zone.

7. In Zone 1 Weather, write "None. HI CELL CNTRD IN ——.——TURBC", filling in the blanks.

8. Fill in Zone 2 Weather.

9. In Zone 3 Weather, include the kind of front running through this zone.

10. Using 10,000' altitude and IAS 200 mph, figure ETA for Lowry Field.

11. The plane will not land at Lowry Field, but will drop required material by parachute, and return to base by the same route. Figure the ETA for return to your field.

12. Forecast the altimeter setting for departure 0910C.

13. Forecast the altimeter setting for the turning point on the route out. This goes in the second blank under "altimeter settings".

14. Forecast the altimeter setting for DV and put it in the third blank.

15. Forecast the altimeter setting for your field on return. This is "Dest".

16. The answers to the last ten questions will go on the back of the log. This is number 16. This mission will be flown in mP air as one can see by the synoptic maps. What are the characteristics of mP air east of the Rockies?

17. What are the chances of dangerous weather developing on the front that runs through Zone 3?

18. Predict the time the storm from the north will reach Denver. Comparison of the two maps will show that the "stationary" front is moving at a moderate speed.

19. Which way does the frontal surface of the storm to the north of Denver slope?

20. Does the storm (Low) seem to be intensifying or dissipating?

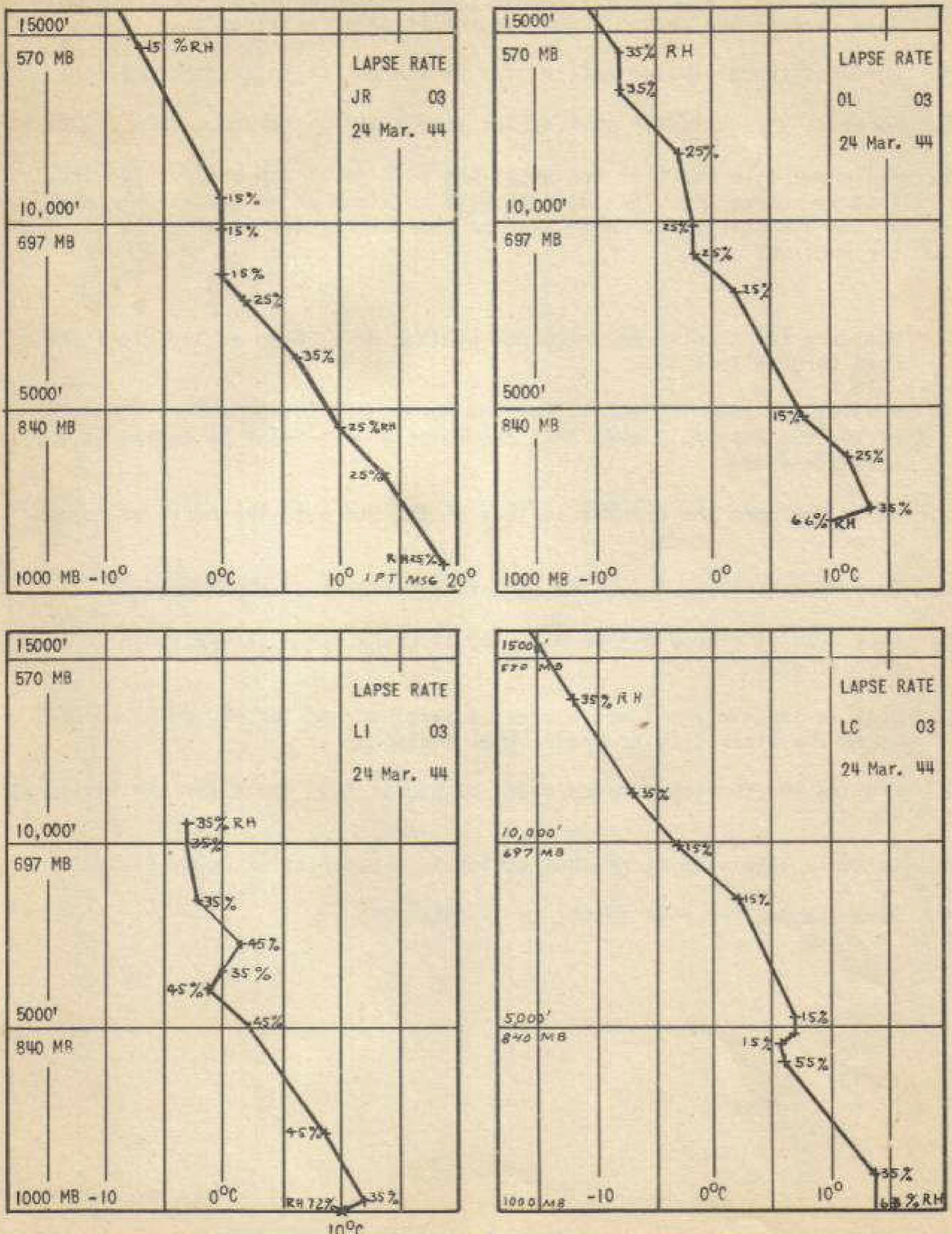
21. What type of clouds may be expected at Lowry Field as the storm approaches?

22. What is the average temperature-dew point spread for UO, DMS, and DHN? Check the visibility at these three stations.

23. What is the temperature-dew point spread at DV? Check the visibility at DV.

24. Is smoke likely to be an obstruction to visibility at Lowry Field?

25. Give reasons for your answer to question 24.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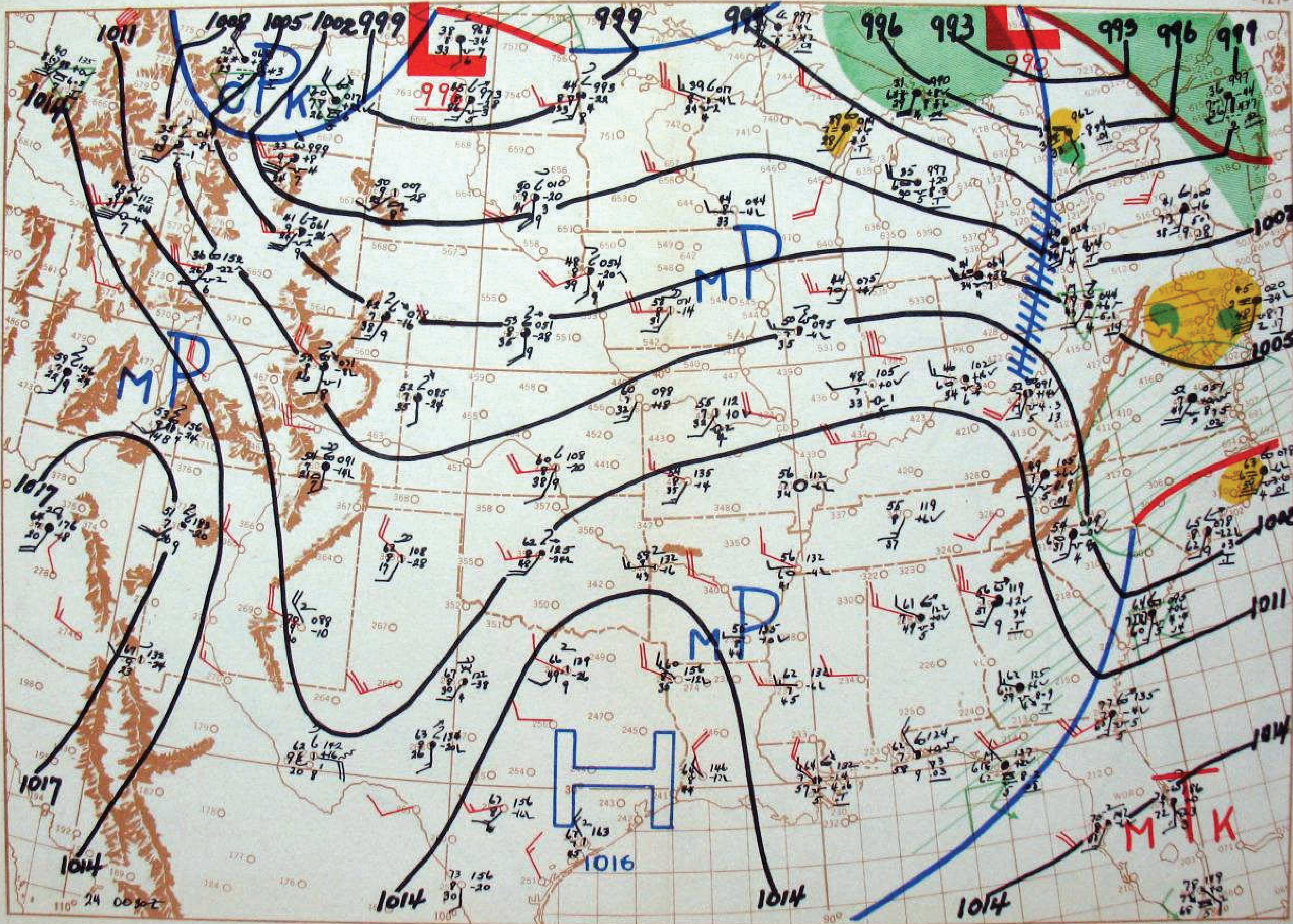

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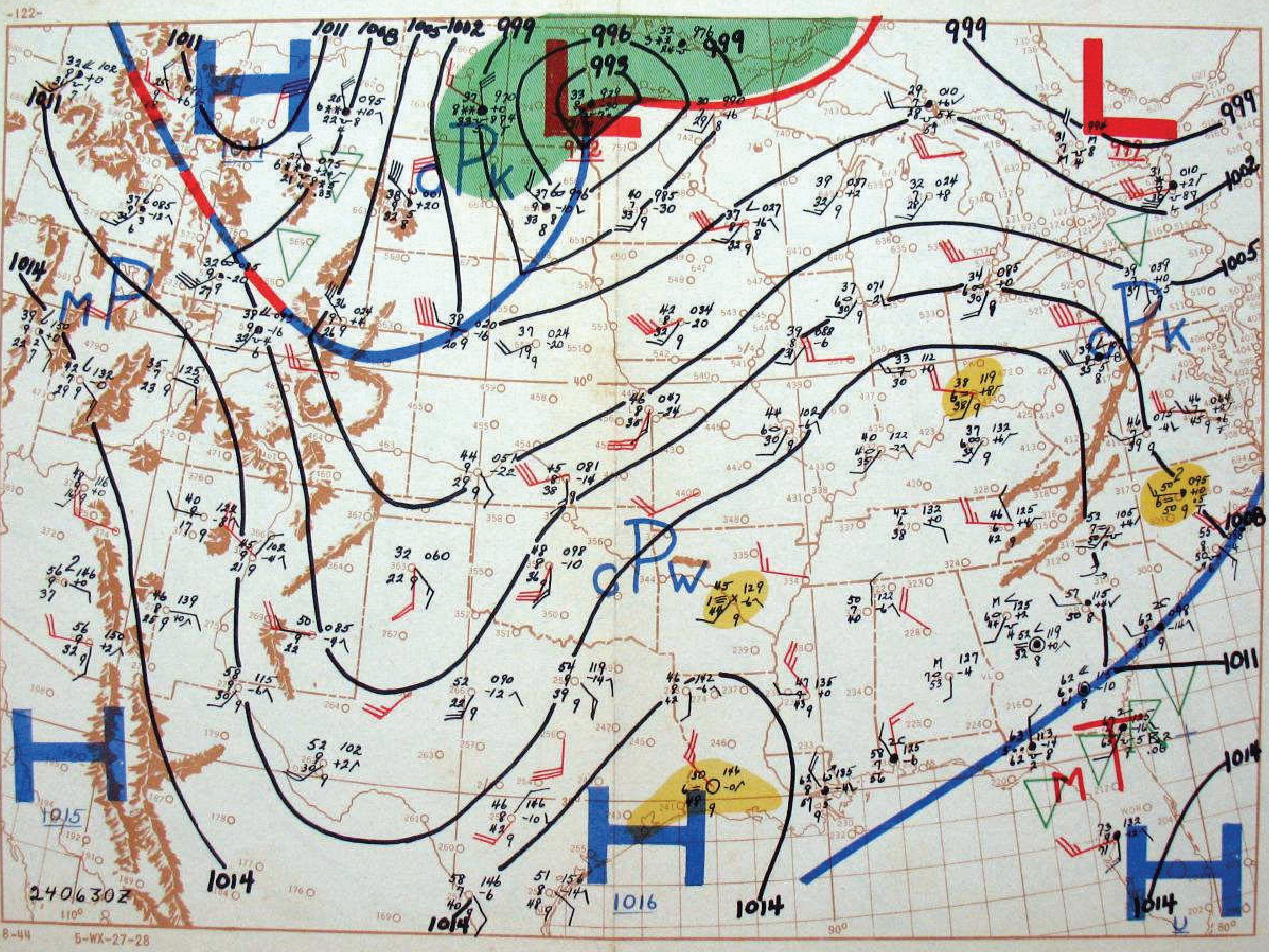
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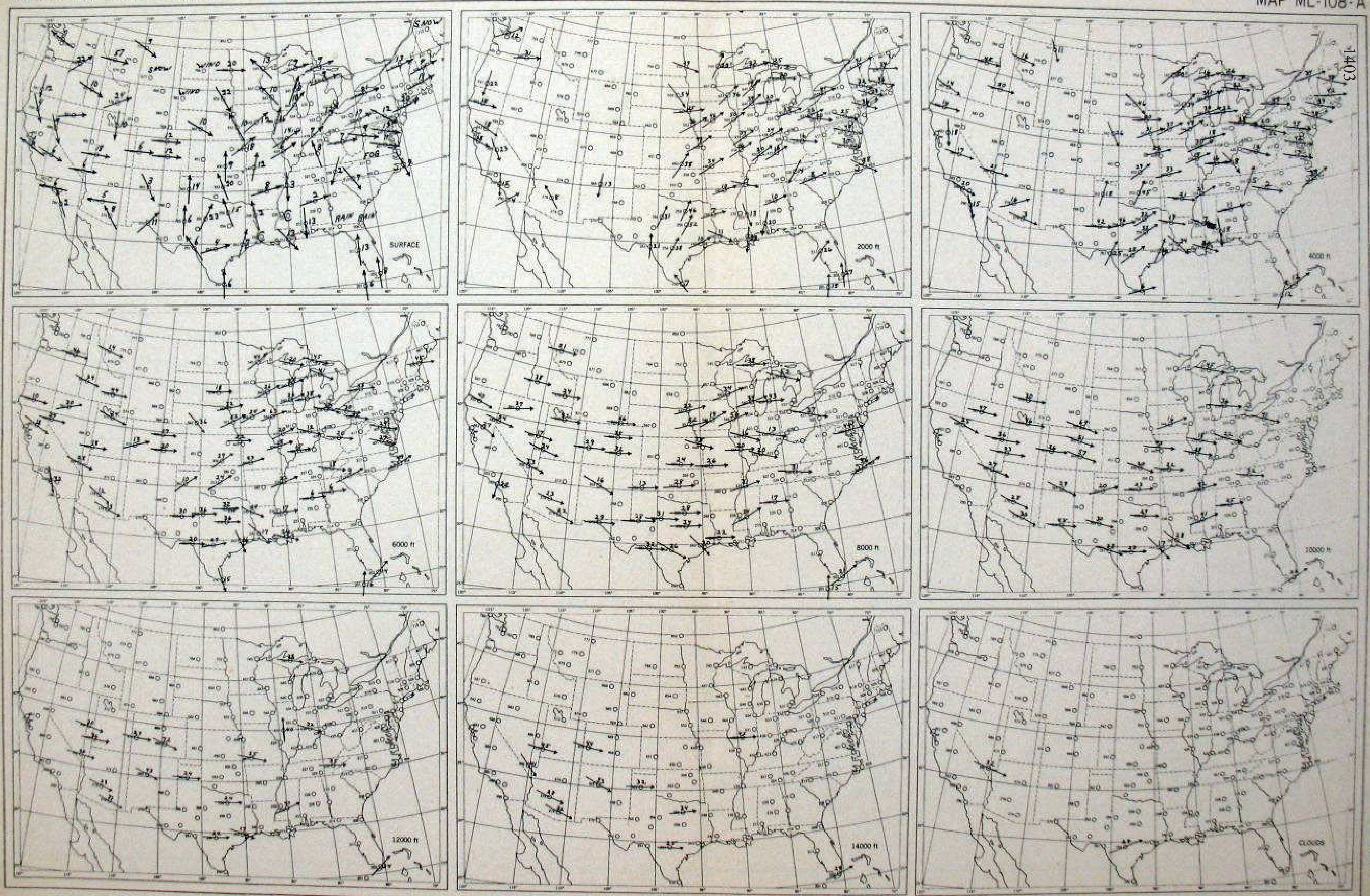
SIGNAL CORPS. U. S. ARMY

MAP ML-108-A

1403



WINDS ALOFT 24 MAR 44 0500 CWT 1000 Z

F - 1403

1404

SC 240730E
KX C SPL 25⊕3K- 132/40/35↓↙7/991
NGU SPL Φ/4GF - 102/48/44→8/984
PHA Φ/ 102/52/51/↘7/982
DIL SPL E60⊕3HK - 115/56/53↓3/986
CS N SPL E50⊕2R-F- 108/59/56→↘6/984
JX C P20⊕3TR-F-K- 112/66↑12/985/LTNG E VSBY E1 SE2
GC C SPL E70⊕5K- 102/45/40↓11/984/1/2GF - W
FV C -Φ/ 075/50/36↑↖19/977
AG C Φ/70⊕3K - 119/48/45↑2/988/GF↑ LOW PLACES
TJ X E3⊕3TR- 095/62/62↓10/980/ CIG RGD
DXW E60⊕20⊕4K- 108/53/47←↙4/985
BH C Φ/3GF-K- 125/40/40←↙3/989
PS C O5K - 115/38/37C/987
GD C SPL O3K- 125/41/40↑7/989/K LYRS ALF RANDI
NO C Φ/ 132/57/44↙6/991
TTV -Φ/ 102/46/36↑↖11/982
ZH C O119/42/38↑6/986
UO O3K- 125/40/39↖5/989/K LYRS E HRZN
VS O125/35/34C/989
UM C Φ 4K- 125/43/42C/989/VSBY E 1/2
NAS E65⊕7 109/60/58↘8/984
CG C Φ/4K- 064/34/31↑8/9/9
TPI Φ/9 064/36/32↑↗7/970
LS C Φ/5K- 085/38/31↑11/976
KC C Φ/8 037/47/33↑↗15/962
AF O6GF- 098/33/31C/980
ZF O 075/41/33↑↖13/973
TS C O 068/46/36↑12/973
TR O/K- 115/43/38↑↗9/987
LI C O/K- 102/40/37↗3/983
DKX O2F-K- 129/33/31C/989
TH SPL O4GF- 102/33/31↑4/981
LN Φ/ 031/42/33↑16/962
WD C O 044/40/35↑↖10/965
TWY -Φ/ 024/41/34↑10/961
OL C O 047/44/38↑↖19/966
AT O 058/45/38←↖9/970
AP C O 047/49/29↑↗22/971
BZ C O 061/44/20↑11/974
WP O 061/44/19→↗14/978
DHH O 020/43/17→12/966
DEH O 044/47/20→5/977
AQ C O 027/34/17→8/966
WF C O 031/50/36↑16/964
WC C O 091/52/39↑↗18/980
CR C O 135/47/45↗6/992
LC C O3F-K- 132/45/43→↘3/991
DLX O4F- 132/39/38↑↗2/991
NT O 115/48/40↑13/987
DHN O7 122/48/40↓↙3/990
DMS O 119/46/42↑↗9/988
OH C Φ/7 980/41/34↑↖9/945
AB C O 071/37/20←↖5/986
EO C O 102/52/22→↗22/990
DV C O 003/43/22→↗11/961
LQ C O 105/50/22→↗9/987

PDW HU C 240730E O 125/50/46↑↗13/989

PS C SPL 240644C O4GF-K- 115/38/37↑↗2/987/VSBY 1 N

JX N SPL 240744E P30⊕2TR-F-K- 105/66/66↑↗13/984

UO SPL 240645C O2GF-K- 125/40/39↖5/989/K LYRS E HRZN

BH N SPL 240645C Φ/30⊕2GF-K- 125/40/40↖3/990

AG N SPL 240805E E70⊕50⊕21/4GF-K- 119/48/45↘2/988

UM X SPL 240708C O3/4GF-K- 125/43/42C/989/VSBY N3/4 E1/4 S1/2
W21/2 K ALF N

JX C SPL 240817E A30⊕3R-K- 105/66/66→↗4/984

SC 240830E
LB O 119/41/32↑4/987/ 314 ↑9 RCVNO 3117.5
KX C O3K- 135/39/34↓↙9/991/ 104 5001 39
NGU -Φ/4HK- 113/48/33↓7/987/RAFRZ 91/MSL RH 13 0745E/ 316
DIL E50⊕2HK- 132/56/53↑↗2/990/E80⊕/ 415 5109
CS C SPL E50⊕4R-F- 115/57/54↓5/986/ 00518 5209 57
JX C A30⊕4R- 105/67/64→↗6/982/E65⊕/ 00043 5705 66
GC X Φ/70⊕3/8KGF- 115/41/38→↘5/986/ 306 0335 40
FV C O 071/50/36↑↖18/976/608 0059 50
AG N SPL E70⊕50⊕21/4K- 115/48/44↓↘4/988/ 005 5806 47
TJ X E4⊕5R- 102/61/61↓↘13/982/TSTM DSIPTD CIG RGD/ 20774 6008 61
DXW A90⊕4K- 112/53/47↓↙6/986/BRONO PIREPS TOVC 180 MSL/104 0706
BH N 50⊕ 21/2GF-K- 132/40/40←↖3/991/ 403 0305 40
PS C O4GF-K- 119/40/36↑5/988/VSBY 1N/ 302 38
GD C SPL O3GF-K- 125/41/- -----5/ 103 40 RANDI
ZH C O6K- 119/42/38↑↖5/987/ 503 41
UO SPL O3GF-K- 125/40/38←2/989/K LYRS ALF/ 000 39
VS O6GF- 132/34/32↖2/991/ 400 34
UM X O3/4GF-K- 129/42/41C/990/VSBY N3/4 E1/2 S1/8 W21/2 K ALF
NAS E 65⊕/⊕7 119/58/55↓↘O↙987/ 404 5705 58
CG Φ↘3C- 0-8/3 →30↑05⊕9↗8/ 90 8306 -4
TPI Φ/ 064/37/32↑↗7/970/ 603 0705 35
LS N Φ/21/2K- 081/39/30↑12/975/ 803 0747 38
KC C Φ/5K- 031/47/33↑↗TXOYQX IPE PEQY
AF -Φ/6GF- 098/33/31C/980/ 602 0107 31
ZF Φ/ 075/40/33↑↖12/973/ 805 40
TS C Φ/ 068/44/36↑9/972/ 805 0246 44
TR O6K- 119/43/39↑↗10/988/ 502 42
LI C O4GF-K- 108/40/37↗4/984/K LYR OVR FLD/ 603 40
TH Φ/6H 102/33/30↑5/981/ 300 0526 31
LN Φ/ 034/42/33↑18/962/ 603 0417 40
WD C O 031/39/34↑15/961/ 810 0409 39
TWY -Φ/ 034/35/32↗9/963/ 506 0059 35
OL C -Φ/ 037/43/38↖20/963/ 812 0066 43
AT O 058/45/38←5/969/ 610 0709 33
AP C O 054/50/28↑↗23/972/ 606 50
BZ C O 064/43/20↑13/974/ 605 42
WP O 064/43/21→12/978/ 603 43
DHH O 031/39/18→↘11/968/ 400 93644 39

DEH O 044/47/21→6/977/ 603
AQ C O 027/37/21→↘8/966/ 605 0019 93548 31
WF C O 017/50/36↑12/962/ 810 0109 50
WC C O 088/53/39↑↗16/978/ 608 50
CR C O 135/45/43↑↗9/992/ 805 45
LC C O5F-K- 132/44/42↘4/991/K LYR W/ 300 43
DLX SPL O3/4GF-K- 132/39/37↗2/991/ 303 38
NT O 125/46/41↑11/989/ 502 45
HU C O 125/49/41↑14/989/ 804 49
DHN O7 122/45/41C/990/ 603
DMS O7 122/47/41↑↗4/989 602
AB C O 071/39/19↙6/987/ 605 0019 94198 39
EO C O 095/52/23↗23/989/ 607 94298 50
DV C O 003/43/22→14/961/ 807 0409 93440 43 08507
LQ C O 098/44/23↓5/989/ 810 44

OH C Φ/6K- 983/41/35↗11/946/ 608 0059

PDW TTV 240830E O 102/46/36↑14/982/ 606

PDW NO C 240830E Φ/ 132/57/45↓↙7/991/ 102 0452 56

LS C SPL 240740C Φ/3K- 081/39/30↑12/975/VSBY 21/2S

BH X SPL 240750C 50⊕3/4GF-K- 132/40/40←↖3/993/VSBY N3/4
E1/2 S1/2 W3/4 K AND GF LYRS SHLW

JX C SPL 240902E E65⊕30⊕6R- 108/67/64↑↗5/984

TJ C SPL 240905E E20⊕5⊕3RW- 108/61/61↓↘15/984/ CIG RGD

F - 1404

PRACTICAL CONCEPTS OF ICE FORMATION

In the study of clouds, it was noted that clouds were composed of either water droplets or ice crystals or both. In a water droplet cloud, the drops vary in size from small droplets (less than 1/50 inch in diameter) in strati-form clouds with only a little vertical motion to large droplets in cumuliform clouds of large vertical development. Water drops as a rule may exist in liquid state to a temperature of -20°C or lower.

In water clouds with temperature well above freezing, visibility is restricted and turbulence is present in varying degrees, but no accumulation of structural icing results. If the water droplets exist at a temperature from 0°C to -10°C, ice accumulation on wings, props, external instruments and all external surfaces of a plane is a hazard to flying. The lower limit of this temperature range in which icing presents a hazard depends upon the plane, pilot, turbulence and cloud type. Ice crystal clouds, as a rule, present no icing hazard.

Structural icing may be divided into three types - clear, rime and frost. Clear ice presents the worst hazard. It is a hard, tenacious, transparent coating of ice which is difficult to remove. Clear ice formation is caused by the freezing of large drops of supercooled water upon the external surfaces of the plane. Consequently, the worst icing hazard occurs between 0°C and -10°C in cumuliform clouds. When the temperature is below freezing at the flight level, cumulus or cumulonimbus clouds should be avoided.

Rime icing on the other hand is white, opaque and granular in appearance. Because of its structure, its removal is accomplished rather easily by modern de-icing equipment. When supercooled drops touch the surface of the plane they freeze into ice. The large drops run over the surface and freeze with other supercooled liquid into a clear sheet of ice, while the small drops freeze upon contact into the granular rime ice. Rime ice is found in strati-form clouds and to some extent in cumuliform clouds with temperatures ranging from -2°C to -30°C. It should be borne in mind that actual conditions will give a mixture of clear and rime ice in most cases with one type predominating.

Frost is formed when the plane's surface cools clear air to its dew point, which at the same time must be below freezing. Frost will accumulate on planes which are left out in the open air during winter nights or which let down rapidly from cold levels into warmer levels of the atmosphere. Frost may prove to be hazardous on landing or take-off by obstructing vision through windshield or decreasing lift.

Structural icing presents a hazard to flying by increasing the drag, diminishing lift by deformation of the airfoil, decreasing propeller efficiency, causing incorrect readings in airspeed indicator and the altimeter.

Carburetor ice, which reduces the flow of air and literally chokes the engine, can form in weather conditions greatly different from those of structural icing. Air entering a carburetor is cooled by expansion into the low pressure area within, thereby making the air 10° to 20°C cooler than the outside temperature. Moisture may condense in the cooled air and freeze into ice if the carburetor temperature lowers to freezing. It is not uncommon for carburetor ice to form in cloudless, relatively moist air with free air temperature as high as 15°C.

NOTES

QUESTIONS

1. What conditions are necessary for formation of clear and rime ice? Water droplet clouds 0°c or lower

2. Which type of ice (clear or rime) is easier to remove? Rime

3. What navigation instruments may be affected by ice? air speed - altimeter

4. What type of icing would predominate in cumulonimbus clouds? Clear

5. A temperature inversion exists between 4000' and 5000' with temperature of -5°C at 4000' and +3°C at 5000'. No clouds were present. The dew-point of the air at 5000' is -2°C. A plane which has been flying for sometime at 4000' climbs quickly to 5000'. What type of icing is most likely? _____

6. In flying through a cold front from warm to cold air, will the freezing level lift or descend? Descend

7. In flying through a warm front from cold to warm air, will the freezing level lift or descend? lift

8. Can temperatures be too cold for dangerous icing conditions? yes

9. Why is carburetor icing unlikely in relatively dry air that has a temperature-dew point spread more than 25°C? The air going through the carburator is only cooled from 10-20°C

10. What type of icing, if any, is predominant in altostratus clouds? Rime

11. What temperature range is most dangerous from the standpoint of formation of structural icing? 0° to -10°C

12. Will clear or rime ice form when a plane flies through freezing rain? Yes

13. Will clear or rime ice form in cloudless air that has a temperature of -10°C? No

FLYING CONDITIONS IN ICING AREAS

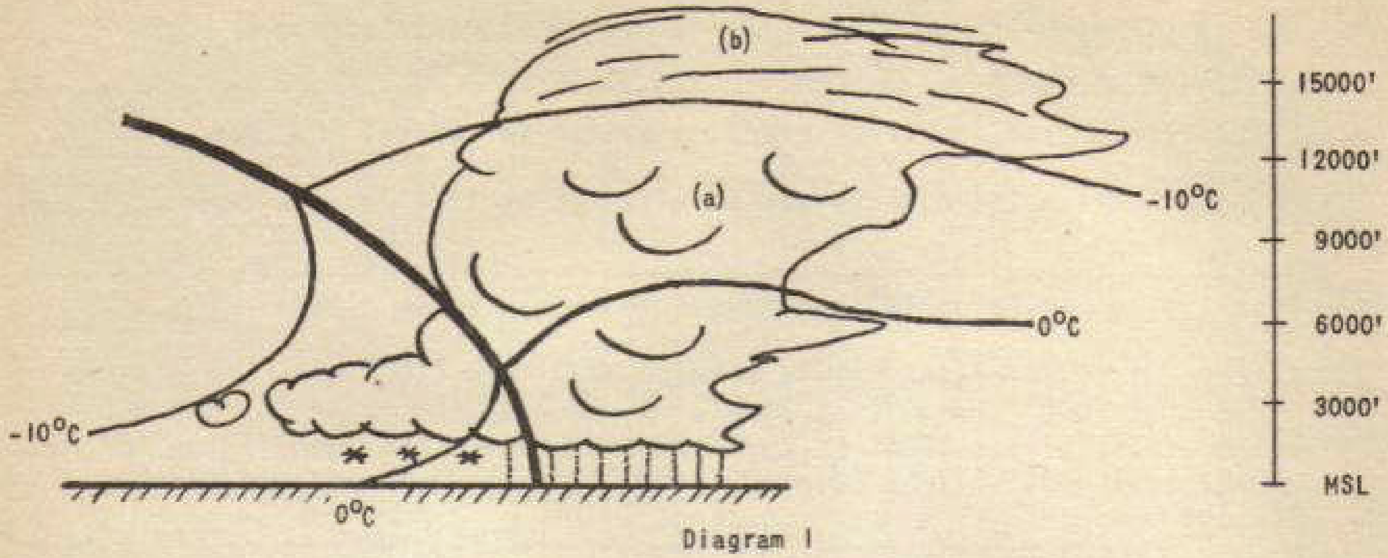


Diagram 1

1. What type of icing should predominate in the three diagrams in the regions indicated? (a) Clear (b) Rime
(c) ________ (d) ________ (e) ________

2. What effect does ice have on navigation instruments? ________

How can this hazard be avoided when flying in icing conditions? ________

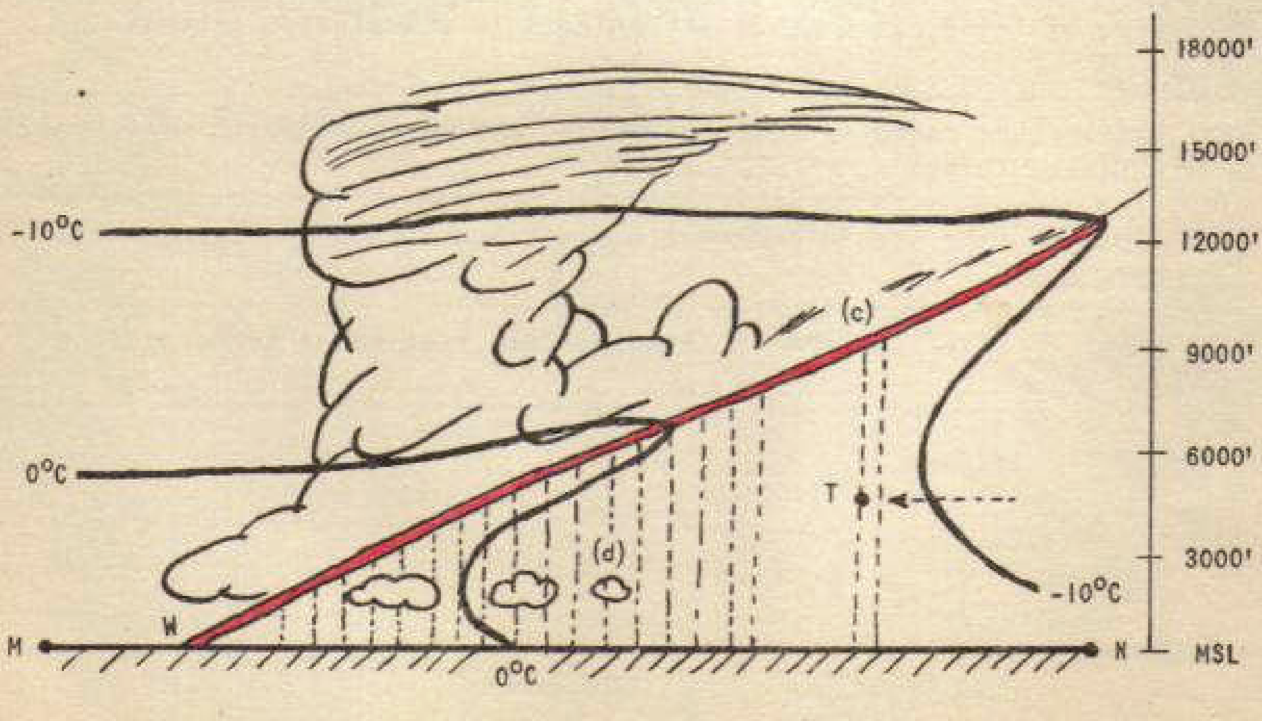


Diagram 2

3. Flying at 2000' from M to N in diagram 2, clouds are entered with temperature of +4°C. How does the temperature vary before reaching N? ______

What flying conditions will be encountered? ______

Would a flight at 14,000' be encountering more or less icing hazard than at 2000'? ______

4. A pilot flying at 5000' from N to M begins to enter freezing rain at T. Knowing there to be a warm front on surface map at W and having seen the cirrus and altostratus overcast before reaching T, the pilot should change his flight attitude in what way before continuing on to M? ______

______

______

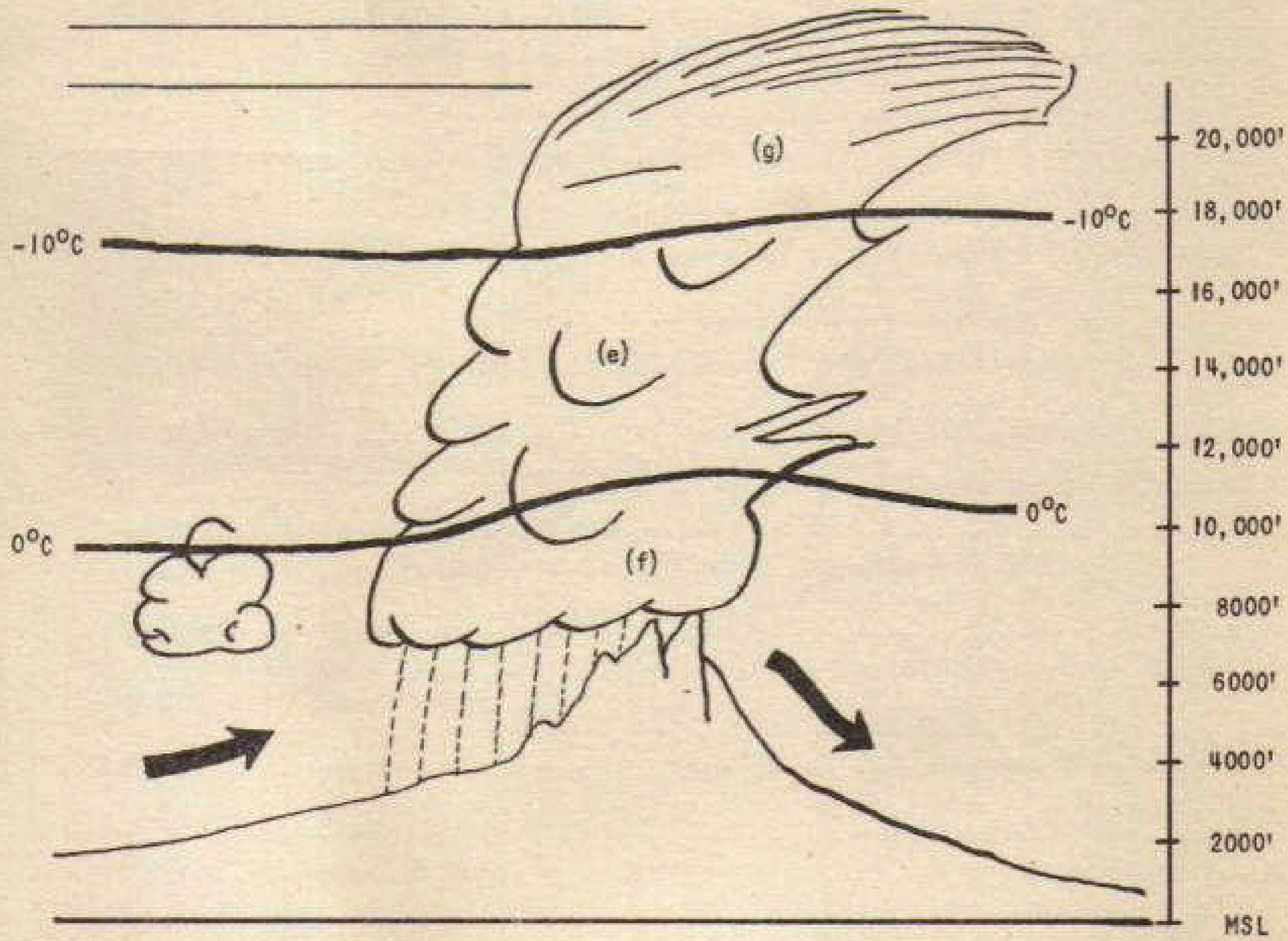


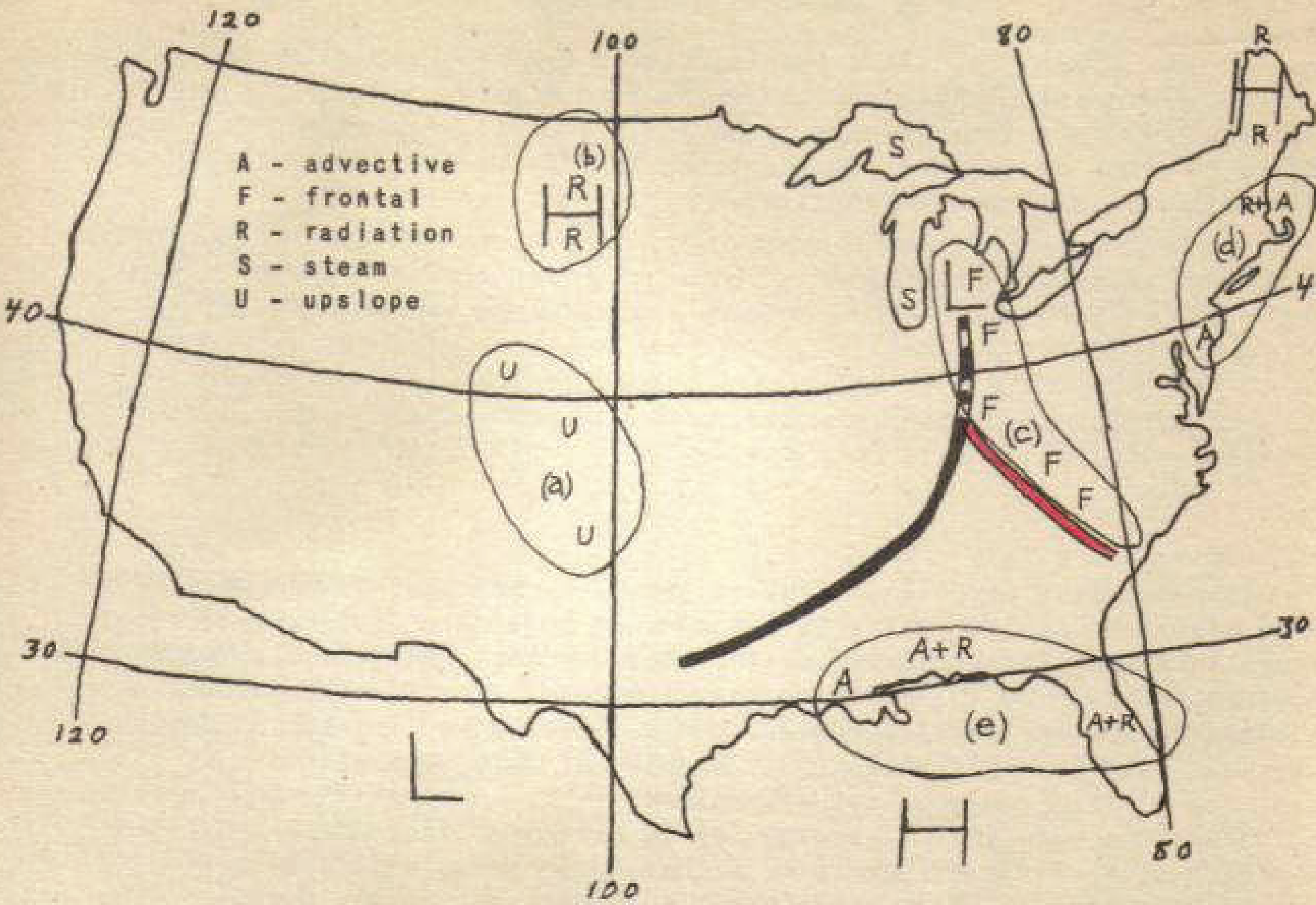
Diagram 3

5. In diagram 3, why is it inadvisable to fly underneath the cumulonimbus cloud? Not enough Clearance

Region f would present heavy turbulence. Why would it be inadvisable to fly through region e? More turb than in f

What hazards would be encountered at g? Hail

LOCATION OF TYPES OF FOG



TYPES OF FOG AND THEIR FORMATION

On page 60, it was pointed out that condensation is produced when the temperature of a parcel of air is cooled to its dew point. Condensation causes the invisible water vapor to appear as visible water droplets. The only distinction between fog and clouds is the height of the base above the ground; clouds have bases more than 50' above the surface while fog is lower. Since fog may make take-offs and landings difficult or impossible for aircraft, an understanding of its causes and the conditions under which it may form is essential to aircrew members.

Conditions that favor the formation of fog include the following: (1) small temperature-dew point spread indicating the degree of saturation of the atmosphere and the amount of cooling necessary for condensation to occur; (2) clear skies and weak winds both favoring radiational night cooling; (3) stable lapse rate in lowest 1000' with accompanying small wind velocities preventing fog from being carried aloft into stratus; (4) upslope motion of winds over terrain, assisting in the cooling of the air; and (5) presence of smoke in the vicinity. Fogs may be classified as to the cause of their formation.

The types of fog which are due to a lowering of surface temperature are:

1. *Radiation fog.* This type is caused by night radiation being favored by clear skies (at night), surface winds 3 to 8 miles per hour, a relatively high dew point and the drainage of cool air into valleys at night. Radiation fog is thickest around sunrise and tends to dissipate within 2 or 3 hours after sunrise, due to solar heating.

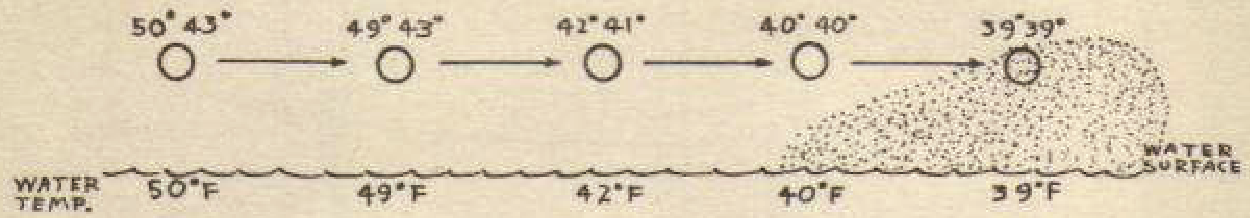


Diagram 1.

2. *Advection fog.* This type is caused by relatively warm moist air being blown over colder surfaces. When warm moist air from over the Gulf Stream in the Atlantic blows over the cold Labrador Current, the Grand Banks fogs are formed. In the winter, when warm moist air from the Gulf of Mexico is blown northward over the cooler land surface, advection fog is formed. Diagrams 2 and 3 illustrate another example of this type of fog. In this case, the air field may be suddenly closed if the wind shifts and carries the fog across the runways. Advection fog is different from radiation fog in that it usually is denser and more extensive in area, drifts with wind, does not require clear skies for its formation and is not easily dissipated by solar heating.

Diagram 2.

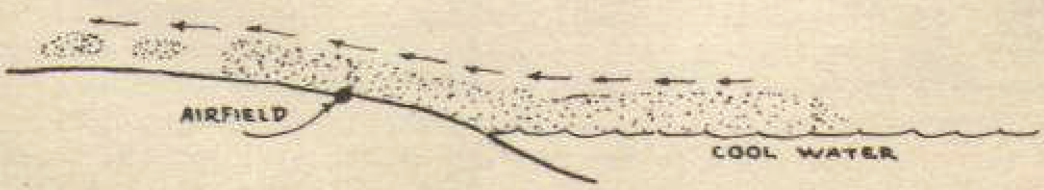


Diagram 3.

3. *Upslope fog.* Figure 4 illustrates the lowering of the temperature to the dew point as moist air moves upslope. Upslope fog requires a fairly strong wind, 15 to 20 mph, is little affected by sunshine and often lifts to low stratus. Texas, Oklahoma, Kansas, Colorado, Nebraska and the Dakotas are ideal locations for upslope fog when easterly winds bring moist air up the sloping terrain.

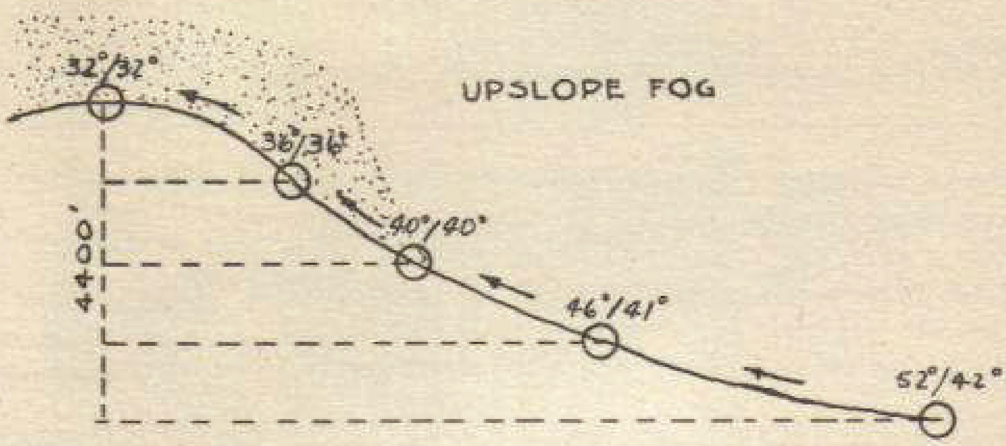


Diagram 4.

The types of fog which are due to the raising of the dew point are:

1. *Steam fog.* This type is caused by cold air moving slowly over warmer water. Evaporation of water into the cold air soon causes saturation and fog. Steam fog presents very little hazard to flying because it rises and dissipates rapidly, giving only very limited and thin patches.

2. *Frontal fog.* This type is caused by warm rain falling into cold air under the frontal clouds, evaporating and saturating the cold stable air to the point of fog formation. Frontal fog associated with warm fronts is usually of great depth, frequently merging with higher layers of clouds.

NOTES

QUESTIONS

1. What type of fog is located in the following regions of the map, page 131? (a)________ (b)________ (c)________ (d)________ (e)________

2. Is radiation fog more likely on a cloudy or clear night? Clear

3. What type of fog requires the highest wind velocity? Upslope

4. What time of day is radiation fog most frequently observed? ~~sunrise~~ (morning)

5. What wind velocity is most favorable for radiation fog? 3 - 8 MPH

6. During what time of year is advection fog over the Great Lakes most likely? ~~[illegible]~~ Summer

7. What type of front produces most favorable conditions for fog? Warm

8. When air is lifted by upslope motion over terrain, the temperature decreases 5.6° per 1000' while the dew point decreases only about 1°F per 1000'. mT air over Little Rock, Arkansas (elev. 265') is moving toward the west northwest. If the temperature and dew point of the air at Little Rock are 60°/50°, will either fog or low stratus be formed by the air flowing to Dodge City, Kansas (elev. 2509')? low stratus

9. What effects do cold water currents near the Aleutians have on fog formation? ________

10. Is radiation fog more likely to form on hills or in valleys? valleys

11. How does falling rain produce fog? By warm rain falling into cold air

12. What effect does the presence of smoke have on fog formation? ~~By warm air falling into cold air~~ The particals of smoke act as nuclei for the fog to form around

INTRODUCTION TO THUNDERSTORMS

If the one single weather phenomenon that has the most effect on flying in the United States in the summer was to be chosen, that phenomenon would no doubt be the thunderstorm. The thunderstorm is dangerous and the proper management of a flight in its presence requires particular flying techniques.

Thunderstorm clouds begin with cumulus clouds which under favorable conditions build up into bulging cumulus and finally into cumulonimbus as shown in diagram A. The cumulonimbus is usually marked by the formation of an ice crystal and generally flat cloud top. Thunderstorms may occur as an isolated cumulonimbus cloud only a few miles in diameter or as a line of storms several hundred miles long without a break. The thunderstorm cloud may have its base almost on the ground or on a cold dome several thousand feet above the surface. The top of thunderstorm clouds may be about 10,000' MSL or in some cases as high as 40,000' MSL. In many thunderstorms, a low dark rolling cloud with accompanying strong gusty turbulent wind may precede the main cloud by a few minutes and high cirrus may be thrown out from the tops to a distance of 100 miles or more.

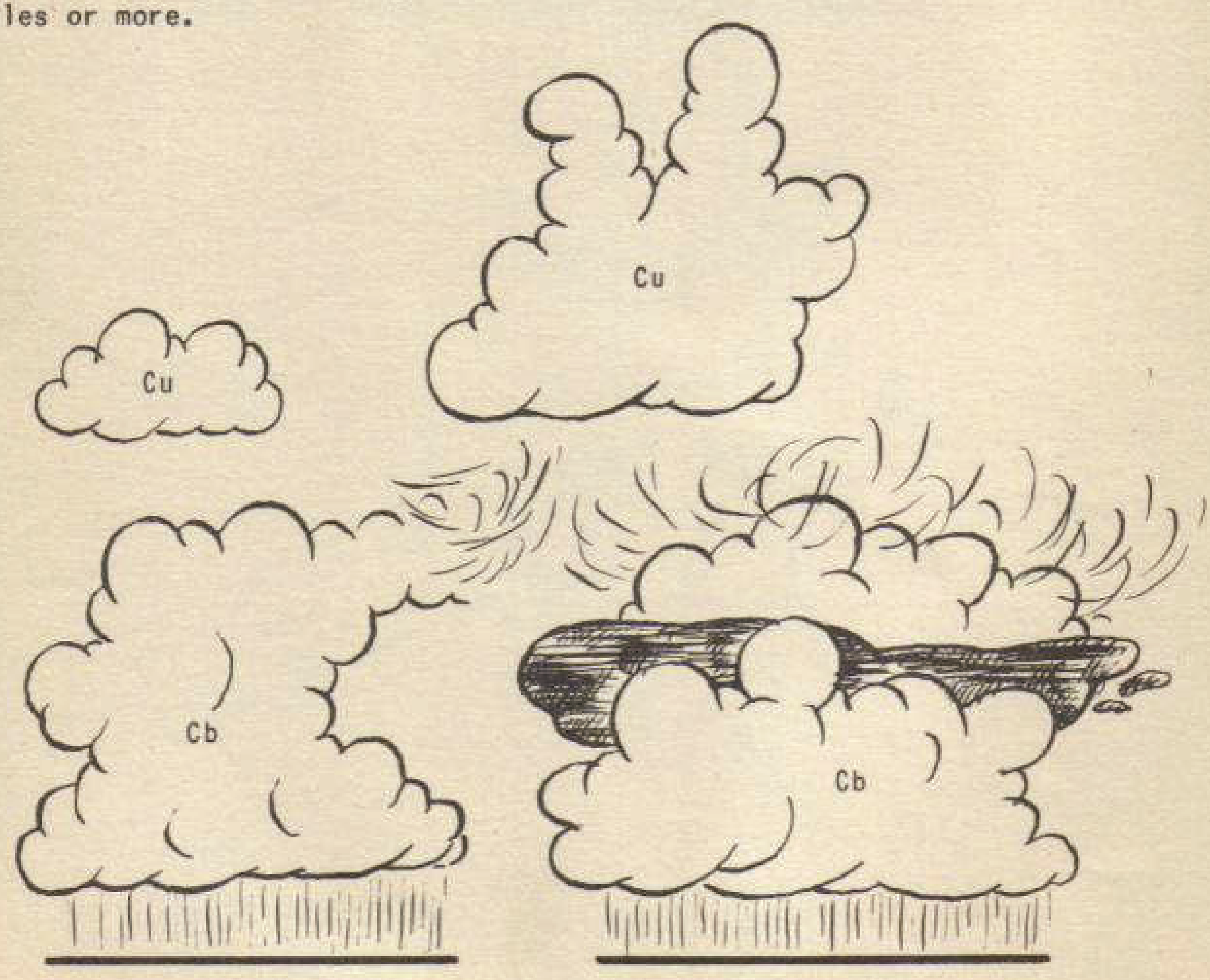


Diagram A.

The thunderstorm presents five hazards to flying: turbulence, icing, hail, lightning, and poor visibility. Updrafts and downdrafts within thunderstorms are said to have exceeded 200 mph as determined from the updraft necessary to produce large hail stones. Opposing vertical currents may lift and drop a plane thousands of feet, put it through strange acrobatics and shear off its wings.

Any plane that enters the water droplet part of a thunderstorm cloud that has a temperature between 0°C and -10°C will receive a coating of clear tenacious ice. In summer thunderstorms, the icing hazard is seldom serious because the lower limit of the zone of icing is several thousand feet above the ground. But at other seasons icing may extend to the surface, thus making the icing hazard more serious.

Water drops can be carried upward in strong updrafts and frozen into pellets of ice. These pellets descend and collect more moisture. Driven upward again, the new moisture also freezes. Repeated ascents and descents cause the hailstones to grow until they become too heavy to be supported by the updrafts. Hail is present in many thunderstorms even when no hail reaches the ground and is most often encountered along the upper edges of the cumulonimbus.

Lightning usually occurs in regions of strongest turbulence. Lightning from cloud to ground indicates that the thunderstorm is reaching its peak of intensity (as far as turbulence is concerned) and that the intensity is near the ground. On the other hand, in old, mature and high level frontal thunderstorms, cloud to cloud lightning is most common. When cloud to cloud lightning exists stable air usually exists below the cloud even though a wide rain area is present. Flight under a thunderstorm with cloud to ground lightning is extremely hazardous because of excessive turbulence. Lightning in itself presents a hazard to flying in damage to electrical equipment and in causing temporary blindness of the pilot.

TYPES OF THUNDERSTORMS

Air Mass Thunderstorms (greatest frequency in summer)

1. Thermal thunderstorms are caused by convection due to heating of surface. This type is usually scattered and occurs most frequently in the afternoon over warm land.

2. Orographic thunderstorms are caused by unstable moist air being lifted over the terrain. This type occurs on the windward side and near the top of mountains, is usually scattered, persists in the same location for some time and occurs during both day and night with greater frequency in the afternoon. Orographic thunderstorms in mountainous country are extremely hazardous to air flights because updrafts, downdrafts and excessive turbulence exist near the ground surface.

3. Nocturnal thunderstorms are quite frequent in the spring and fall of the year over land and are usually of the high level type. This type is thought to be released by the rapid cooling of the tops of clouds at night.

4. Convergence thunderstorms are very common in tropical regions often reaching to 40,000' in the convergence zone known as the equatorial front in the tropics. This type occurs in troughs in wind flow and where winds from different directions come together (as in the case of the equatorial front shown in diagram B). In both the trough and the equatorial front, inflowing air is piled up and forced upward, causing cooling and producing thunderstorms. This type of thunderstorm is very dangerous, being lined up for several hundred miles, occuring both day and night, giving large amounts of rain.

Wind Flow Patterns Giving Convergence Thunderstorms

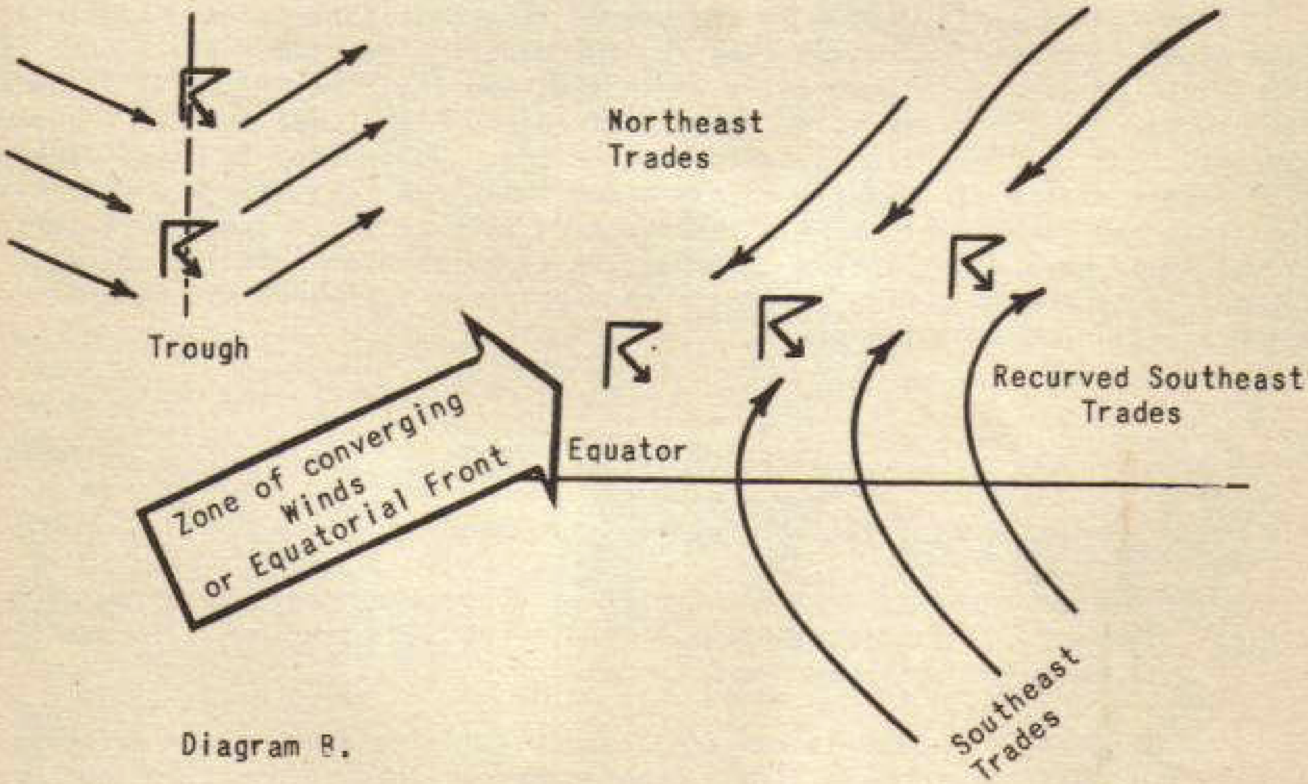


Diagram B.

Frontal Thunderstorms

1. Warm front thunderstorms are initiated by the upward thrusts of the air as it moves upslope over a warm front surface. Warm front thunderstorms vary much in intensity and extent depending on the amount of lifting of the warm moist air as well as the degree of instability of the air. On several occasions, a front several hundred miles long has become a solid thunderstorm 100 to 200 miles across. Turbulence within the thunderstorm exists only above the base of the cloud. Flight in the cold air underneath the base of the cumulonimbus cloud will usually be free from turbulence and usually free from icing in the summer.

2. Cold front thunderstorms are usually very severe. The sudden upward thrust of air over the steep cold front slope and the convergence in the warm air ahead of the front both add to the extreme severity of the cold front thunderstorm. When tornadoes occur, it is usually in conjunction with instability preceding a rapidly moving cold front. Often thunderstorms may extend 100 to 200 miles in the warm air ahead of the cold front.

NOTES

QUESTIONS

1. What are the five hazards connected with thunderstorms? (1) hail
(2) Turbulence (3) lightning
(4) icing (5) poor visibility

2. How can you detect when a swelling cumulus is approaching thunderstorm proportions? When it has an anvil top of cirrus

3. How high may cumulonimbus build? 40 000 ft.

4. During what time of year do most cumulonimbus occur? summer

5. During what time of day do most thermal (convective) thunderstorms occur?
afternoon

6. Indicate whether the following types of thunderstorms are usually isolated or connected in a line.

Thermal ______

Orographic ______

Convergence ______

Warm frontal ______

7. What type of precipitation accompanies thunderstorms? ______

8. Check the following types of thunderstorms that present extreme turbulence when flight beneath base is attempted.

Orographic ______

Warm front type ______

Cold or pre-cold front type ______

9. A trough in a wind flow pattern shows a clockwise or counter-clockwise wind shift? ______

10. The equatorial front is a zone of ______ winds. It is characterized by ascending or descending air? ______

Important features to notice in film MN 119C - Part 1. Note the conditions under which thunderstorms develop over land and water and the comparison of their violence with the seasons. Pay particular attention to the distinguishing features of a thunderstorm, its appearance from front and rear, its direction of movement, areas of severe turbulence, and appearance and location of the roll cloud. Note that the thunderstorm is a cloud factory in itself, producing layers of clouds that may hide the thunderstorm activity from the navigator.

NOTES

QUESTIONS

1. Is a thunderstorm over water more likely to occur when warm moist air moves over cold water surface or when cold moist air moves over warm water surface? ______________________________

2. During what time of day are thunderstorms over water most likely in summer? ______________________________

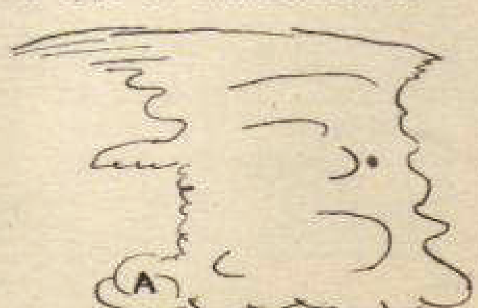
3. Are thermal afternoon thunderstorms over flat land usually isolated or lined up? ____________________ Should flight, as a rule, be attempted around, under, over or through this type of thunderstorm?

____

4. In the accompanying diagram, what is the direction of movement of the thunderstorm?

____

____



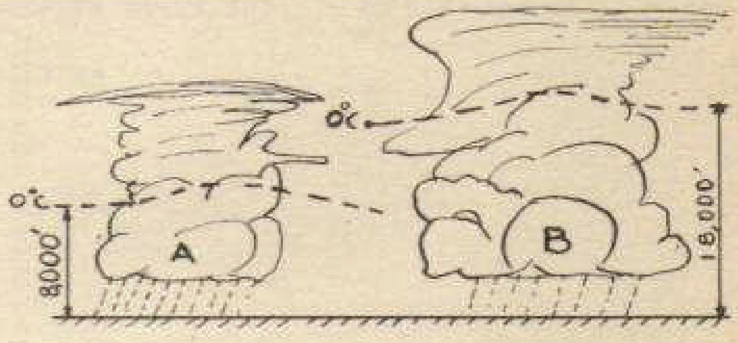
5. What is the name given to part A?____________________________

6. How may the intensity of vertical (cloud to ground) lightning be used in estimating regions of greatest activity?________________________

7. Considering the whole thunderstorm cloud, what part has least turbulence?

8. In the accompanying diagram, which thunderstorm is most typical of those experienced in the Southern United States in the summer?____________

   In the winter?____________

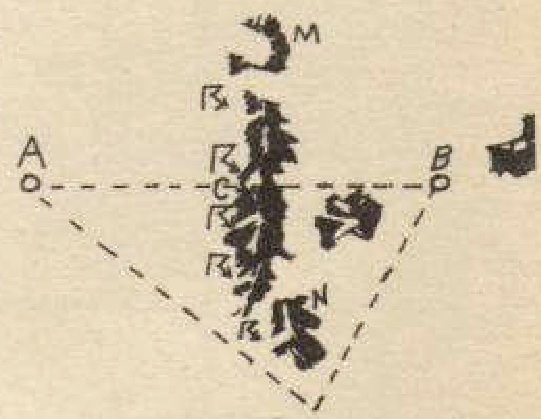


9. Which type is more violent?______

10. Why are thunderstorms less violent and less frequent in winter than in summer?________________________

11. A navigator approaching thunderstorm activity at night notices a large amount of vertical lightning from cloud to ground. Is he approaching the front or rear of the storm?____________ Is the storm at its peak of activity or is it worn out?____________

12. A flight is planned from an airfield A near the seashore to B in a valley on the other side of a mountain range. A group of thunderstorms is located in a line as shown. Why would it be better to fly around the end of range MN than across range at C?____________



13. On the diagram draw arrows showing most probable prevailing winds.

FLYING CONDITIONS IN THUNDERSTORM AREAS

Features of the Film MN 119C - Part 2. This film is designed to show the different methods of "flying thunderstorms". Although it might appear to be a pilot's problem, the navigator will find that he, too, can profit by knowing the accepted procedures of managing flight in the presence of cumulonimbus activity. Whether thunderstorms are flown around, under, over or through depends, among things, upon whether the thunderstorms are isolated or knitted together, the terrain under the cloud, the height of the base and tops, the urgency of the flight through the area, the type of plane, as well as the experience of the pilot. Watch the film to find what precautions are taken to maneuver the various types of thunderstorms.

NOTES

QUESTIONS

1. Why is flight over thunderstorms in the United States usually more advisable in winter than in summer? ____________________

2. Do thunderstorms usually reach greater heights over water or adjacent islands? ____________ Why? ____________________

3. Check the following types of thunderstorms that can usually be flown best by going around:

   Isolated air mass ____________

   On mountain peak ____________

   On warm front ____________

   Along a cold front in winter ____________

4. Check the following thunderstorms that can usually be flown under:

   Tall wall of thunderstorms on the sea ____________

   Thunderstorms at night that have cloud to cloud lightning ____________

   Orographic thunderstorms. ____________

5. Enter thunderstorms from the rear a ____________ level than from the front.

6. A large isolated thunderstorm with a roll cloud is approaching a landing field. Why would it be dangerous for a plane to land as the front edge of this storm is moving over the field? ____________________

7. In flying under the base of a thunderstorm whose base is 3000' above the level terrain, it is advisable to fly at what altitude above the ground? ____________________

8. In flying through the equatorial front, the orientation of the front should be determined either from the weather station or from observation upon approach. With the position of the front determined, at what angle is it advisable to encounter the front, assuming that it must be flown? ____________________

9. What hazard is often encountered when flight under an altostratus or altocumulus shelf of a thunderstorm is attempted? ____________________

The tropical cyclone is a storm which develops over tropical oceans having nearly circular isobars closely packed around an extremely low pressure area and very strong winds circulating in a cyclonic (counterclockwise in the northern hemisphere and clockwise in the southern hemisphere) direction. In the Gulf of Mexico, West Indies and off the west coast of Mexico, the tropical cyclone is called a "hurricane". In the Philippines and East Asia, the term "typhoon" is used, in the Arabian Sea and India, the word is "cyclone", and in Western Australia, they are called "willy-willies". They are all similar in structure, path and violence.

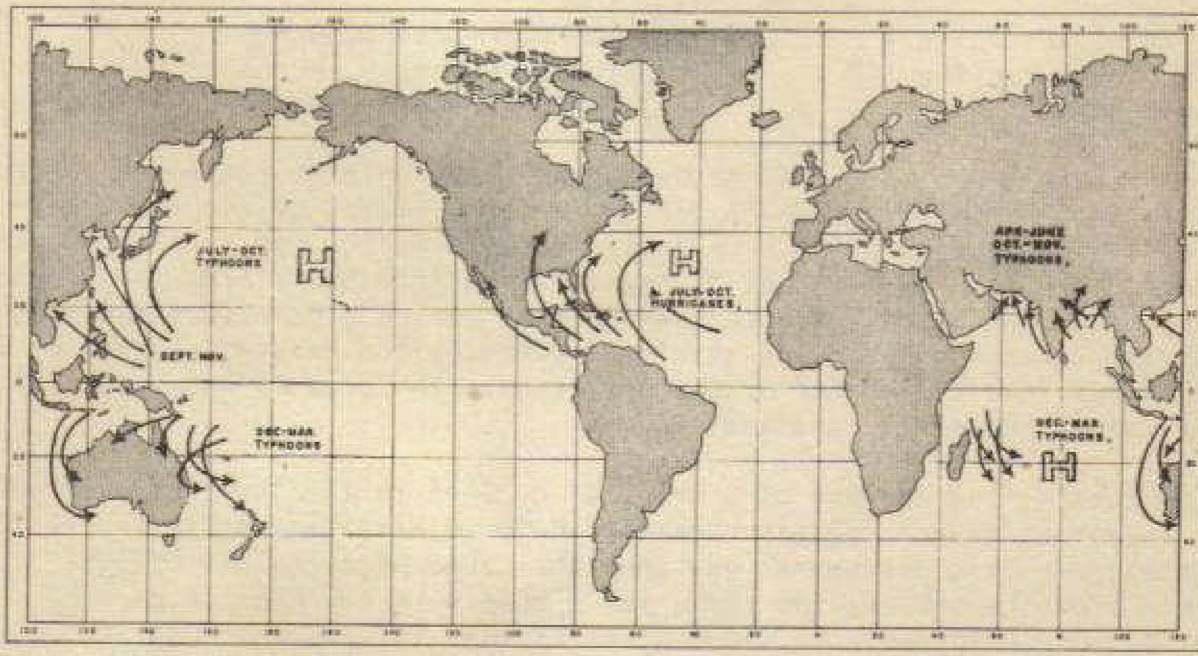


Diagram A.

Tropical cyclones, as seen from diagram A, originate over oceans on the equatorward and western side of semipermanent high pressure cells between 6°N and 20°N or 6°S and 20°S. General conditions necessary for the formation of a tropical cyclone include a widespread area of calm winds (doldrums) at least 6 to 10° from the equator, so that the trade winds from the other hemisphere may recurve ano converge with the prevailing trades. (Note diagram B, lesson 33.) Tropical cyclones usually form in conjunction with this equatorial front or line of convergence.

In their formative stage, the tropical cyclones in the northern hemisphere travel about 10 to 15 knots in a general east to west direction around the southwestern edge of the semipermanent high, cutting to the right at about 20° across the flow pattern at 10,000'. At about 25°N, these storms move more slowly and recurve to the north and northeast after which their speed usually increases to several hundred miles per day.

Time and Place of Maximum Frequency of Tropical Cyclones

Arabian Sea	July, October, November
Western Caribbean	October
Bay of Bengal	July, August, September, October
Western North Pacific	July, August, September, October
Eastern North Pacific	September, October
Atlantic (Cape Verde)	August, September

- - - - - - - - - -

Vicinity of Australia	January, February, March
Western South Pacific	January, February, March
Indian Ocean	January, February, March

A cross section of a typical hurricane shows a large region of ascending currents of warm moist air which produce a large amount of clouds, torrential downpours and winds reaching a velocity from 100 to 150 mph. Extremely low pressures have been observed at the center of a tropical storm, the lowest reading on record being 26.18 inches reported during a hurricane near the Philippine Islands in 1927. A shield of cirrus often extends as much as 600 to 800 miles from the center of the hurricane. The area of heavy rainfall is usually about 500 miles in diameter.

An interesting feature of a tropical cyclone is the "eye", a calm and clear region of descending air current, 10 to 20 miles across in the center of the storm. This phenomenon has been the cause of much loss of life because people are apt to believe the storm has passed. In the Florida Hurricane of 1935, the sudden increase in storm strength that follows the complete calm of the "eye" was responsible for the deaths of many people vacationing in that area.

The tremendous wind speeds produce waves on the sea that extend several hundred miles in front and to the right of the storm center moving roughly in the direction of travel of the storm. The frequency, direction and strength of these waves or swells are used to determine the path of the storm. Normal waves on the Gulf of Mexico number about 12 to 15 to the minute. A fully developed hurricane causes 4 or 5 swells per minute on shore at some distance from the storm center. Natives use the pitch of the beat of waves against the shore as a hurricane warning.

In the calm center, the wind velocity dies down but the inertia of the water causes a rough sea. The converging winds cause a large amount of water to be brought into the center from all sides - producing a higher level in the sea surface in the center than outside the storm. If the hurricane in diagram B moves left of land station A, the combined effect of high level of water within the storm and the strong winds will raise the water level at A producing a "tidal wave" effect.

Due to the relatively slow forward motion of a tropical cyclone, 10 to 15 knots, no sane navigator will ever get caught in such a storm. However, the winds of the outer portion of the storm may be used to increase ground speed on long flights. Due to the sharp curvature and resultant change of wind direction, the navigator must be on the alert, when using such winds or he may wake up 50 miles off course.

Signs of the Approach of a Tropical Cyclone:

1. A high sea, which may precede destructive winds by several hours.

2. (a) Cirrus and Cirrostratus - clouds which may extend far out ahead of the storm.
   (b) The cloud phenomenon to be on the lookout for is an area of dense clouds which are the body of the hurricane. If this area of dense clouds seems to be advancing head-on, it means that you are heading directly into the center of the storm. A change of course to the right will take you away from the center of the danger zone and will give you tail winds (northern hemisphere).

3. Wind increasing in velocity.

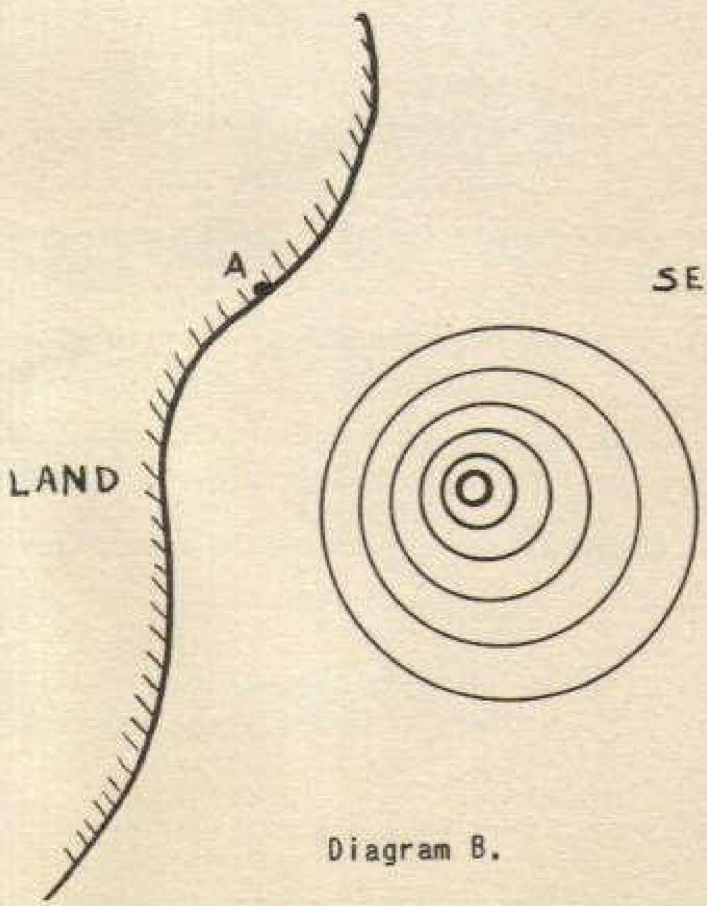
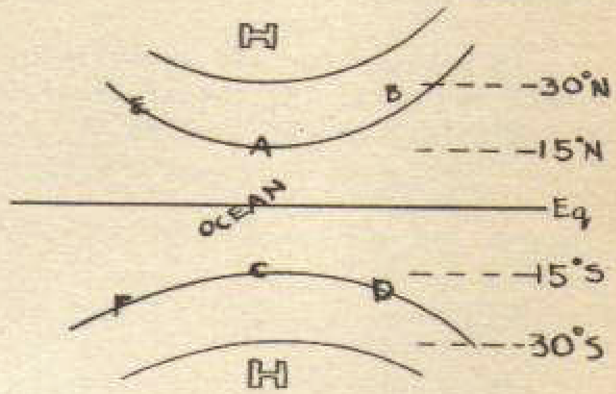


Diagram B.

QUESTIONS

1. The wind circulation around a tropical cyclone is in what direction in the northern hemisphere?__________ In the southern hemisphere? __________



2. Are hurricanes more likely to occur at A or B?__________

3. Are hurricanes more likely to occur at C or D?__________

4. Which of the following months has the greatest frequency of tropical storms as observed at E: January, April or September?__________

5. Which of the following months has the greatest frequency of tropical storms as observed at F: January, April or September? __________

6. Is A located in a belt of easterlies or in a belt of westerlies?__________

7. Is C located in a belt of easterlies or in a belt of westerlies?__________

8. What is the average speed of tropical storms while travelling in the belt of easterlies?__________

9. How can the winds aloft be used to forecast the direction of movement of tropical storms?__________

10. The eye of a hurricane is a region of __________ air currents.

11. What type of weather conditions follow the passage of the eye of a hurricane?__________

12. How can the pitch of sea swells along the seashore cliffs be used to forecast the approach of tropical storms? __________

13. What range of wind velocities are experienced near the center of a well-developed hurricane? __________

PROBLEM

The student will fly from Knoxville, Tennessee to Fort Worth, Texas. He will fill out the first page of the log and answer certain questions. Such answers as do not fit on the first page of the log will be neatly written on the back thereof.

As a basis for his analysis of the weather, the student is provided the latest two maps, the latest pibals, some recent temperature charts and some of the latest hourly reports.

NOTES

NOTES

1. What pressure centers (highs and lows) are in control of your route?
   HIGHS AND LOWS
2. In what air masses will your flight be made? mPw ; mTk ; cPk
   What are the characteristics of these air masses?
3. What fronts lie on your route, or will move across your route?
   Cold and warm
4. How fast are the various fronts moving? 36 K/hr
5. Will the fronts accelerate or decelerate during your mission? decelerate
6. In which direction are the various fronts moving? EASTWARD

7. Is the activity connected with each front ahead or behind the front, and will it stay that way? On both sides (BEHIND THE COLD FRONT) (AHEAD OF WARM FRONT)

8. Will the fronts become more or less active? less active

9. How high does activity extend? 6000

10. Which way and how much do the fronts slope? 1/365

11. What windshift is connected with each of the fronts? BACKING WITH WARM FRONT VEERING WITH COLD FRONT

12. Note the type and amount of clouds reported along your route. How may these be expected to change while you are in the air? CUMULUS

13. What are the ceilings along your route and what changes do you expect?
500 TO 1500

14. What is the visibility and how will it change? It will change from 3 to 7 miles [illegible]
What will restrict visibility? Rain, fog & smoke

15. Check the temperature-dew point spread along your route and in the approaching air.

16. Will smoke over the destination interfere with the successful completion of the mission? No

17. Will there be precipitation? Yes

18. What are the chances of thunderstorms? Yes

19. What will be the surface wind wherever you might make a forced landing?

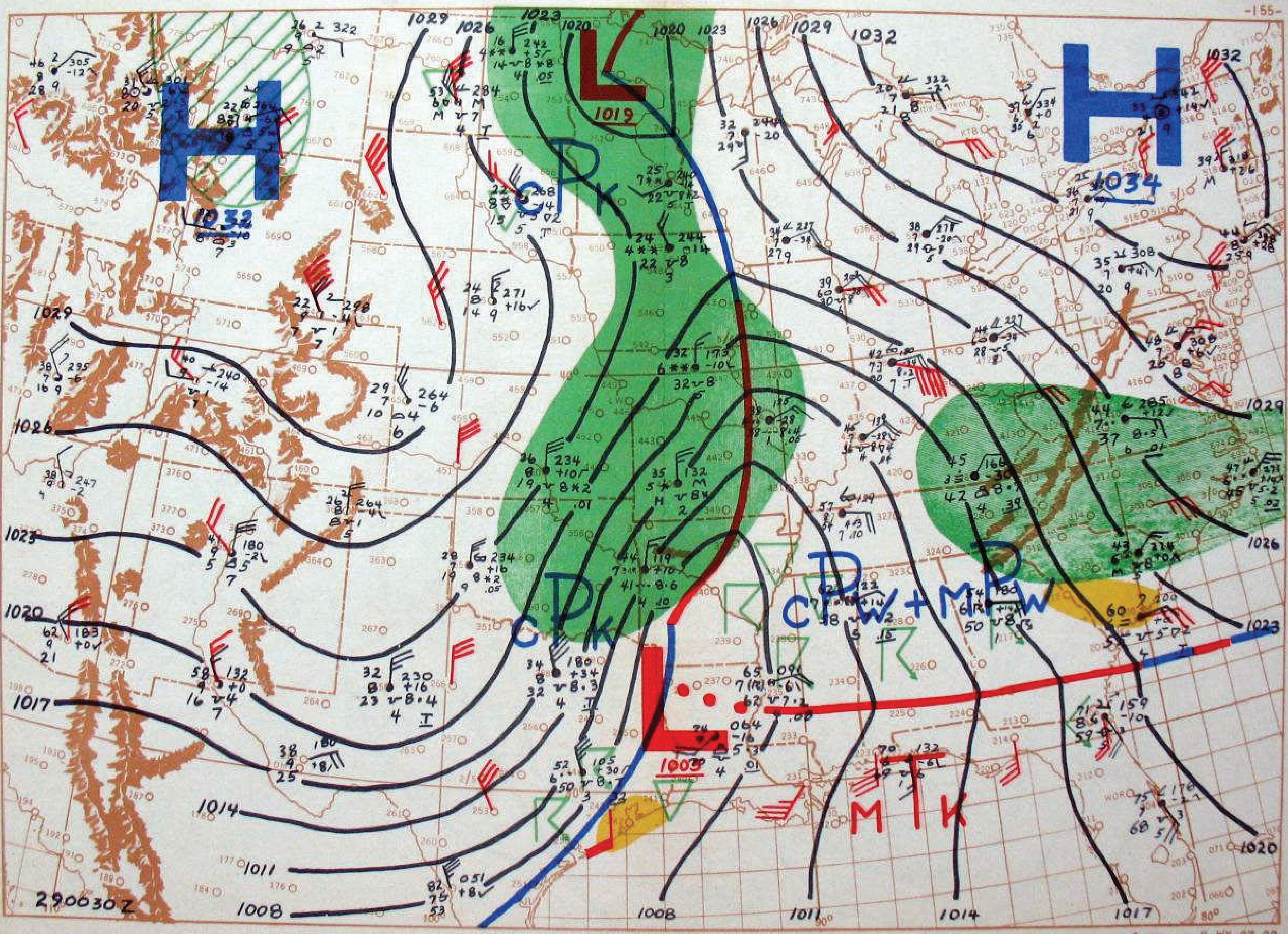
20. What are the winds at possible flight levels?
How will they change?

21. How much turbulence is expected?

22. How are the air masses being modified?

23. Do you know of any local or terrain effects that might be important?
Wind shift west of the Mississippi

24. What altimeter setting are you going to use? 29.80 to T.P.
Will you change it during flight? T.P. to dest 30.30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H
1034
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1019
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1005
cPk
cPk
cPw+mPw
mTk
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1008
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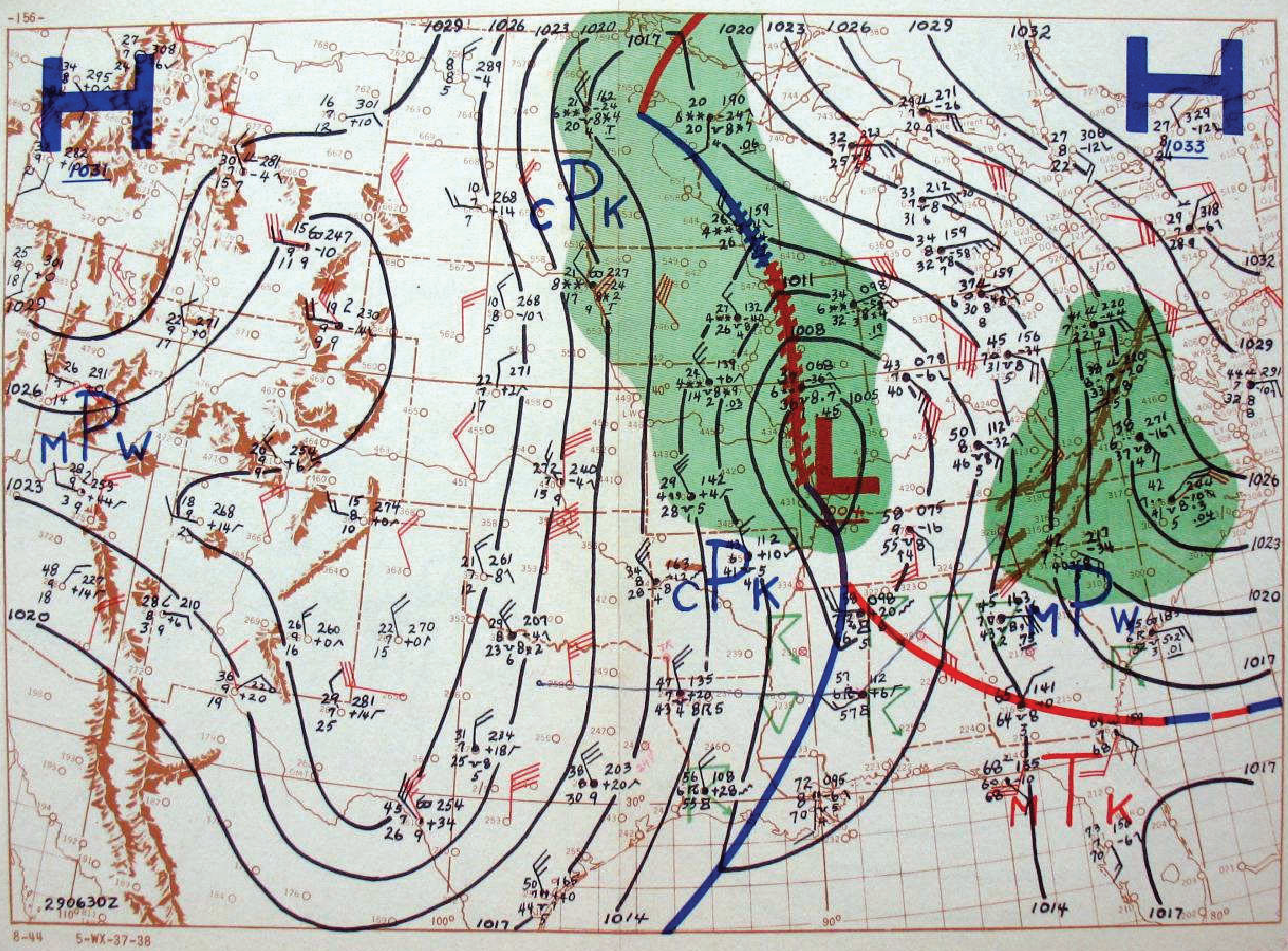
8-44
4-WX-37-38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mTK
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1008
1005
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1017
1014
1017
1031
1033
2906302
8-44
5-WX-37-38

1432

F - 1432

SC 290730E
LB N W5⊕3R-F- 244/35/35↙18E/023
KX C 15⊕⊕3TR-K- 159/48/47→15/999/ T MOVG NE E50⊕
NGU M5⊕⊕1R-F- 240/44/44←↙27+/025
PHA SPL E10⊕3R-F- 207/57/57←↖17/014
DIL SPL E6⊕1R-F- 173/60/60↙16-/002
CS N SPL E6⊕/⌽4GF-K- 149/53/53↓8/996
JX C ⌽6K- 147/68/67↑↖5/995
GC X SPL W5⊕5L-F- 183/41/40↘18/005
NA SPL ⊕/6⌽ 058/56/53↖22/968

FV C 60⌽ 257/29/20↘25-/030
AG X W3⊕13/4RF- 176/44/43↓13/004/OCNL LTNG S
TJ X SPL W3⊕3F-K- 122/70/70↑↖7/988
DXW E30⊕2R-F- 119/59/58←↙11/988/BRONO
BH N E8⊕7R- 119/55/54↑↖11/987
PS C SPL M14⊕6L- 125/43/38→↘21+/990
GD N W5⊕1L-F- 119/49/47→↘25+/987/RANDI
NO C SPL M24⊕RW- 095/66/64↓↘16/980/BINOVC OCNL LTNG
TTV 45⊕ 213/34/28↓↘21/005/BINOVC
ZH C M20⊕ 196/39/32↘24/010
UO U QRYXRUXREHGQTXOOT
UM C SPL E10⊕7TR- 095/59/58↑↖10/980/TSTM OVHD
NAS W4⊕4H 105/70/69↑↗16/983/CIG RGD

CG X E4⊕1/2L-FK- 010/36/36↑2/954
TPI E12⊕4F- 051/30/30→23+/965
LS N M6⊕ 112/30/26↘26+/983
KC C ⌽/ 193/21/14↘13/006
AF E12⊕ 112/38/35→↘13/985
ZF M25⊕⌽8 176/24/20→↘14/000/E65⊕
TS C O 237/25/20↘10/020
TR M22⊕ 196/36/29↓↘13/010
LI C M18⊕ 156/40/33→↘19+/998
DKX E7⊕2R-K- 068/54/53↑8/971/PCPN INTMT
TH M8⊕5H 041/42/40→↗13/963

NAS SPL 290650C E10⊕⌽3H 105/70/69↑↗16/983/E70⌽ SCUD 3 HND

NT SPL 290648C ⊕/E- 220/37/31↓↘27+/018

LN O 220/16/11↘14/011
WD C -⌽/7 234/20/14↘9/015/SMK LYRS ALF
TWY O 251/18/14↑9/020
OL C O 251/22/13→↘10/021
AT O 254/27/18↓↘11/024
AP C O 271/25/18↘12/029

SC 290730E
BZ C O 288/20/17→↘3/030
WP O 278/19/17↘6/030
DHH O 257/19/15→↗7/021
DEH O 247/22/15↗7/025
AQ C O 254/16/12→↘6/017
WF C O 271/25/20→↘10/028
WC C ⦶/ 244/34/18↓↘25+/024
CR C E60⊕8 217/45/39↓↘29+/016
LC C SPL M15⊕7 152/47/42↓↘23/997
DLX W16⊕6H 163/47/43→↘17/000
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HU C M20⊕/⦶R- 196/40/34↘20+/010/R- INTMT
DHN -⦶/ 237/37/27↓12/023
DMS ⊕/ 230/38/27→↘28+/020

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OH C O 183/17/13→↘15/002
AB C O 230/25/3↓↘4/020
EO C O 227/27/15←5/023
DV C ⊕/80⦶ 196/26/7→17/001/BINOVC
LQ C O 257/36/15↙1/029

CG N SPL 290756C E5⊕1F-K- 010/36/36↗17/956/CIG RGD

LS N SPL 290814C E9⊕S- 139/30/24↘24+/991

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NGU SPL P5⊕21/2R-F- 230/44/44←25/022/ 812
PHA E5⊕1R-F- 203/62/62←↖3-------- 5002 46
DIL SPL E5⊕11/2R-F- 169/61/61↓↙10/002/ 70308 5001
CS X M3⊕4F-K- 149/53/53↙3/996
JX C ⦶/7 156/69/67↑5/998/K LYRS ALF/ 401 0304 67

FV C 60⦶ 257/29/19↘20/030/ 105 0409 29
AG X W3⊕11/2RF- 190/44/42↓6/008/ 42442 5008 44
TJ X SPL W4⊕4K- 125/71/70↑↖12/989/HIR CLDS VSBL THRU BINOVC/
20599 5004 67

DXW SPL E15⊕1R-F- 122/59/58↓↙15/989/BRONO/ ONE 20824 5001
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PS C E15⊕6L-K- 139/42/37↘24+/994/L- INTMT/ 42099 5007 42

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TTV E45⊕/⊕ 234/33/27↘18/021/BINOVC 8⊕ BRM RSG RPDLY/ 418 5369
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CR C SPL 290755C E40⊕ 240/40/40↓↘25/023

TTV SPL 290800C ⊕/ 237/33/27↓↘16/022

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TWY O 237/20/14→↗4/017/ 604 18
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AT O 254/27/18↓↘8/024/ 109 26
AP C O 274/25/16→↘9/030/ 300 24
WP O 284/17/15↗3/031/ 400 17
DHH O 264/18/14→↗5/022/ 502 94905 18
DEH O 251/22/15↗7/023/ 807
AQ C O 257/14/10→8/017/K ALF K LYRS ALL QUADS/ 605 94804 14
WF C O 261/25/20→7/026/ 103 25
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DMS ⦶/ 240/38/26↓↘30+/023/ 214 0703

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UM C SPL 290806C E10⊕3L- 108/58/58↗5/984

AQ C SPL 290800C O8 257/14/10→9/017/K LYRS SW VSBY 4

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EO10 01311 0606 60314 0222 83419 3020 03220 3316 23118 3022 43032
BZ10 03106 0112 40322 3426 63524 3430 83333 3340 03332 3240 23440
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CR NGP10 PIWI
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PS10 PICO
NO10 PIRA
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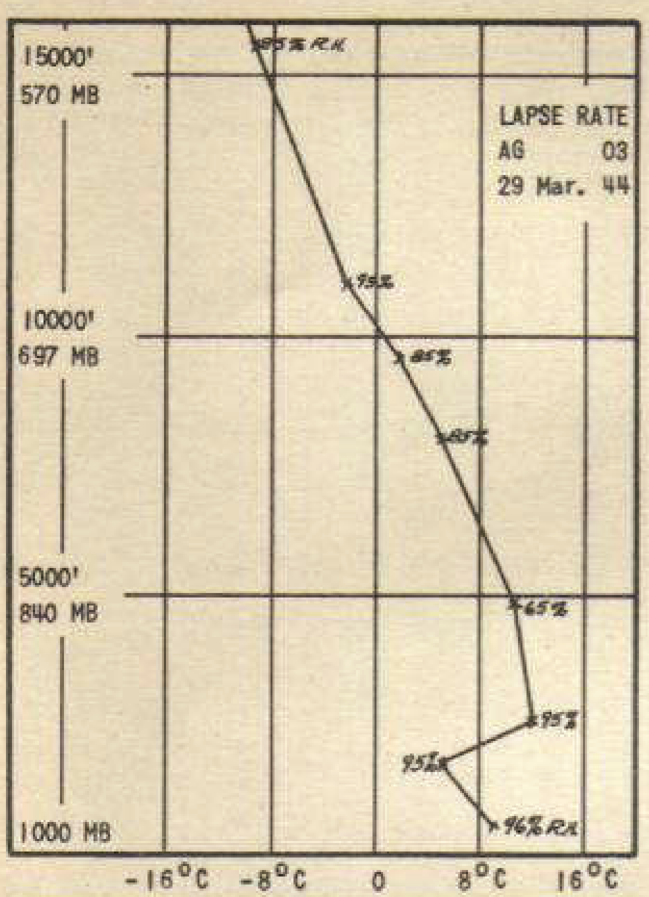
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570 MB
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LAPSE RATE
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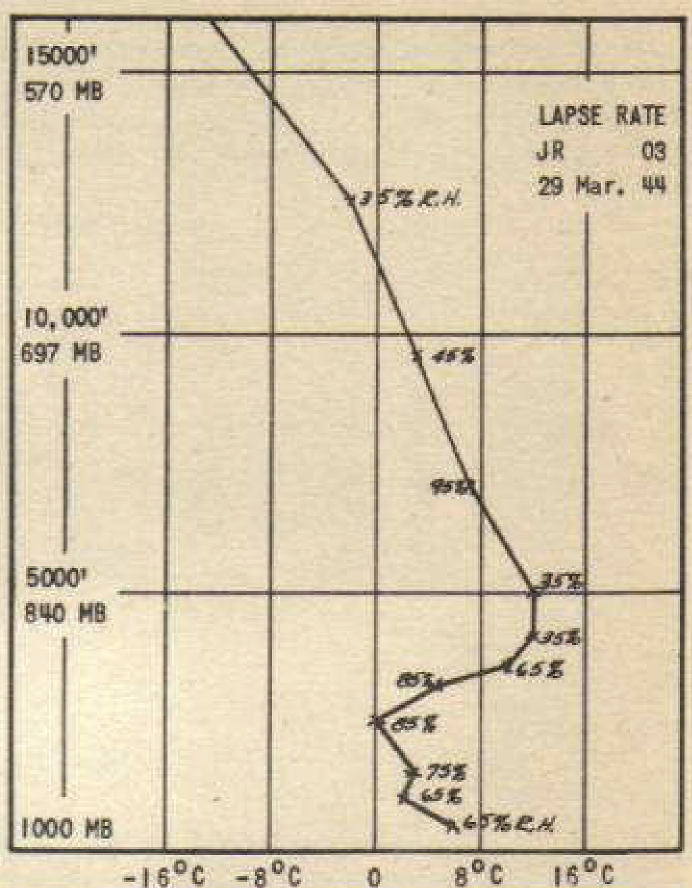
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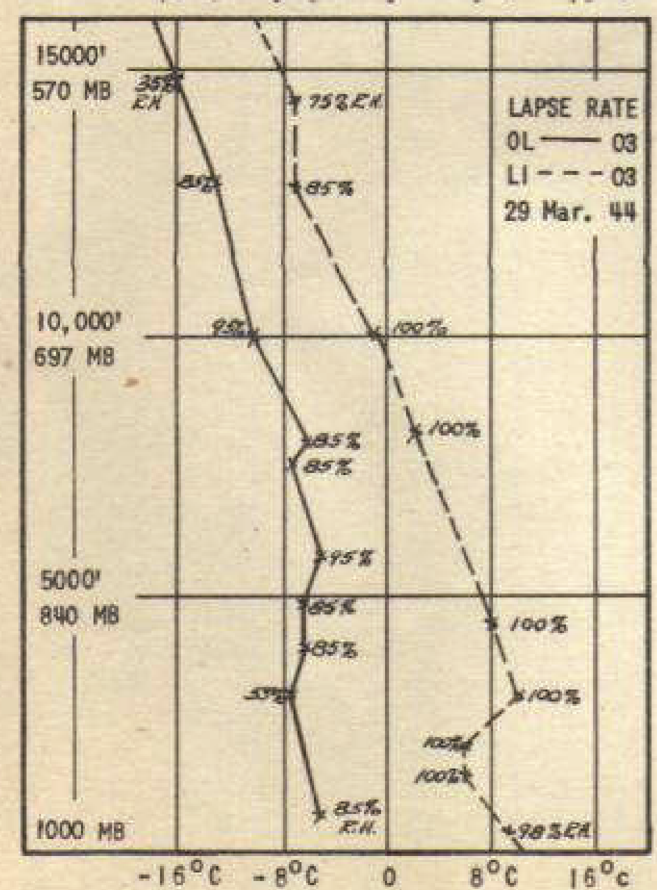
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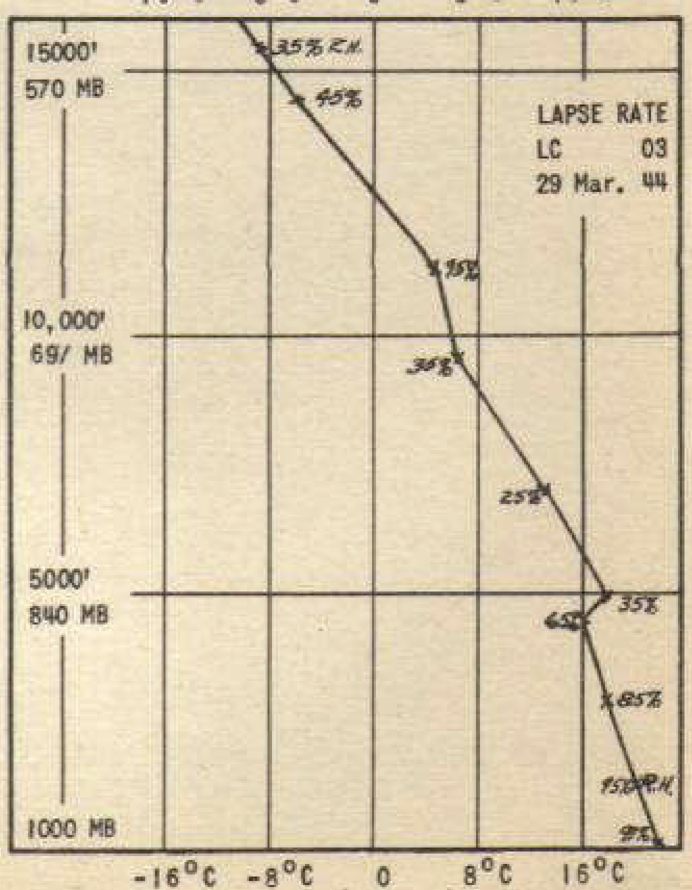
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SUMMARIZATION PERIOD

An attempt should be made to fit together all ideas studied and to seek clarification of ideas still hazy in meaning. The purpose of this period is to assist the student in this clarification of ideas. The following questions will also assist the student to do this.

NOTES

QUESTIONS

1. In what ways does icing affect a plane?

2. What conditions are necessary for the formation of ice?

3. Why is icing a greater problem in the United States in winter than in summer?

4. How does the icing hazard vary in stratiform and cumuliform clouds of the same temperature?

5. What charts obtained from the weather stations most conveniently show where icing will be encountered in flight?

6. In flight, the pilot realizes that his plane is picking up ice too quickly. Why is the knowledge of the existing temperature lapse rate and frontal positions important when deciding how to change flight level?

7. For radiation, advection, upslope, steam and frontal fog, summarize the following:
   (a) conditions favoring formation
   (b) how formed
   (c) ideal wind velocities
   (d) time of day
   (e) time of year of greatest frequency
   (f) where
   (g) how dissipated

8. Is fog more common in "w" or "k" air mass?

9. Why is fog more commonly associated with warm than cold fronts?

10. A sharp contrast of surface water temperatures is observed in the North Atlantic where the warm Gulf Stream and the cold Labrador currents are near each other. When the winds blow 10 mph from warm to cold water, what type of weather would be expected over the cold water? If the winds blow 10 mph from cold to warm water, what type weather would be expected over the warm water?

11. What procedure is recommended when flying to an airport where conditions are favorable for fog formation?

12. In respect to the thermal, orographic, nocturnal, convergence and frontal thunderstorms, review the following aspects:
    (a) How is the unstable air lifted to produce the thunderstorms?
    ____
    (b) What time of day is the greatest number observed? ______________
    (c) What conditions favor the development of each? ______________
    (d) How can each be best flown? ______________
    (e) Are they usually isolated or connected? ______________

13. How do winter thunderstorms differ from those occuring in summer? ________
    ____

14. While in flight, how does one go about determining:
    (a) the intensity of thunderstorm activity? ______________
    (b) the type of thunderstorm? ______________
    (c) whether the thunderstorm will permit travel under the base? ________
    (d) areas of least intensity? ______________
    (e) whether icing would be encountered? ______________
    (f) whether flight through the thunderstorm should be attempted? ________
    ____

15. Where are tropical cyclones most frequently found? ______________

16. What is the direction and speed of movement of tropical storms? ________
    ____

17. Describe the typical cloud pattern, rain areas, winds and temperatures that accompany the passage of a hurricane over an island air base.

SURFACE WEATHER OBSERVATIONS

Date, time	Clouds	Vsby	Weather and Obstn to Vision	Remarks

PARTIAL LIST OF STATION IDENTIFICATION LETTERS

	NUM	STATION	LATD	LNGD	ALT
AB	365	Albuquerque, N. Mex.	35-03	106-37	5314
AF	431	Advance, Mo.	37-04	89-55	359
AG	219	Atlanta, Ga.	33-39	84-25	976
AP	266	Abilene, Tex.	32-26	99-41	1750
AQ	363	Amarillo, Tex.	35-15	101-44	3604
AT	350	Ardmore, Okla.	34-19	97-09	866
AY		Anthony, Kans.	37-12	98-05	
AZ	518	Albany, N.Y.	42-45	73-48	292
BH	228	Birmingham, Ala.	33-34	86-45	630
BU	288	Burbank, Calif.	34-12	118-22	725
BW	509	Boston, Mass.	42-22	71-02	29
BZ	265	Big Spring, Tex.	32-14	101-30	2537
CA	445	Columbia, Mo.	38-57	92-20	785
CG	534	Chicago, Ill.	41-47	87-44	623
CJ		Cochise, N.M.	32-02	109-53	4260
CO	428	Columbus, Ohio	40-00	82-53	833
CR	251	Corpus Christi, Tex.	27-45	97-25	44
CS	208	Charleston, S.C.	32-34	80-02	48
CY		Cassoday, Kans.	38-02	96-38	
DAO		Altus, Okla.	34-36	99-17	1350
DBY		Barksdale Fld, La.	32-31	93-40	165
DEH	268	Roswell, N. Mex.	33-24	104-27	3566
DGM		Greenville, Miss.	33-22	91-00	128
DHH	267	Lubbock, Tex.	33-38	101-49	3241
DHN		Hondo, Tex.	29-25	99-15	918
DIL	301	Wilmington, N.C.	34-14	77-57	72
DIP		San Angelo, Tex.	31-20	100-33	1901
DJR		Baton Rouge, La.	30-33	91-12	62
DKX		Fort Knox, Ky.	37-55	85-58	732
DL	258	Dallas, Tex.	32-51	96-52	488
DLX	246	Alexandria, La.	31-18	92-27	84
DM	546	Des Moines, Iowa	41-32	93-39	963
DMS		San Marcos, Tex.	29-58	97-52	584
DMT	262	Marfa, Tex.	30-16	103-54	4854
DMZ		March Fld, Calif.	33-55	117-16	1528
DN		Salt Flat, Tex.	31-47	105-05	3710
DND		Enid, Okla.	36-23	97-52	1287
DOI		Indio, Calif.	33-41	116-10	
DON		Sloan Fld., Tex.	31-56	102-12	2856
DOX		Biloxi, Miss.	30-27	88-54	21
DRD	261	Del Rio, Tex.	29-20	100-53	960
DRL		De Ridder, La.	30-47	93-17	193
DRQ		Randolph Fld, Tex.	29-32	98-17	752
DV	469	Denver, Col.	39-46	104-53	5299
DVF		Victoria, Tex.	28-50	96-59	104
DWR		Walnut Ridge, Ark.	36-04	90-56	270
DXW		Maxwell Fld., Ala.	32-23	86-24	165
EB	782	Ellensburg, Wash.	47-02	120-31	1735
EF	436	Effingham, Ill.	39-09	88-33	614
EO	270	El Paso, Tex.	31-48	106-24	3916
EX	275	Engle, N. Mex.	33-12	107-02	4779
FE		Frontenac, Minn.	44-30	92-21	775
FO	753	Fargo, N. Dak.	46-54	96-48	899
FV	259	Fort Worth, Tex.	32-49	97-21	706
GC	312	Greenville, S.C.	34-50	82-24	1040
GD	238	Greenwood, Miss.	33-30	90-11	133
GE		Gainsville, Tex.	33-40	97-08	833
GS	242	Galveston, Tex.	29-16	94-52	9
HBI	505	Block Island, R.I.	41-10	71-36	26
HN		Hutchinson, Kans.	38-01	97-52	1516
HR	654	Huron, S. Dak.	44-21	98-14	1289
HU	243	Houston, Tex.	29-39	95-17	62
HV		Harpersville, Tex.	32-37	98-53	1396
IX	543	Iowa City, Iowa	41-38	91-34	653
JA	235	Jackson, Miss.	32-20	90-13	330
JI	250	Brownsville, Tex.	25-55	97-28	18
JM	754	Jamestown, N. Dak.	46-56	98-40	1494
JR	253	San Antonio, Tex.	29-27	98-28	582
JU		Beaumont, Tex.	30-04	94-16	32
JX	206	Jacksonville, Fla.	30-25	81-39	31
KC	446	Kansas City, Mo.	39-05	94-37	750
KN	414	Charleston, W. Va.	38-23	81-46	606
KS		Columbus, N.M.	31-49	107-35	4025
KX	326	Knoxville, Tenn.	35-49	83-59	980
LB	410	Lynchburg, Va.	37-20	79-12	937
LC	240	Lake Charles, La.	30-13	93-09	32
LE	643	La Crosse, Wis.	43-56	91-17	672
LG		LaGuardia Fld., N.Y.	40-44	73-55	12
LI	340	Little Rock, Ark.	34-45	92-16	265
LK		Lone Rock, Wis.	43-13	90-11	713
LN	452	Lebo, Kans.	38-26	95-47	1164
LQ	386	Las Vegas, Nev.	36-14	115-02	1869
LS	434	St. Louis, Mo.	38-45	90-23	564
LV	423	Louisville, Ky.	38-13	85-40	545
MK	640	Milwaukee, Wis.	42-57	87-54	698

PARTIAL LIST OF STATION IDENTIFICATION LETTERS (Cont'd)

	NUM	STATION	LATD	LNGD	ALT
MM	202	Miami, Fla.	25-55	80-17	12
MN	784	Mullen Pass, Idaho	47-27	115-41	6037
MP	658	Minneapolis, Minn.	44-53	93-13	720
MS	223	Mobile, Ala.	30-38	88-04	31
MX	773	Missoula, Mont.	46-52	114-00	3189
NA	327	Nashville, Tenn.	36-07	86-41	605
NAS	222	Pensacola, Fla.	30-21	87-16	90
NGU	308	Norfolk, Va.	36-53	76-12	30
NK	502	Newark, N.J.	40-42	74-10	30
NO	231	New Orleans, La.	30-02	90-04	30
NT	244	Navasota, Tex.	30-24	96-04	337
NTP	699	Tongue Point, Oreg.	46-12	123-57	
OA	493	Oakland, Calif.	37-44	122-12	7
OD	451	Dodge City, Kans.	37-45	100-00	2509
OH	553	Omaha, Nebr.	41-18	95-54	982
OL	353	Oklahoma City, Okla.	35-34	97-36	1304
OM		Vichy, Mo.	38-06	91-44	1120
PC	357	Ponca City, Okla.	36-46	97-06	998
PD	698	Portland, Oreg.	45-36	122-36	39
PDR	261	Del Rio, Tex.	29-20	100-53	960
PES	395	Estero, Calif.	35-26	120-52	6
PH	278	Phoenix, Ariz.	33-26	112-03	1112
PHA	304	Hatteras, N.C.	35-15	75-40	11
PKA	779	Kalispell, Mont.	48-10	114-25	2984
PO	688	Pendleton, Oreg.	45-41	118-51	1495
PS	334	Memphis, Tenn.	35-03	89-59	284
PU	464	Pueblo, Col.	38-16	104-36	4805
PW	606	Portland, Me.	43-39	70-15	103
RD		Rockford, Ill.	42-20	89-05	730
RH	272	Rodeo, N. Mex.	31-56	109-00	4126
RP	488	Reno, Nev.	39-30	119-47	4400
RR	644	Rochester, Minn.	44-00	92-29	1021
RT	574	Rock Springs, Wyo.	41-37	109-13	6374
SA	793	Seattle, Wash.	47-32	122-16	30
SF	494	San Francisco, Calif.	37-37	122-23	18
SM	785	Spokane, Wash.	47-40	117-20	1968
TH	437	Terre Haute, Ind.	39-29	87-24	485
THJ	268	Roswell, N. Mex.	33-24	104-27	3566
TJ	214	Tallahassee, Fla.	30-27	84-20	68
TJW		Brinkley, Ark.	34-54	91-12	
TJZ		Pampa, Tex.	35-34	100-47	3130
TNV	504	New Haven, Conn.	41-16	72-54	13

	NUM	STATION	LATD	LNGD	ALT
TOY	792	Olympia, Wash.	46-58	122-53	200
TPI	532	Peoria, Ill.	40-43	89-36	662
TR		Texarkana, Ark.	33-29	94-01	360
TS	356	Tulsa, Okla.	36-11	95-54	674
TTV		Tyler, Tex.	32-22	95-25	544
TU		Tuscaloosa, Ala.	33-11	87-35	
TUT		Beaumont, Calif.	33-56	116-58	
TWY	358	Waynoka, Okla.	36-38	98-50	1533
TY	233	Tylertown, Miss.	31-03	90-03	395
TZ	274	Tucson, Ariz.	32-07	110-55	2555
TZB	383	Sandberg, Calif.	34-45	118-44	4523
UG		Lafayette, La.	30-12	92-00	40
UM	234	Meridian, Miss.	32-21	88-40	375
UO	237	Monroe, La.	32-32	92-04	77
UX	255	Palacios, Tex.	28-45	96-17	15
VM		Gage, Okla.	36-19	99-44	2198
VS	236	Vicksburg, Miss.	32-24	90-48	263
WA	405	Washington, D.C.	38-52	77-03	15
WC	256	Waco, Tex.	31-33	97-06	578
WD	450	Wichita, Kans.	37-38	97-17	1392
WF	351	Wichita Falls, Tex.	33-54	98-31	1030
WP	264	Wink, Tex.	31-47	103-13	2813
XN	254	Austin, Tex.	30-19	97-42	621
YA	781	Yakima, Wash.	46-36	120-30	1076
YK		Yoakum, Tex.	29-16	97-14	387
ZF	440	Springfield, Mo.	37-13	93-15	1360
ZH	248	Shreveport, La.	32-33	93-46	181
ZO	240	Sulphur Springs, Tex.	33-10	95-36	488

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