NAVAL STATION NEWPORT, R.I.

LOCAL AREA
FORECASTER'S HANDBOOK

Prepared For:
COMANDER,
NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND
STENNIS SPACE CENTER, MS 39529-5000

Prepared By:
NAVAL TRAINING METEOROLOGICAL
AND OCEANOGRAPHY DETACHMENT
NEWPORT, RI 02841-1207

NAVTRAMETOCDETNPTINST 3140.2B
05 June 2000

NAVTRAMETOC DET NEWPORT INSTRUCTION 3140.2B

Subj: THE NAVAL TRAINING METEOROLOGY AND OCEANOGRAPHY DETACHMENT NEWPORT, RHODE ISLAND LOCAL AREA FORECASTER'S HANDBOOK

Ref: (a) NAVMETOCCOMINST 3140.2E

1. Purpose. To promulgate the Naval Training Meteorology and Oceanography Detachment, Newport RI, local area forecaster's handbook. in accordance with the provisions of reference (a).

2. Cancellation. NAVTRAMETOCDETNPTINST 3140.2A

3. Discussion. The enclosed handbook is intended to provide command forecasters with an effective guide to Newport area meteorological and oceanographic phenomena and time-tested local prediction techniques.

4. Action. NAVTRAMETOC DET Newport forecasters will be cognizant of the information contained within this instruction and apply this guidance in carrying out their duties. The demonstrated knowledge of this handbook's contents is a prerequisite to local accreditation and a Forecast Duty Officer.

B. H. WEBB

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LOCAL AREA FORECASTER'S HANDBOOK

FOR

NAVAL TRAINING METEOROLOGY AND OCEANOGRAPHY DETACHMENT

NEWPORT, RHODE ISLAND

NAVAL TRAINING METEOROLOGY AND OCEANOGRAPHY DETACHMENT

686 CUSHING ROAD

NEWPORT, RHODE ISLAND 02841-1207

RECORD OF CHANGES

Change Number	**Date of Change**	**Date Entered**	**Entered By**

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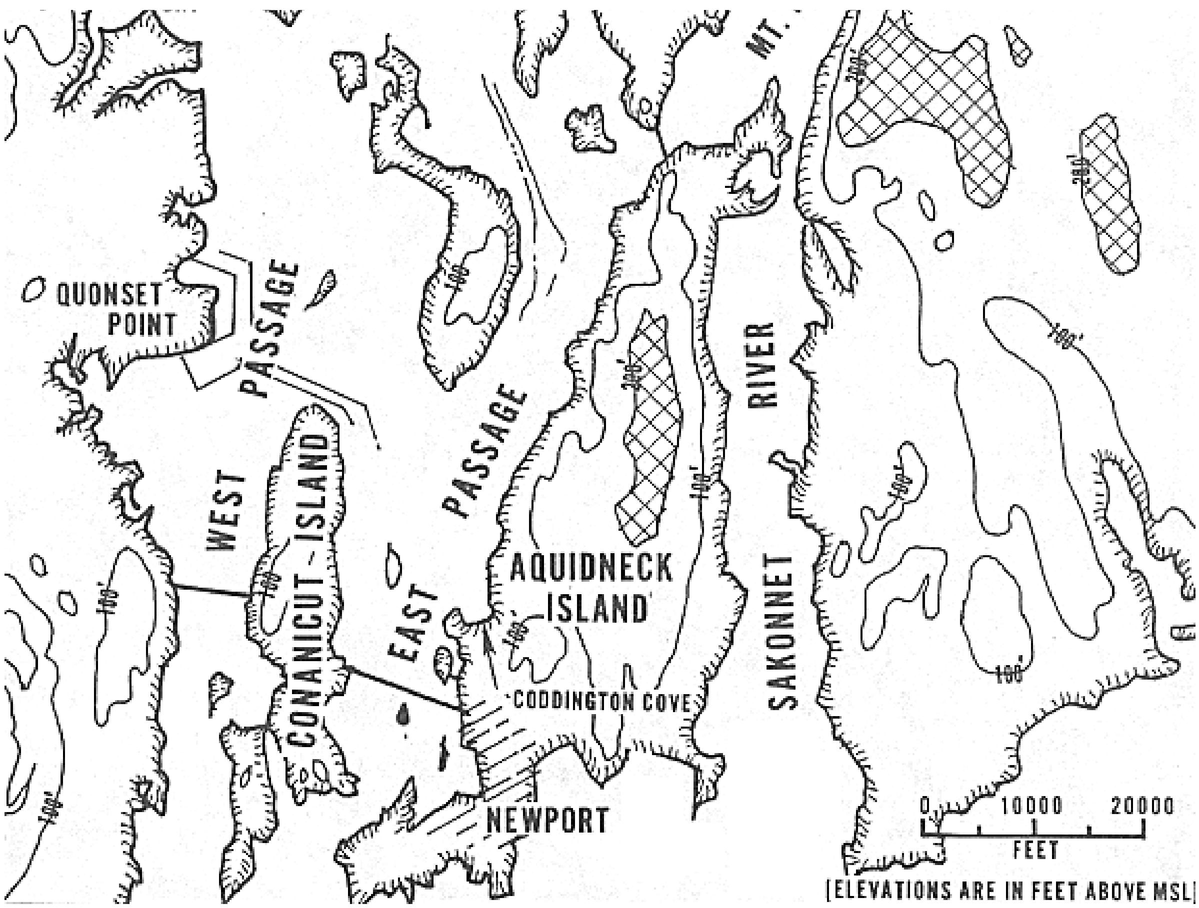
SECTION I

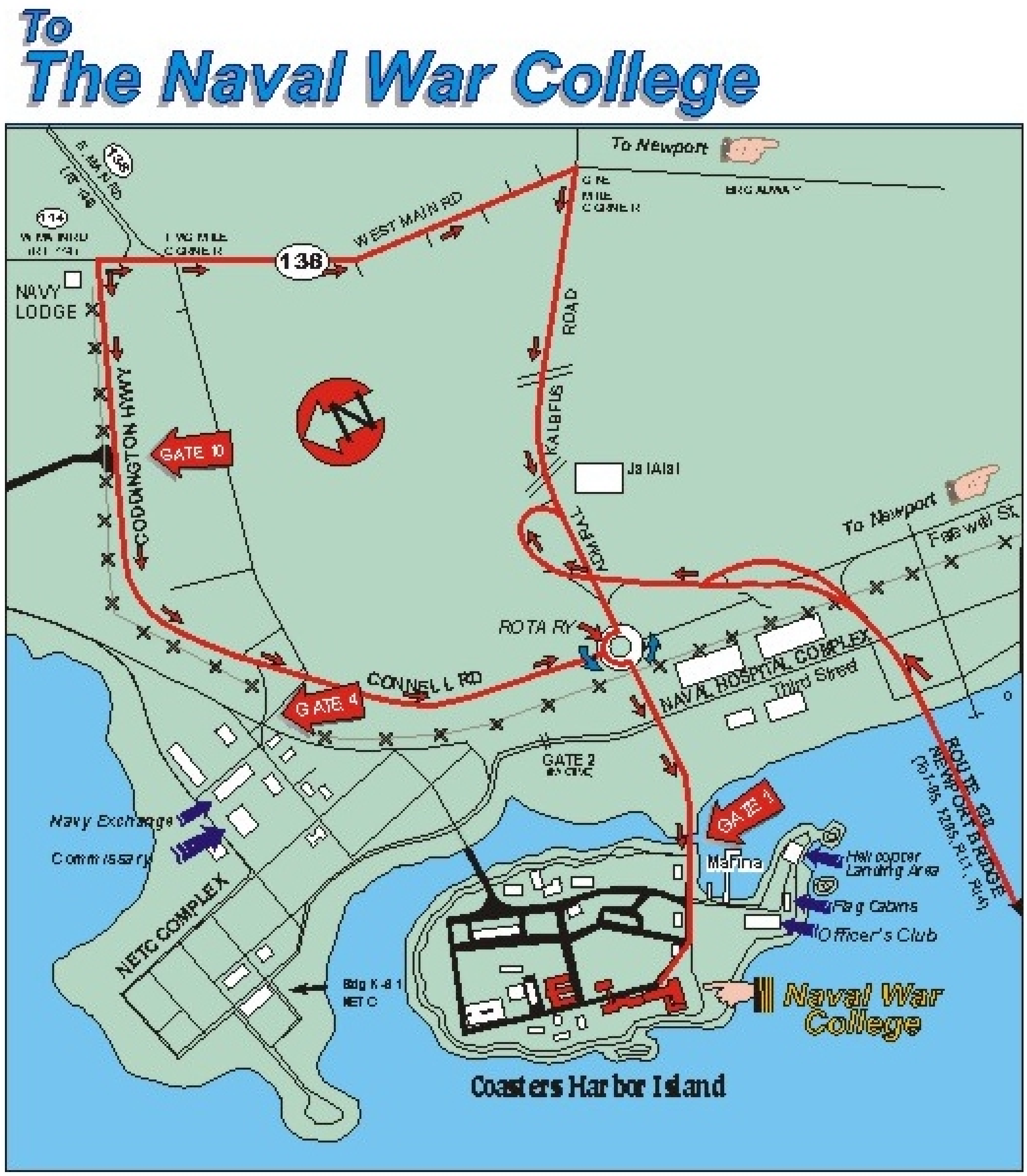
BASIC DESCRIPTION

A. GENERAL INFORMATION

1. Definition of Local Area. The local forecasting area centers on Naval Station Newport and the lower half of Narragansett Bay to include the east and west passages.



2. <u>Location of Naval Training Meteorology and Oceanography Detachment Newport</u>. NAVTRAMETOC DET is a tenant activity of Naval Station Newport. NAVSTA is located on the west side of Aquidneck Island and includes Coasters Harbor Island. NAVTRAMETOC DET is located on the Naval War College complex on Coasters Harbor Island in McCarty-Little Hall, room 340.



B. GEOGRAPHICAL AND TOPOGRAPHICAL DESCRIPTION

1. New England Area.

a. New England is divided into four major topographic regions; the Coastal Lowlands, the Uplands, the Mountains, and the Valleys

1) Coastal Lowlands are areas of low, generally flat land with rocky beaches, rounded hills, glacial deposits, swamps, small lakes and ponds. Elevation varies from sea level to 1530 feet, but tends to average less than 600 feet. In general, the Coastal Lowlands extend inland 10-40 miles along the Maine coast (where the area is marked by small coves and strips of sand between high cliffs), 14 to 20 miles inland along the New Hampshire coast, up to 50 miles inland in Massachusetts, and 10-15 miles along the Connecticut and Rhode Island coasts.

2) The mountains and valleys of New Central New England divide New England Uplands into Eastern and Western Uplands. The Eastern Uplands lie to the west of the Coastal Lowlands and extend southward from Maine in a 20-60 mile wide strip. This rough, hilly region forms the eastern and southern extension of the White Mountains. Elevations vary from 200 to 800 feet. Many small rivers lace the area dividing it into wooded hills and farmland valleys. The Western Uplands include most of Eastern Vermont, a 20-30 mile strip of Western Massachusetts and half of Western Connecticut. Elevation rises to 2000 feet in some areas.

3) The Mountain Regions include the White, Green and The Berkshires Mountains. These areas are considered to be the northeastern extension of the Appalachian Highlands. Some of the higher elevations of note in this region are:

MOUNT	HIGHEST POINT
Mount Washington, NH	6288' (New Hampshire)
Mount Mansfield, VT	4393' (Vermont)
Mount Greylock, MA	3491' (Massachusetts)
Mount Katahdin, ME	5268' (Maine)

4) The four major Valley Regions are the Connecticut Valley Lowlands, the Vermont Valley, the Berkshire Valley and the Champlain Valley. There are several other valleys, but these four are the largest and exert the most influence on area weather.

b. The main oceanographic feature off of the New England Coast is the Gulf Stream. This warm ocean current flows northward from the Gulf of Mexico along the East Coast from Florida to North Carolina. At Cape Hatteras, NC the current flows offshore into the Atlantic. With the current's northeastward flow toward the vicinity of the Grand Banks off Newfoundland, the Gulf Stream passes approximately 180 NM south of Narragansett Bay.

2. NAVSTA

a. Naval Station Newport is situated on the western side of Aquidneck Island in Narragansett Bay (41° 30'30" N, 71°19'50" W). The mean elevation of the complex is 23' above MSL. The areas most susceptible to flooding during a 100-year storm are the southern tip of Coasters Harbor Island (Marina and Officer's Club), Coddington Cove, and the area around building K-61 (PSD).

3. Effects on Local Weather.

a. The New England topography, specifically the Appalachian-Adirondack Mountain Chain, results in the decrease of water content of systems moving through the area. The modifying effects of the nearby Atlantic Ocean and Narragansett Bay produce a milder climate with higher humidity and increased frequency of fog.

b. The cold Labrador Current Extension flowing down the northeastern coast of the U.S., in conjunction with a heated land mass during the warmer months of the year often creates a strong sea breeze circulation, which has been observed as early as February. Frequently, the sea breeze will cause an offshore fog bank to move into Narragansett Bay. Sea breeze flow is predominantly southwesterly in the Newport area.

C. METEOROLOGICAL EQUIPMENT

1. Davis Weather Monitor II. A wind transmitter, temperature probe, barometer and rain gauge are installed adjacent to McCarty-Little Hall. The receiver is located in room 340, in the forecaster's work area, and the data is displayed via the MIDDS workstation #1 and on the Detachment's web site. Wind, temperature, humidity, pressure and precipitation information is collected and archived. The Davis weather set allows the detachment to collect, store, and graph meteorological elements for trend setting and forecast verification.

2. Wind Measuring Set (AN/PMQ-3(C)). The hand held wind measuring set is stored in the supply cabinet. It is used only as a backup to the Weather Wizard and as a training aid.

3. Electric Psychrometer. Used only as a backup to the Weather Wizard and as a training aid.

D. COMMUNICATIONS FACILITIES

1. Message traffic is received through Mail and File department located in Hewitt Hall. Unclassified messages are distributed via public bulletin boards over NWC Intranet using Microsoft Outlook. Classified messages must be signed for over the counter.

2. The primary communication sources available within NTMOD are:

a. CPU FAX Modems. Fax modems connecting the MIDDS system allows NTMOD to communicate with the various local commands and activities that want METOC support.

b. Telephones. Standard telephone capabilities including DSN, five phone lines, and voice mail are available in the office spaces. A single STU-III is located in the OIC office for secure phone communications.

e. FAX. A Brother Intellifax 980M Telecopier is utilized to rapidly transmit written documents between compatible sites over available telephone lines.

f. Personal Computers. Personal computers located in all offices are connected to the NWC LAN that supplies email, Internet and Intranet communications. Classified communications is also available over SIPRNET though one classified computer.

E. COMMANDS AND STAFFS SUPPORTED

1. NAVTRAMETOC DET Newport provides a variety of meteorological and oceanographic support to the various commands and staffs located in the Newport area. They include the following:

a. Naval War College. NTMOD provides all METOC support to the War Gaming Department. The DET is involved in all phases of war gaming including design inputs, scenario development, briefings and METOC product production to players during the games, and assistance to game controllers during the assessment process.

b. Surface Warfare Officers School. NTMOD instructors teach classes that include Meteorology, EO/EM impacts (AREPS), Heavy Weather Shiphandling, and Tactical Oceanography to students in the Division Officer Course, Department Head School, and International Surface Warfare Officer School. The OIC teaches the METOC classes to Prospective Commanding Officers (PCOs), Prospective Executive Officers (PXOs), and any specialty METOC classes such as for Amphibious Warfare.

c. Naval Station Newport. The detachment offers recommendations to Commander, NAVSTA concerning the setting of snow and severe weather conditions, including Hurricane Conditions. NTMOD instructors teach classes in Basic Meteorology to NAVSTA Staff. The detachment also provides severe weather briefings and climatology packages.

SECTION II

CLIMATOLOGY

A. ANNUAL AVERAGES

Sky Cover (% frequency)

47% mostly cloudy (greater than 8/10 cloud cover)
17% partly cloudy (4/10 cloud cover or more but < 8/10)
37% mostly clear (less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 45.4

Precipitation Extremes: Max 12.70" (1983)
Min 0.39" (1957)
Average/Extreme Snowfall: 32.0"/70.2" (1977-78)

Average number of days of occurrence

Precipitation > 0.01": 123
Snow/Sleet: 24
Thunderstorms: 21
Rain/Drizzle: 169
Fog: 157

Wind Data (% freq of occurrence)

Direction	Avg	Speed	Direction	Avg	Speed
N	12%	10	S	16%	10
NE	06%	09	SW	18%	08
E	03%	08	W	14%	09
SE	05%	10	NW	14%	10

Prevailing Wind Direction: South-southwest
Average Wind Speed: 10 knots
Peak Gust: South 81 knots in 1985

Ceiling and Visibility (% chance)

25%	Below	3,000' and < 3NM
16%	Below	1,000' and < 3NM
6%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less an average of 29 days annually.

Temperature Data

Average: 51F/ 11C
Average Maximum: 59F/15C
Average Minimum: 42F/8C
Extreme Maximum: 102F/ 38C in 1991
Extreme Minimum: -13F/ -25C in 1976
Average Relative Humidity: 68%

On average, the temperature will be at or below freezing for some part of at least 121 days.

Normal Degree Days (base 68F):

	Providence	Block Island
Heating:	5917	5682
Cooling:	625	412

Narragansett Bay

Average Sea Surface Temperature: 55F/ 9C
Wave Height (% frequency): 0-2 FT 68%
2-4 FT 25%
5-6 FT 2%

B. DESCRIPTIVE MONTHLY CLIMATOLOGY

JANUARY CLIMATOLOGY

Winter is well established and outbreaks of cold polar air keep the average temperature below freezing. The major storm tracks are northeasterly from the vicinity of Cape Hatteras and east-southeasterly from the Western Great Lakes. Low pressure systems from the south can develop into "Nor'easters" with 1-3 storms typically developing during the month. The Great Lakes storms generally bring only scattered snowfall but can produce significant accumulations under certain conditions.

Sky Cover (% frequency)

51%	mostly cloudy	(greater than 8/10 cloud cover)
12%	partly cloudy	(4/10 cloud cover or more but < 8/10)
37%	mostly clear	(less than 4/10 cloud cover)

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
17%	Below	1,000' and < 3NM
8%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 4.1
Precipitation Extremes: Max 11.7" (1979)
Min 0.5" (1970)
Average/Extreme Snowfall: 7.7"/28.7" (1965)

Average number of days of occurrence
Precipitation greater than 0.01": 10
Snow/Sleet: 3
Thunderstorms: 0
Rain/Drizzle: 11
Fog: 11

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	16%	11	S	08%	10
NE	04%	10	SW	18%	08
E	02%	08	W	21%	09
SE	03%	11	NW	24%	10

Prevailing Wind Direction: Northwest
Average Wind Speed: 11 knots
Peak Gust: South 53 knots in 1992

Temperature Data

Average: 28F/ -2C
Average Maximum: 38F/ 3C
Average Minimum: 23F/-5C
Extreme Maximum: 65F/ 18C in 1974
Extreme Minimum: -13F/ -25C in 1976
Average Relative Humidity: 65%

On average, the temperature will be at or below freezing for some part of at least 28 days.

Normal Degree Days (base 68F):

	Providence	Block Island
Heating:	1141	1051
Cooling:	0	0

Narragansett Bay

Average Sea Surface Temperature: 42F/ 6C
Wave Height (% frequency): 0-2 FT 62%
2-4 FT 28%
5-6 FT 4%

FEBRUARY CLIMATOLOGY

February is characterized by moderate to strong outbreaks of cold polar air moving across New England from central Canada. Major storms that affect New England usually develop along the Gulf Coast and track rapidly to the northeast. These storms often become stronger in the vicinity of Cape Hatteras and may continue to develop, becoming Nor'easters as they approach the New England coast. It is these storms which can produce major local snowfalls. During a typical February, southern New England will experience two such storms.

Sky Cover (% frequency)

37% mostly cloudy (greater than 8/10 cloud cover)
14% partly cloudy (4/10 cloud cover or more but < 8/10)
49% mostly clear (less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 3.7
Precipitation Extremes: Max 7.2" (1984)
Min 0.4" (1987)
Average/Extreme Snowfall: 7.7"/30.9" (1962)

Average number of days of occurrence

Precipitation greater than 0.01": 10
Snow/Sleet: 3
Thunderstorms: 0
Rain/Drizzle: 11
Fog: 2

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg	Speed
N	16%	11	S	08%	10
NE	04%	10	SW	18%	08
E	02%	08	W	21%	09
SE	03%	11	NW	24%	10

Prevailing Wind Direction: WNW
Average Wind Speed : 12 knots
Peak Gust: southwest 59 knots in 1967

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
16%	Below	1,000' and < 3NM
7%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 29F/ -2C
Average Maximum: 39F/ 4C
Average Minimum: 24F/-4C
Extreme Maximum: 72F in 1985
Extreme Minimum: -7F in 1979
Average Relative Humidity: 63%

On average, the temperature will be at or below freezing for some part of at least 25 days.

Normal Degree Days (base 68F):

	Providence	Block Island
Heating:	1000	952
Cooling:	0	0

Narragansett Bay

Average Sea Surface Temperature: 40F/ 4C
Wave Height (% frequency): 0-2 FT 59%
2-4 FT 32%
5-6 FT 4%

MARCH CLIMATOLOGY

Sporadic outbreaks of cold polar air from central Canada continue to pass over Narragansett Bay. However, the major storm track runs from the Gulf Coast across Cape Hatteras. These systems can intensify rapidly becoming Nor'easters producing rain, snow and sleet. At least one Nor'easter can be expected during March.

Sky Cover (% frequency)

50% mostly cloudy (greater than 8/10 cloud cover)
14% partly cloudy (4/10 cloud cover or more but < 8/10)
36% mostly clear (less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 4.3"
Precipitation Extremes: Max 8.8" (1983)
Min 0.6" (1981)
Average/Extreme Snowfall: 7.3"/31.6" (1956)

Average number of days of occurrence
Precipitation greater than 0.01": 12
Snow/Sleet: 8
Thunderstorms: 1
Rain/Drizzle: 12
Fog: 12

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg	Speed
N	09%	11	S	07%	09
NE	04%	11	SW	08%	11
E	03%	08	W	08%	09
SE	02%	10	NW	12%	11

Prevailing Wind Direction: WNW
Average Wind Speed: 11 knots
Peak Gust: Northeast 62 knots in 1958

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
15%	Below	1,000' and < 3NM
5%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 38F/ 3C
Average Maximum: 46F/ 8C
Average Minimum: 29F/-2C
Extreme Maximum: 90F in 1945
Extreme Minimum: 1F in 1967
Average Relative Humidity: 63%

On average, the temperature will be at or below freezing for some part of at least 20 days.

Normal Degree Days (base 65F):

Speed	Providence	Block Island
Heating:	865	792
Cooling:	0	0

Narragansett Bay

Average Sea Surface Temperature: 42F/ 5C
Wave Height (% frequency): 0-2FT 60%
2-4FT 32%
5-6FT 3%

APRIL CLIMATOLOGY

The first full month of spring generally heralds the first summer-like weather of the year as the Bermuda high builds from the east and brings occasional warm, moist air over the eastern seaboard. Inland temperatures can approach the 70's while the 50's are more likely along the coast due to the moderating influence of the relatively cool ocean. Winter effects aren't completely over, however, as the last freeze in spring generally occurs around the middle of the month.

There are two major storm tracks affecting the area, one from the mid-west extending through the St. Lawrence Valley and then across Newfoundland: the other extending northeast from Cape Hatteras and having the greatest potential for causing severe local weather. Weaker cold fronts generally produce isolated rain showers while moderate to strong one can produce thunderstorms accompanied by gusty winds, hail, heavy precipitation, lightening, and, under the most severe conditions, tornadoes. The local area can expect at least three frontal passages during the month.

Sky Cover (% frequency)

43% mostly cloudy (greater than 8/10 cloud cover)
17% partly cloudy (4/10 cloud cover or more but < 8/10)
40% mostly clear (less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 4.0"
Precipitation Extremes: Max 12.7" (1983)
Min 1.5" (1982)
Average/Extreme Snowfall: 0.6"/7.3" (1982)
Average number of days of occurrence
Precipitation greater than 0.01": 11
Snow/Sleet: 2
Thunderstorms: 1
Rain/Drizzle: 18
Fog: 13

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg	Speed
N	11%	12	S	20%	11
NE	08%	09	SW	16%	09
E	05%	08	W	14%	09
SE	07%	10	NW	15%	10

Prevailing Wind Direction: South
Average Wind Speed: 11 knots
Peak Gust: Southeast 54 knots in 1984

Ceiling and Visibility (% chance)

24%	Below	3,000' and < 3NM
16%	Below	1,000' and < 3NM
6%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 48F/ 3C
Average Maximum: 57F/ 14C
Average Minimum: 38F/ 3C
Extreme Maximum: 98F in 1976
Extreme Minimum: 14F in 1954
Average Relative Humidity: 61%

On average, the temperature will be at or below freezing for some part of at least 6 days.

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	513	588
Cooling:	0	0

Speed

Narragansett Bay

Average Sea Surface Temperature: 50F/ 10C
Wave Height (% frequency): 0-2FT 60%
2-4FT 32%
5-6FT 3%

MAY CLIMATOLOGY

The Bermuda high dominates the eastern seaboard bringing warm moist air to the area. Daytime temperatures average near 70 F along the coast and slightly higher inland.

The most significant local weather phenomenon is fog, which can be expected to occur on about half of the days of the month. When it does occur, it will generally develop after 0300 EDT and often reduces visibility to less than 3 miles. After 0900 EDT the fog usually begins to burn off and by noon is usually totally dissipated.

Frontal passages become less frequent. The weaker cold fronts can produce isolated rainshowers, but moderate to strong fronts can produce thunderstorms, gusty winds, hail and heavy rainshowers. The local area can expect at least two cold frontal passages during the month.

Sky Cover (% frequency)

53% mostly cloudy (greater than 8/10 cloud cover)
18% partly cloudy (4/10 cloud cover or more but < 8/10)
29% mostly clear (less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation (water equivalent): 3.5”
Precipitation Extremes: Max 8.38" (1984)
Min 0.71" (1964)
Average/Extreme Snowfall: TRACE/7.0" (1977)

Average number of days of occurrence
Precipitation greater than 0.01": 11
Snow/Sleet: 2
Thunderstorms: 3
Rain/Drizzle: 19
Fog: 15

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	13%	11	S	25%	11
NE	07%	09	SW	17%	09
E	04%	07	W	11%	08
SE	08%	09	NW	10%	09

Prevailing Wind Direction: South
Average Wind Speed: 11 knots
Peak Gust: Southeast 49 knots in 1990

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
18%	Below	1,000' and < 3NM
09%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 58F/15C
Average Maximum: 68F/20C
Average Minimum: 48F/09C
Extreme Maximum: 94Fin 1964/1987/1992
Extreme Minimum: 29F in 1956
Average Relative Humidity: 68%

On average, the temperature will not fall below freezing at any time of the month.

Normal Degree Days (base 68F):

	Providence	Block Island
Heating:	239	335
Cooling:	0	0

Narragansett Bay

Average Sea Surface Temperature: 57F/ 14C
Wave Height (% frequency): 0-2 FT 65%
2-4 FT 29%
5-6 FT 2%

JUNE CLIMATOLOGY

The Bermuda High has become established bringing warm moist air to New England. Weak cold fronts infrequently track through the area and may produce isolated thunderstorms, gusty winds, hail and heavy showers.

Fog is a significant weather concern and can be expected to occur on approximately half the days of the month. When it does occur, it will generally develop after 0300 EDT and may reduce visibility to less than three miles. After about 0900 EDT the fog will begin to burn off and will generally dissipate by noon.

June marks the beginning of the North Atlantic Hurricane season. Local activities are encouraged to review the Heavy Weather Bills. The following references are applicable:

COMNAVSURFLANTINST 3140.2 (Tropical Cyclone Evasion Handbook)
Hurricane Havens Handbook for the North Atlantic Ocean (Ch 9, Newport, R.I.)
COMNETCNPT/Local Area RI Coord Disaster Preparedness Plan, Annex B (Destructive Weather)

Sky Cover (% frequency)

49% mostly cloudy	(greater than 8/10 cloud cover)
21% partly cloudy	(4/10 cloud cover or more but < 8/10)
30% mostly clear	(less than 4/10 cloud cover)

Ceiling and Visibility (% chance)

25%	Below	3,000' and < 3NM
18%	Below	1,000' and < 3NM
08%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 5 days.

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:3.2”
Precipitation Extremes: Max 11.08" (1982)
Min 0.39" (1957)

Average number of days of occurrence
Precipitation greater than 0.01": 11
Thunderstorms: 4
Rain/Drizzle: 16
Fog: 17

Temperature Data

Average: 65F/18C
Average Maximum: 73F/23C
Average Minimum: 57F/14C
Extreme Maximum: 97Fin 1952/1988
Extreme Minimum: 39F in 1980
Average Relative Humidity: 70%
Normal Degree Days (base 68F):

	Providence	Block Island
Heating:	31	83
Cooling:	85	35

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	10%	10	S	29%	09
NE	07%	08	SW	22%	08
E	03%	06	W	11%	07
SE	07%	08	NW	08%	08

Prevailing Wind Direction: South
Average Wind Speed: 09 knots
Peak Gust: Southeast 54 knots in 1989

Narragansett Bay

Average Sea Surface Temperature: 61F/ 16C
Wave Height (% frequency): 0-2 FT 73%
2-4 FT 22%
5-6 FT 1%

JULY CLIMATOLOGY

The Bermuda High is firmly established and brings warm moist air to New England. Migratory lows and associated cold fronts are increasingly rare, averaging less than two a month.

Fog remains the dominant weather concern and can be expected to occur on over half the days of the month. It generally develops after midnight and dissipates by noon. Persistent heat and humidity, combined with the sea breeze, create conditions conducive to afternoon thunderstorms.

Tropical activity begins to pick up, although less than two significant cyclones occur during an average July. Most cyclones develop east or in the Caribbean and either proceed into the Gulf of Mexico or recurve towards the northeast without affecting the eastern seaboard.

Sky Cover (% frequency)

50% mostly cloudy	(greater than 8/10 cloud cover)
22% partly cloudy	(4/10 cloud cover or more but < 8/10)
28% mostly clear	(less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:3.0”
Precipitation Extremes: Max 8.08" (1976)
Min 1.00" (1970)

Average number of days of occurrence
Precipitation greater than 0.01": 09
Thunderstorms: 04
Rain/Drizzle: 16
Fog: 15

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	08%	08	S	25%	08
NE	05%	07	SW	29%	07
E	03%	05	W	12%	06
SE	07%	07	NW	08%	06

Prevailing Wind Direction: Southwest
Average Wind Speed: 10 knots
Peak Gust: Southeast 43 knots in 1984

Ceiling and Visibility (% chance)

27%	Below	3,000' and < 3NM
19%	Below	1,000' and < 3NM
07%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 4 days.

Temperature Data

Average: 73F/22C
Average Maximum: 82F/28C
Average Minimum: 63F/17C
Extreme Maximum: 102Fin 1991
Extreme Minimum: 48F in 1988
Average Relative Humidity: 70%

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	0	07
Cooling:	235	155

Narragansett Bay

Average Sea Surface Temperature: 70F/ 21C
Wave Height (% frequency): 0-2 FT 80%
2-4 FT 16%
5-6 FT 0%

AUGUST CLIMATOLOGY

The Bermuda High continues to dominate local weather bringing generally, hot humid conditions and isolated afternoon showers, This pattern will be occasionally disrupted by the passage of a weak low pressure system. Fog or haze continues to occur on over half the days of the month.

Tropical activity increases, with an average of 3 tropical storms or hurricanes occurring in the North Atlantic during the month. The threat to the local area is initially low but increases throughout the month.

Sky Cover (% frequency)

45% mostly cloudy	(greater than 8/10 cloud cover)
21% partly cloudy	(4/10 cloud cover or more but < 8/10)
34% mostly clear	(less than 4/10 cloud cover)

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
17%	Below	1,000' and < 3NM
05%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:4.0”
Precipitation Extremes: Max 11.1" (1955)
Min 0.7" (1984)

Average number of days of occurrence
Precipitation greater than 0.01": 10
Thunderstorms: 04
Rain/Drizzle: 14
Fog: 17

Temperature Data

Average: 71F/21C
Average Maximum: 78F/26C
Average Minimum: 63F/17C
Extreme Maximum: 98Fin 1975
Extreme Minimum: 41F in 1965
Average Relative Humidity: 73%

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	06	05
Cooling:	195	183

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	11%	09	S	23%	08
NE	07%	08	SW	23%	09
E	03%	06	W	12%	06
SE	06%	08	NW	10%	07

Prevailing Wind Direction: South-southwest
Average Wind Speed: 09 knots
Peak Gust: Southeast 75 knots in 1991

Narragansett Bay

Average Sea Surface Temperature: 72F/ 24C
Wave Height (% frequency): 0-2 FT 78%
2-4 FT 16%
5-6 FT 1%

SEPTEMBER CLIMATOLOGY

The Bermuda High weakens and polar air begins to invade the region. The major storm track extends from northern Florida, along the East Coast, and across Newfoundland. Low pressure systems propagate along this track on an average of once every five days.

Tropical Activity reaches its annual maximum; tropical systems tend to be steered around the western edge of the Bermuda High and parallel to the eastern seaboard.

Sky Cover (% frequency)

44% mostly cloudy	(greater than 8/10 cloud cover)
17% partly cloudy	(4/10 cloud cover or more but < 8/10)
39% mostly clear	(less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:3.5”
Precipitation Extremes: Max 7.92" (1961)
Min 0.77" (1959)

Average number of days of occurrence
Precipitation greater than 0.01": 08
Thunderstorms: 02
Rain/Drizzle: 15
Fog: 16

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg	Speed
N	15%	10	S	18%	09
NE	09%	08	SW	19%	09
E	07%	06	W	12%	06
SE	06%	08	NW	13%	07

Prevailing Wind Direction: Southwest
Average Wind Speed: 09 knots
Peak Gust: Southeast 81 knots in 1985

Ceiling and Visibility (% chance)

25%	Below	3,000' and < 3NM
16%	Below	1,000' and < 3NM
06%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 64F/18C
Average Maximum: 73F/23C
Average Minimum: 54F/12C
Extreme Maximum: 100Fin 1983
Extreme Minimum: 33F in 1980
Average Relative Humidity: 74%

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	94	75
Cooling:	49	39

Narragansett Bay

Average Sea Surface Temperature: 70F/ 21C

Wave Height (% frequency):		
	0-2 FT	75%
	2-4 FT	19%
	5-6 FT	1%

OCTOBER CLIMATOLOGY

The Bermuda High weakens allowing migratory lows to dip further south bringing cooler temperatures. The major storm track extends from central Colorado to the Great Lakes and then into northern Quebec. A secondary track exists from the vicinity of Cape Hatteras to Newfoundland. Lows following this secondary track have the potential to intensify and usually produce the most severe local weather. Hurricanes continue to pose a threat but their likelihood decreases throughout the month.

Sky Cover (% frequency)

41% mostly cloudy	(greater than 8/10 cloud cover)
15% partly cloudy	(4/10 cloud cover or more but < 8/10)
44% mostly clear	(less than 4/10 cloud cover)

Ceiling and Visibility (% chance)

22%	Below	3,000' and < 3NM
14%	Below	1,000' and < 3NM
05%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 3 days.

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:3.3”
Precipitation Extremes: Max 11.9" (1962)
Min 1.5" (1967)
Average/Extreme Snowfall: Trace/2.5” (1979)

Average number of days of occurrence
Precipitation greater than 0.01": 08
Snow/Sleet: 01
Thunderstorms: 01
Rain/Drizzle: 13
Fog: 14

Temperature Data

Average: 55F/13C
Average Maximum: 63F/17C
Average Minimum: 47F/08C
Extreme Maximum: 86Fin 1979
Extreme Minimum: 26F in 1976
Average Relative Humidity: 71%

On average, the temperature will be at or below freezing for some part of at least 4 days.

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	366	316
Cooling:	0	0

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	16%	11	S	15%	08
NE	07%	10	SW	19%	07
E	04%	08	W	15%	07
SE	05%	09	NW	14%	08

Prevailing Wind Direction: Southwest
Average Wind Speed: 09 knots
Peak Gust: Northeast 58 knots in 1991

Narragansett Bay

Average Sea Surface Temperature: 59F/ 15C
Wave Height (% frequency): 0-2 FT 70%
2-4 FT 23%
5-6 FT 2%

NOVEMBER CLIMATOLOGY

The first measurable snowfall usually occurs by late November and freezing temperatures are a common occurrence by the end of the month.

An average of four low pressure systems (storms) can be expected to influence the Newport area. Major storm tracks originate over the Northern Plains and extend across the Great Lakes to Nova Scotia. A secondary storm track extends from the mid-Atlantic coast across Newfoundland. Lows following this track are influenced by the Gulf Stream. Contact with the warm Gulf Stream can cause these lows to deepen rapidly with a sudden increase in wind speed. These coastal storms usually produce the most severe weather.

Sky Cover (% frequency)

51% mostly cloudy	(greater than 8/10 cloud cover)
14% partly cloudy	(4/10 cloud cover or more but < 8/10)
35% mostly clear	(less than 4/10 cloud cover)

Ceiling and Visibility (% chance)

26%	Below	3,000' and < 3NM
13%	Below	1,000' and < 3NM
05%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:4.6”
Precipitation Extremes: Max 9.85" (1983)
Min 0.89" (1976)
Average/Extreme Snowfall: 1.0”/6.0” (1989)

Average number of days of occurrence
Precipitation greater than 0.01": 11
Snow/Sleet: 03
Thunderstorms: 01
Rain/Drizzle: 12
Fog: 13

Temperature Data

Average: 46F/08C
Average Maximum: 53F/12C
Average Minimum: 38F/03C
Extreme Maximum: 75Fin 1974
Extreme Minimum: 11F in 1989
Average Relative Humidity: 70%

On average, the temperature will be at or below freezing for some part of at least 13 days.

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	648	573
Cooling:	0	0

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	14%	10	S	13%	10
NE	06%	10	SW	17%	08
E	04%	09	W	17%	08
SE	04%	11	NW	20%	09

Prevailing Wind Direction: Northwest
Average Wind Speed: 10 knots
Peak Gust: Southeast 62 knots in 1958

Narragansett Bay

Average Sea Surface Temperature: 52F/ 11C
Wave Height (% frequency): 0-2 FT 68%
2-4 FT 24%
5-6 FT 3%

DECEMBER CLIMATOLOGY

December is characterized by moderate to strong outbreaks of cold polar air which originate in the interior of Canada. Stronger outbreaks frequently cause local snowfall with occurrence most likely toward the end of the month when freezing, blustery weather becomes the norm.

Occasionally, low pressure systems (storms) forming in the vicinity of Cape Hatteras track into the local area from the south. These Low pressure systems, or Nor'easters, produce strong north-northeasterly winds which can be accompanied by heavy precipitation in the form of snow, sleet and/or rain.

Sky Cover (% frequency)

49% mostly cloudy	(greater than 8/10 cloud cover)
13% partly cloudy	(4/10 cloud cover or more but < 8/10)
38% mostly clear	(less than 4/10 cloud cover)

Precipitation and Obstructions to Visibility

Average Monthly Precipitation:4.2”
Precipitation Extremes: Max 10.8" (1969)
Min 0.6" (1955)
Average/Extreme Snowfall: 7.7”/19.8” (1963)

Average number of days of occurrence
Precipitation greater than 0.01": 12
Snow/Sleet greater than 1.00”: 02
Thunderstorms: 0
Rain/Drizzle: 12
Fog: 12

Wind Data (% frequency of occurrence)

Direction	Avg	Speed	Direction	Avg.	Speed
N	10%	11	S	03%	09
NE	03%	10	SW	09%	09
E	02%	09	W	12%	08
SE	02%	13	NW	11%	09

Prevailing Wind Direction: West-northwest
Average Wind Speed: 11 knots
Peak Gust: Northwest 51 knots in 1988

Ceiling and Visibility (% chance)

25%	Below	3,000' and < 3NM
15%	Below	1,000' and < 3NM
06%	Below	500' and < 1NM

Heavy fog will reduce visibility to 1/4 mile or less on an average of 2 days.

Temperature Data

Average: 32F/0C
Average Maximum: 41F/05C
Average Minimum: 24F/-04C
Extreme Maximum: 70F in 1984
Extreme Minimum: -10 F in 1980
Average Relative Humidity: 67%

On average, the temperature will be at or below freezing for some part of at least 25 days.

Normal Degree Days (base 65F):

	Providence	Block Island
Heating:	1014	905
Cooling:	0	0

Narragansett Bay

Average Sea Surface Temperature: 45F/ 07C
Wave Height (% frequency): 0-2 FT 65%
2-4 FT 28%
5-6 FT 03%

C. SYNOPTIC CLIMATOLOGY

General

1. The following cyclonic tracks have been classified into eight basic types according to their origin and first appearance in the United States.

Bowie and Weightman Types	California Institute of Technology Types
Alberta	Bn-b and Bn-c
North Pacific	D
Colorado	El (Secondary Low)
Northern Rocky Mountain	Em
South Pacific	A and Cl (So. Cyclone)
Texas	Ha
West and East Gulf	Ga and Gb
Southern Atlantic (Hatteras Low)	

2. Figure II-1 shows the geographic areas in which each classification of storm is likely to first appear on a surface chart.

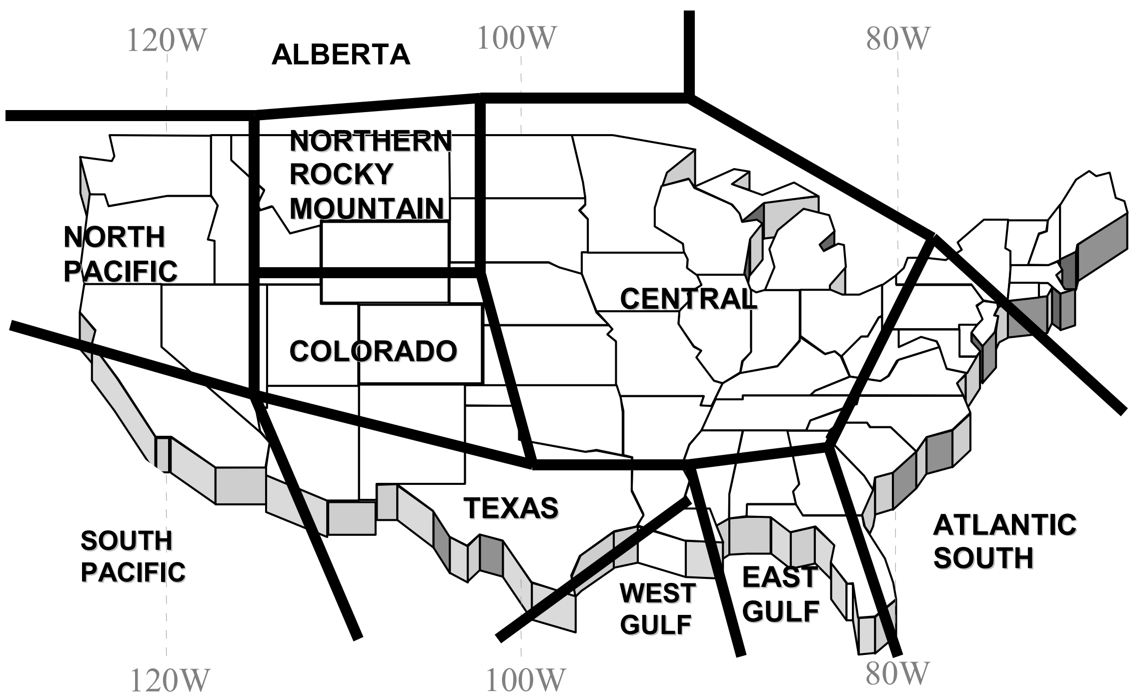


Figure II-1

3. When discussing normal storm tracks, remember that during a low zonal index situation any storm may travel considerably south of its normal track. The forecaster should keep a close watch on the zonal index over New England.

4. The Alberta, North Pacific, Colorado, Central, and South Atlantic type cyclones should be carefully watched because these cyclones normally affect the weather in the Newport area. Upper air steering methods by J. J. George and others are suggested for forecasting the direction and speed of these cyclones.

A. <u>Alberta or Bn-b and Bn-c (CIT) Type</u>. This is a meridional flow type cyclone and is common in all seasons. However, the cyclone occurs most frequently in the fall months when the first cold outbreaks occur and during the spring when the last cold outbreaks are experienced.

The cyclone center enters the North American continent in the vicinity of British Columbia and is associated with a persistent high over the Great Basin. The Northern Alberta Lows are usually the Bn-b type. During winter these lows sometimes deviate as far south as Texas, producing widespread precipitation

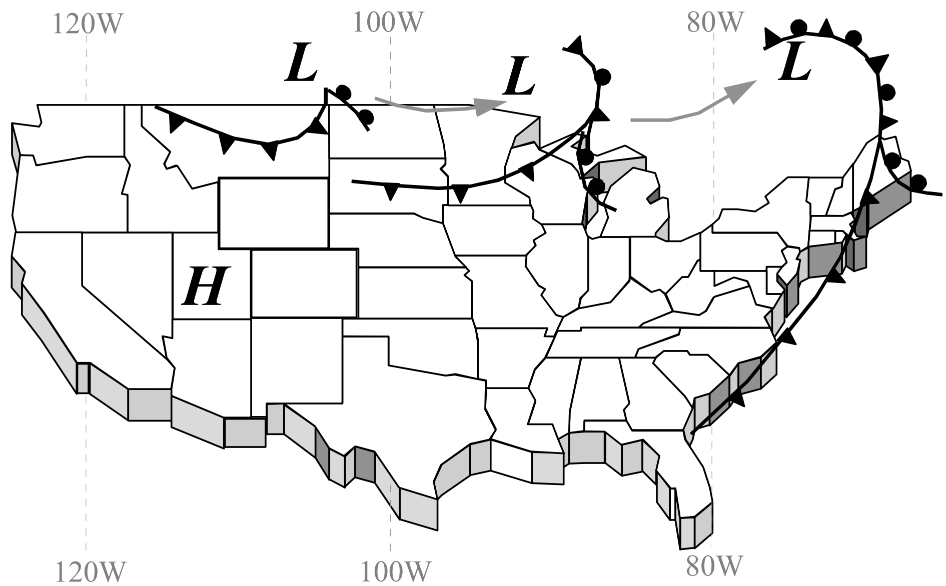
Secondary cold fronts are common with the Alberta type cyclone and for that reason this storm should be carefully watched. Sometimes secondary lows develop in the vicinity of Montana due to the high level divergence produced by the influx of high speed winds from Southeastern Alaska.

During the spring and fall, forecasters should be alert for the characteristic rapid fall in pressure through the Central and Southern Great Basin Areas as the major trough passes eastward. When the low approaches Alberta from Southeast Alaska and warm air advection is indicated from the northwest, pressure falls are very great east of the Great Divide.

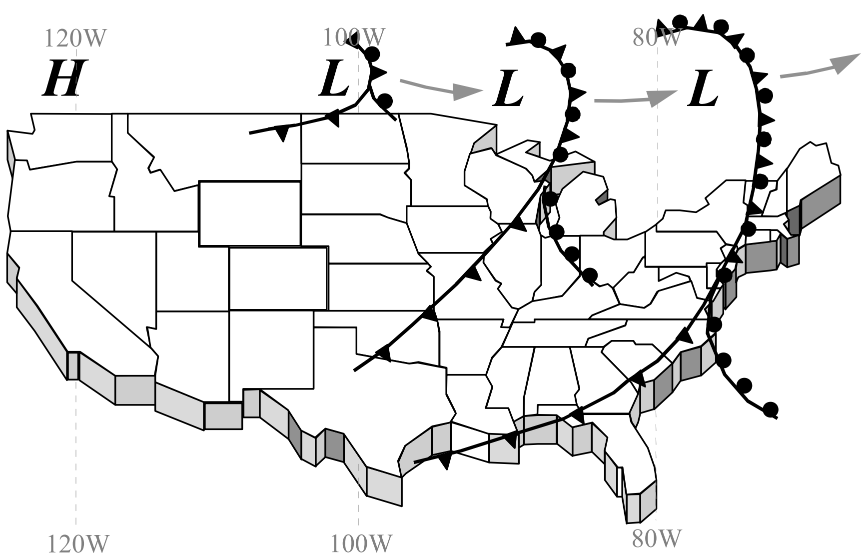
The Alberta or Bn-b and Bn-c type cyclone has the following characteristics:

1) A major trough extends south over the Great Basin into Texas.
2) A persistent surface high exists over the Northwestern United States with no cyclones evident over the West Coast.
3) Lows move from the Gulf of Alaska southeastward over the Great Lakes Region to Northern New England.
4) The first cold front enters Texas and may move as far south as Florida.
5) A deep upper trough exists along the East Coast of the United States causing widespread precipitation along the Atlantic Seaboard.

With a type Bn-b low the weather in Newport is affected by windy conditions as the front approaches from the northwest along with showers developing when the low is near Upstate New York. Cold frontal passage will occur within 12 hours after rainshowers have started, sometimes changing over to snow showers. Strong northwesterly winds will follow (20-30 kts) for 18-24 hours after frontal passage.



Type BN-B



Type BN-C

B. <u>North Pacific or Type D (CIT)</u>. The North Pacific type cyclone occurs mainly in winter, but occasionally can be found in the fall and spring seasons. The major trough enters the continent along the Washington-Oregon Coast or extreme

Southern British Columbia as a deep system. It moves eastward along the northern boundary of the United States south of a polar Canadian High which is over Alaska and extends southeastward toward the Great Lakes

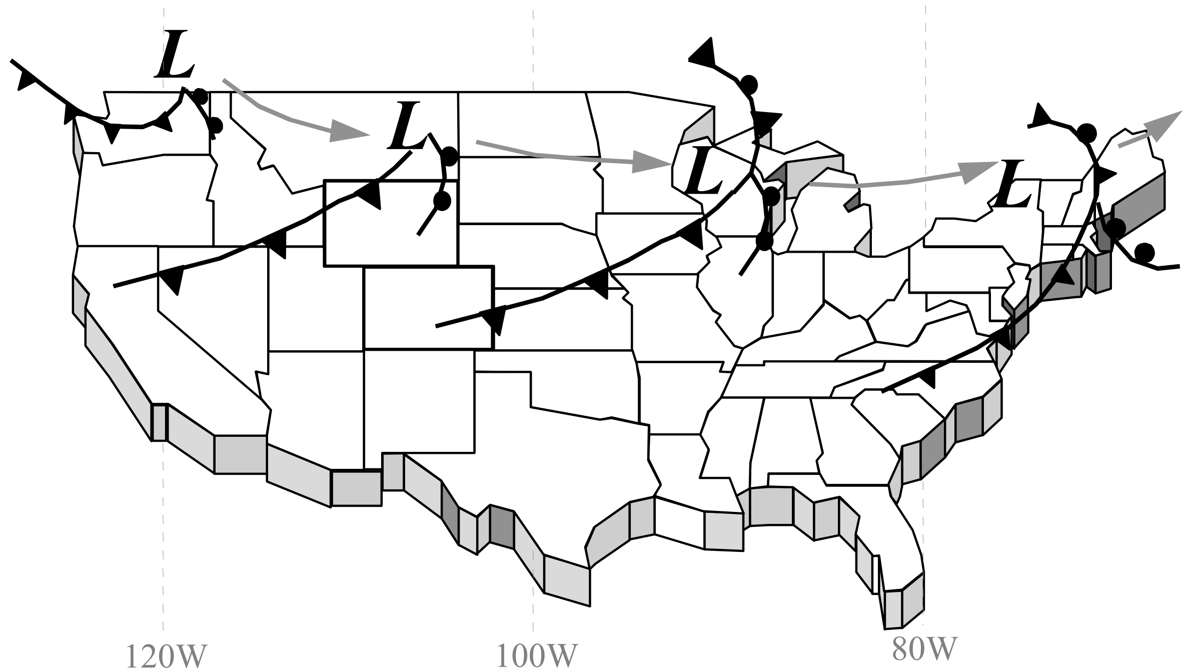
This type of cyclone is somewhat similar to the Alberta type: however, in this case, the trough moves through the continent more rapidly and is followed by a more intense polar Canadian High which sweeps southeastward into the Southeastern United States.

The North Pacific or Type D cyclone has the following characteristics:

1) An unusual crescent shaped high is found over Alaska with a ridge extending toward Lake Superior.
2) A large semi-permanent low persists off the coast of British Columbia.
3) The front moves very rapidly across the continent into the Atlantic.
4) A polar outbreak occurs in the Central Plains following each major trough and low system as it moves rapidly east, intensifying as it passes over the Great Lakes Region.
5) Heavy precipitation can be expected with the low when the Bermuda High is well developed and pumps warm moist air over the area.

This disturbance is usually followed by a series of lows, but unless the storm moves to the southeast most of the moisture is lost while crossing the Rocky Mountains.

The center of the low usually passes northwest of Newport allowing a cold front to pass through rapidly. This is usually a dry frontal passage. The cold air will normally settle the day after frontal passage, sometimes preceded by a trough associated with snow squalls.



Type D

C. <u>Colorado or EI (CIT) Type</u>. The Colorado type cyclone is mainly a secondary low. The low develops in the trough that extends to the southwest from the center of an Alberta storm When the Colorado Low develops, the Alberta Low usually dissipates.

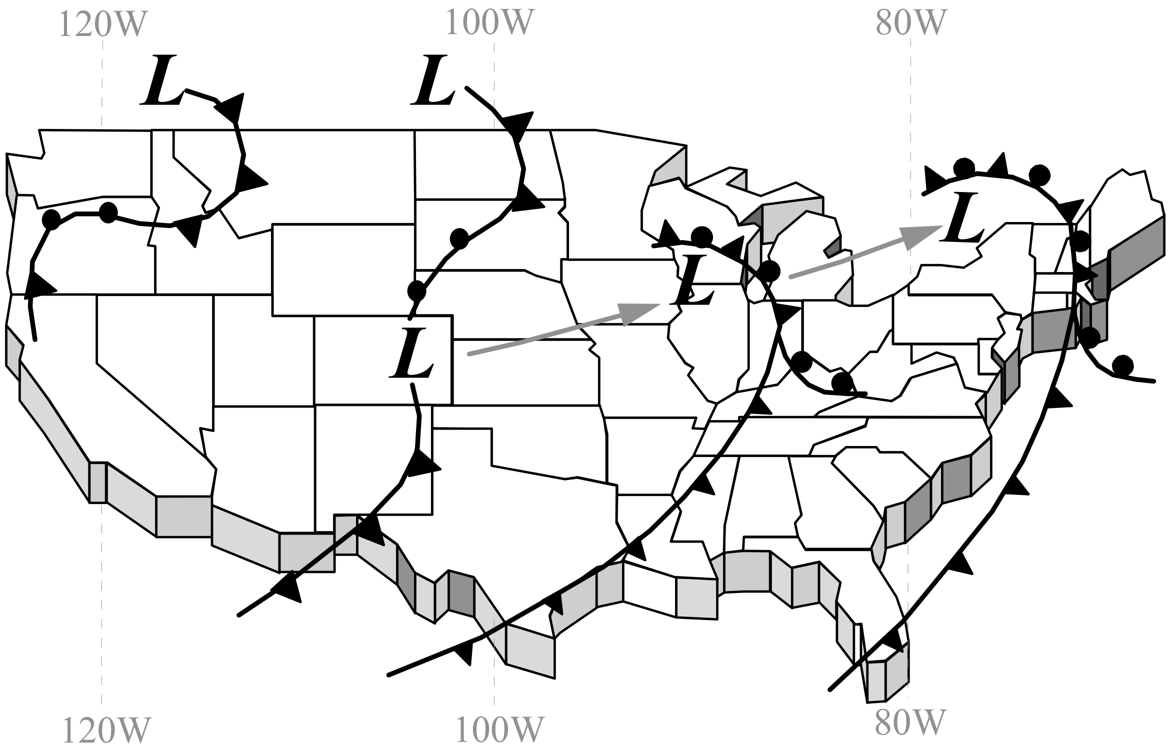
The Colorado type cyclone is most frequent in the winter. The normal track is eastward from Colorado to the Great Lakes Region. However, in winter there is a decided deviation to the south over Oklahoma and thence northeast over the Ohio Valley

The Colorado cyclone produces large amounts of rain in the spring and summer. It causes a warm wave in the Midwest with severe thunderstorms and often tornadoes occurring in the Great Central Valleys and the Southern Plains, specially if the track of the storm is north-northeast.

The Colorado or IE type cyclone has the following characteristics:

1) A cold surface high that persists over Northern Canada and Alaska.
2) Lows enter the United States near the Olympic Peninsula in Washington State and then move east.
3) In crossing the Rocky Mountains, cyclogenesis with a new warm sector of mT air from Texas occurs frequently in the vicinity of the Panhandle. This new storm is the Colorado type cyclone and moves to the northeast.

The low pressure centers of these depressions usually travel northwest in relation to Newport. Frontal passage is slow with scattered rainshowers. The colder air builds in gradually and moderates 48 hours after frontal passage.



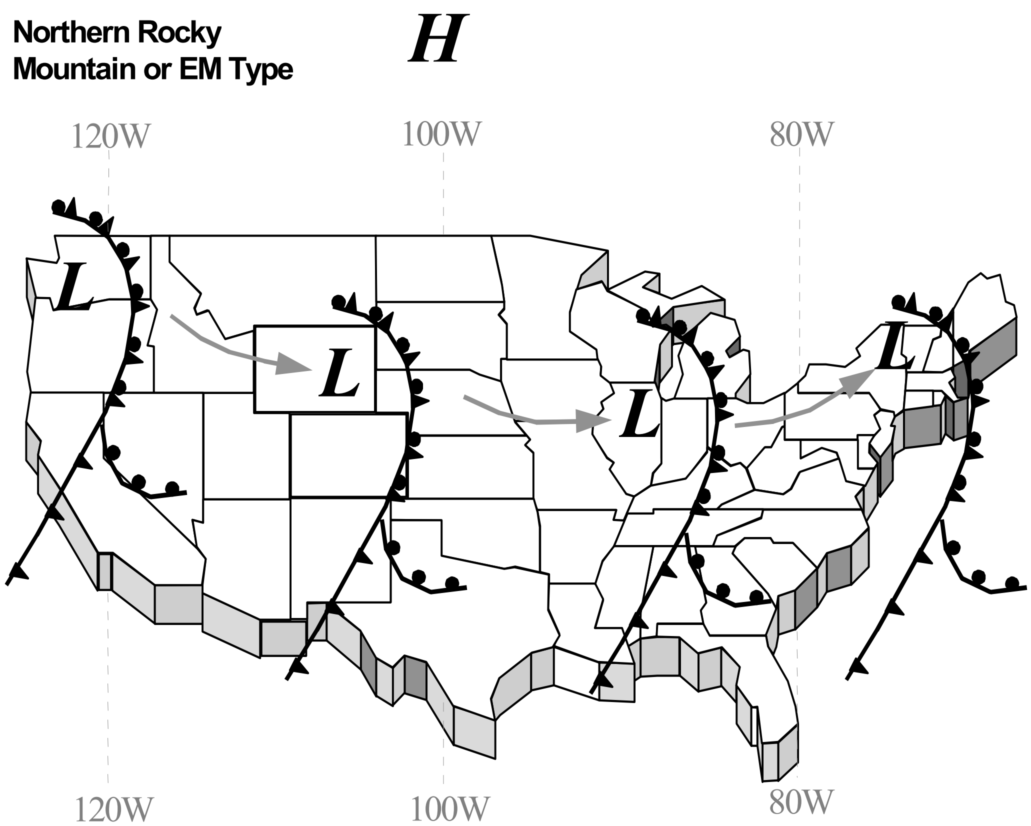
Colorado or EI Type

D. <u>Northern Rocky Mountain or Em (CIT) Type</u>. The Northern Rocky Mountain type cyclone is most frequent during December and January. The usual movement is towards the Great Lakes Region, but sometimes the low is forced far to the south by cP air over Canada. Moderate cold outbreaks the low in the Great Lakes Region

The Rocky Mountain or EI type cyclone has the following characteristics:

1) The westerly belt aloft is displaced far to the south.
2) An intense surface high extends southeastward over most of North America.

Newport is affected by southeasterly winds with rain and drizzle ahead of the cold front and gradual clearing behind the front. This system is usually followed by another rapidly moving system within 2 days.



E. <u>South Pacific / Type A (CIT) and Southern Cyclone / Type CI (CIT)</u>. The South Pacific low is a meridional flow type cyclone, which may occur in any season but is more intense during the winter. The Aleutian Low is absent with this cyclone and high pressure dominates Alaska.

The normal track of the low is southeastward along the Pacific Coast entering the United States in the vicinity of Oregon, continuing southeastward until it reaches the Texas Panhandle, thence moving northeastward over the Great Lakes Region

The South Pacific type cyclone occurs when the Great Basin High is displaced further north than normal. The Southern Cyclone enters the United States in the vicinity of the Southern California Coast and moves across the Gulf States and then northeast along the Atlantic Coast.

Sometimes these depressions disappear from the surface chart after entering the California Coast and moving into the Rocky Mountains. They appear again in

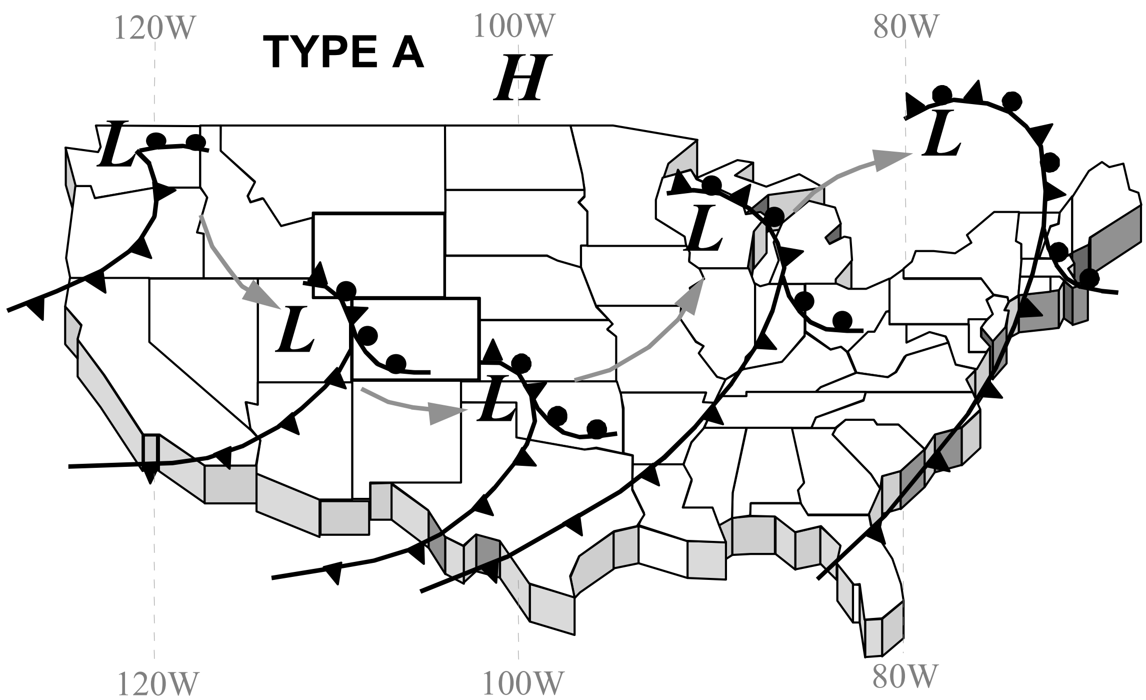
Arizona or New Mexico moving rapidly eastward

The South Pacific type cyclones are meridional flow depressions and are infrequent because it is necessary for the Great Basin High to be displaced to the north in the vicinity of British Columbia.

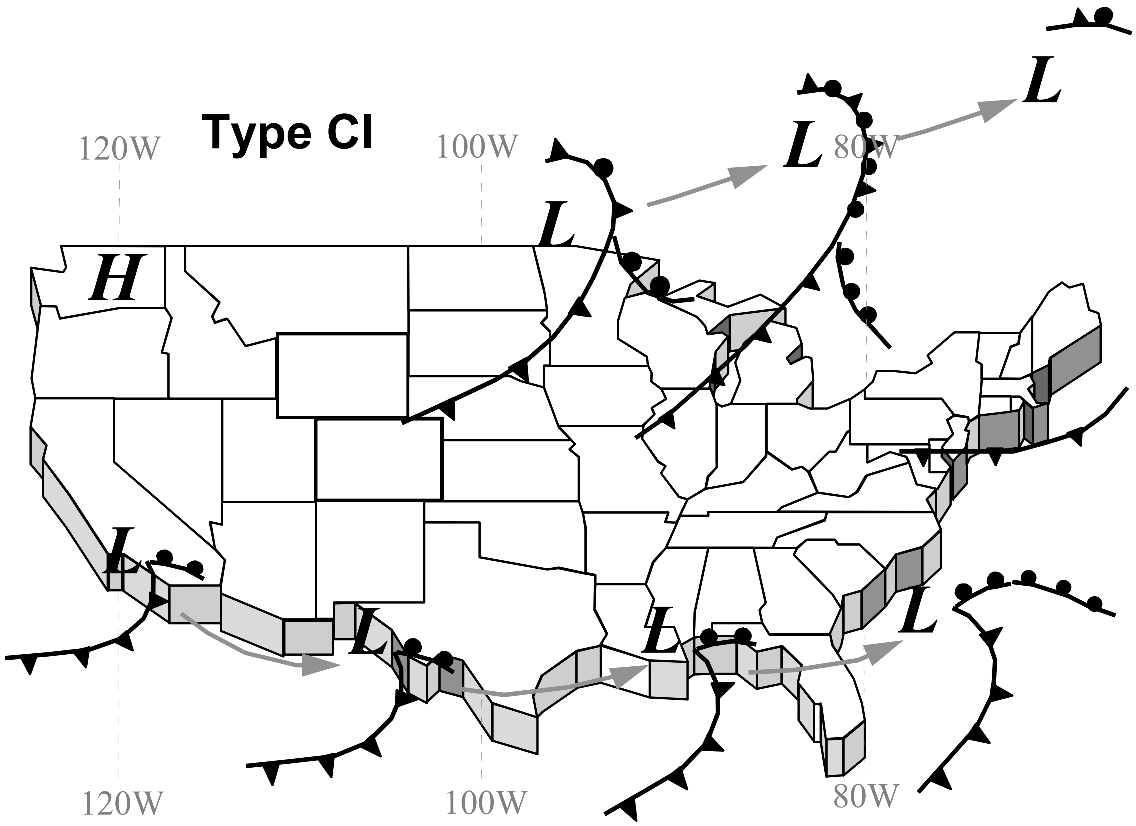
The South Pacific lows are of the blocking type. They are characterized by high latitude highs of persistent nature capped with warm ridges, or closed anti-cyclones aloft with split jets off to the west and low latitude persistent troughs or cold lows aloft in phase with warm ridges to the north.

Type A lows move well west of the Newport area. Newport is not affected except for the associated cold front which moves through with the classic cold frontal passage indicators. Occasionally, showers will change over to snow flurries during the winter months before ending. Newport is usually in the dry slot by the time the cold air arrives.

As the storm tracks across Cape Cod, Newport will receive strong winds and precipitation. Precipitation sometimes begins as a period of snow or mixed snow and rain during the winter months, but usually changes over to all rain as the storm develops. On some occasions, the rain will change back to snow and bring a moderate (2-4") snowfall in the 'backlash' of the storm.



Type CI

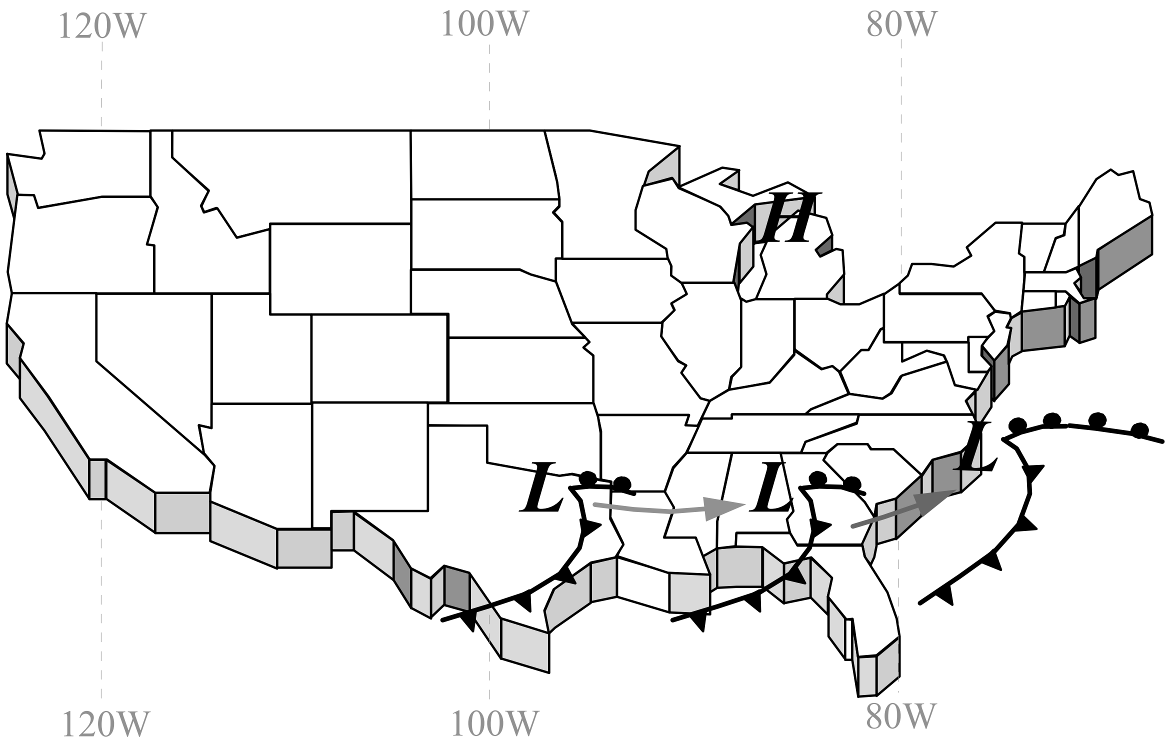


F. <u>Texas or Type Ha (CIT)</u>. The Texas type cyclone forms in low latitudes usually west of New Orleans where the westerly flow is weak. The cyclone tracks eastward steadily and rapidly over the Gulf States and then northeast over the Atlantic Seaboard. The storm develops rapidly, usually when high pressure is dominating the Eastern and Northwestern U.S.

Texas lows are weak wave cyclones which have been stationary and then accelerate when a new weak mP front associated with a progressive trough approaches. It is the approach of the trough in the westerlies that causes the acceleration associated with the Texas low eastward.

It must be emphasized that it is of the utmost importance that these apparently weak Texas frontal waves be studied closely, because it takes only approximately 30 hours after their sudden eastward acceleration for them to reach the East Coast and deepen rapidly. These Texas lows are always a concern to the maritime interests along the East Coast.

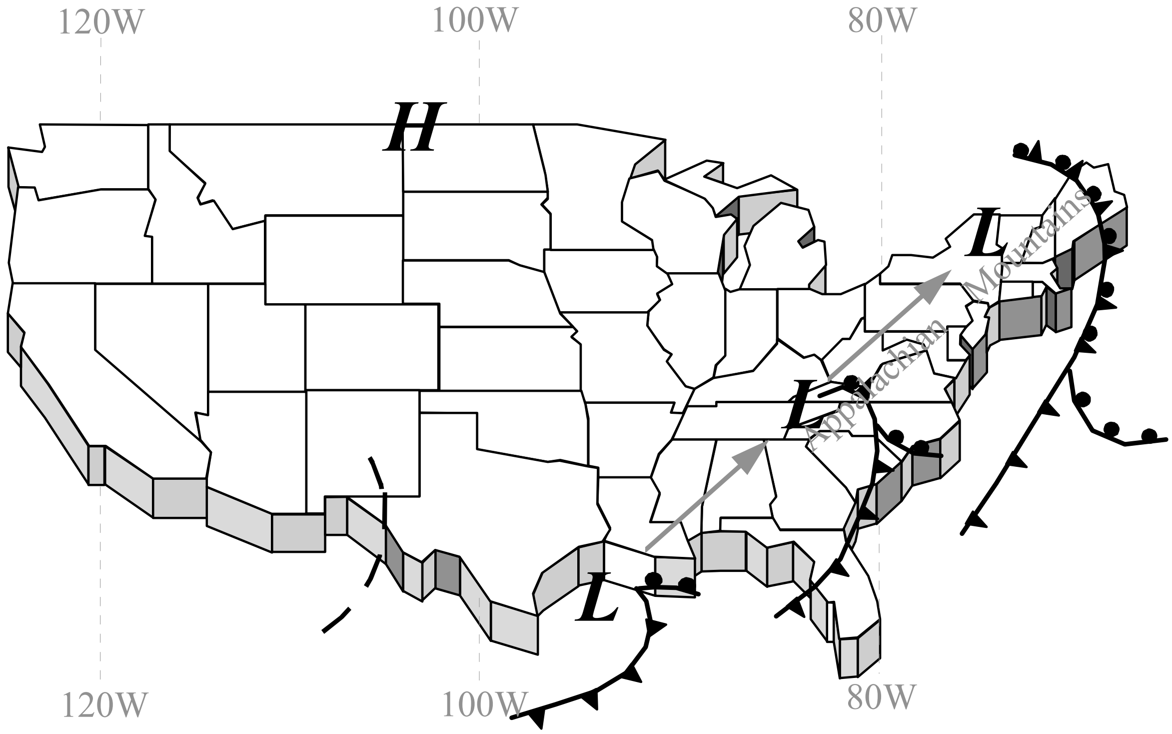
The Texas lows are most frequent in the spring and winter. This low will bring (in winter) a Nor'easter or a significant snowstorm to Newport. However, the track is critical with this type due to its rapid development. A 50 mile deviation in the track will determine the difference between all rain or all snow.



Type HA

G. <u>West and East Gulf Cyclones or Types Ga and Gb (CIT)</u>. Two Gulf types of cyclones are recognized: the West (Ga) and East (Gb) types. As western storms (Alberta, North and South Pacific and Rocky Mountain) move eastward, a trailing frontal remnant is often left in the Gulf of Mexico or the adjacent coastal states. When the frontal trough from a new cyclone enters this area, cyclogenesis often occurs on the Gulf front. This newly formed Gulf wave that moves northeastward and dominates the weather over the Eastern United States. One of the basic differences between the two types is that the Ga track is west of the Appalachians and the Gb track is east of the Appalachians.

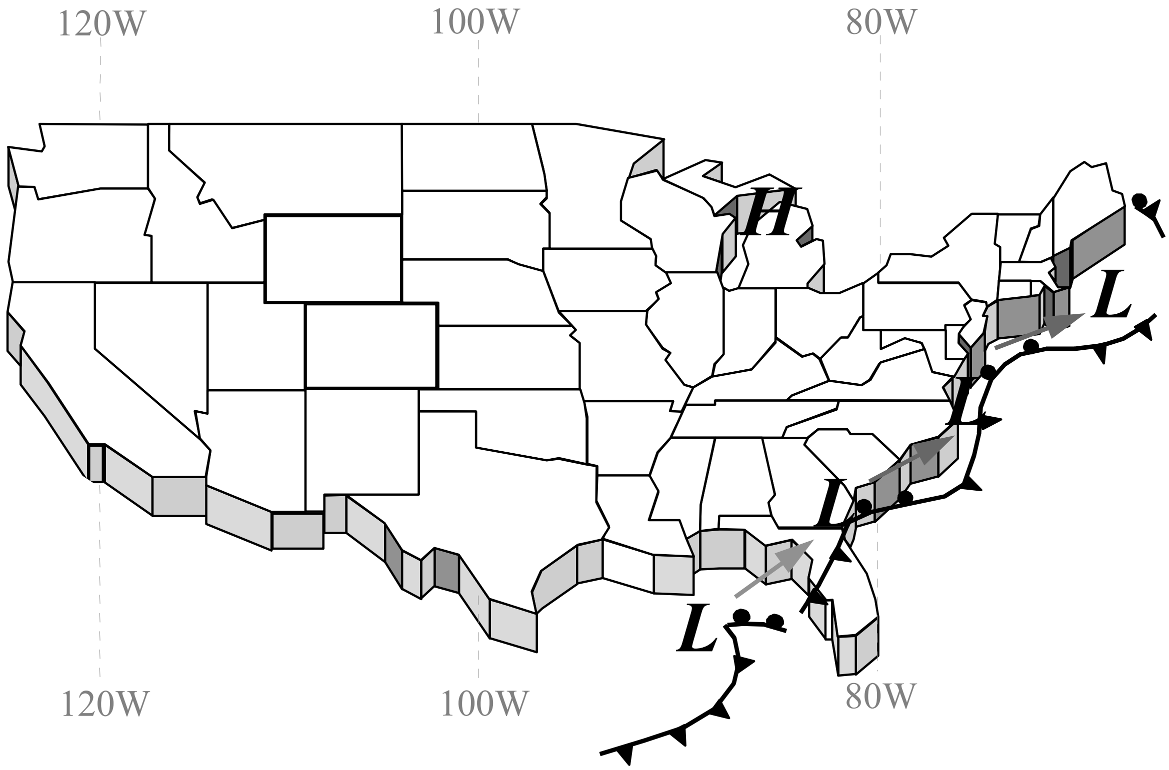
The Ga type is characterized by an upper level trough in the central and eastern part of the United States which steers the newly formed wave north and northeast over the western side of the Appalachians accompanied by widespread precipitation to the north. This type is most frequently observed in the winter and early spring. The general weather in Newport associated with this low are low ceilings with drizzle and rain. Moderated east to southeasterly winds keep widespread continuous precipitation over Newport.



Type GA

The Gb type is associated with a sharp upper ridge over the Central United States and a trough just east of the Appalachians or along the East Coast. A wave forms on a quasi-stationary front in the Eastern Gulf of Mexico due to the approach of another trough from the west. The wave then moves east-northeast entering the United States east of the Mississippi River. As this wave continues east-northeast, a new cyclone forms off the Carolina Coast in the vicinity of Cape Hatteras. This "Hatteras Low" then becomes dominant and advances rapidly northeastward along the coast. This type cyclone is most frequent in the winter and accounts for most of the snow storms south of Washington D.C.

After moving northeast, this cyclone may develop into the New England "Nor'easter". The storm will deepen very rapidly when pressure is high over the Canadian Maritime Provinces and the Grand Banks and will become an intense, nearly stationary North Atlantic Gale as the low becomes blocked by the high to the north. When this occurs, the storm frequently moves slowly northeastward into Maine and fills slowly

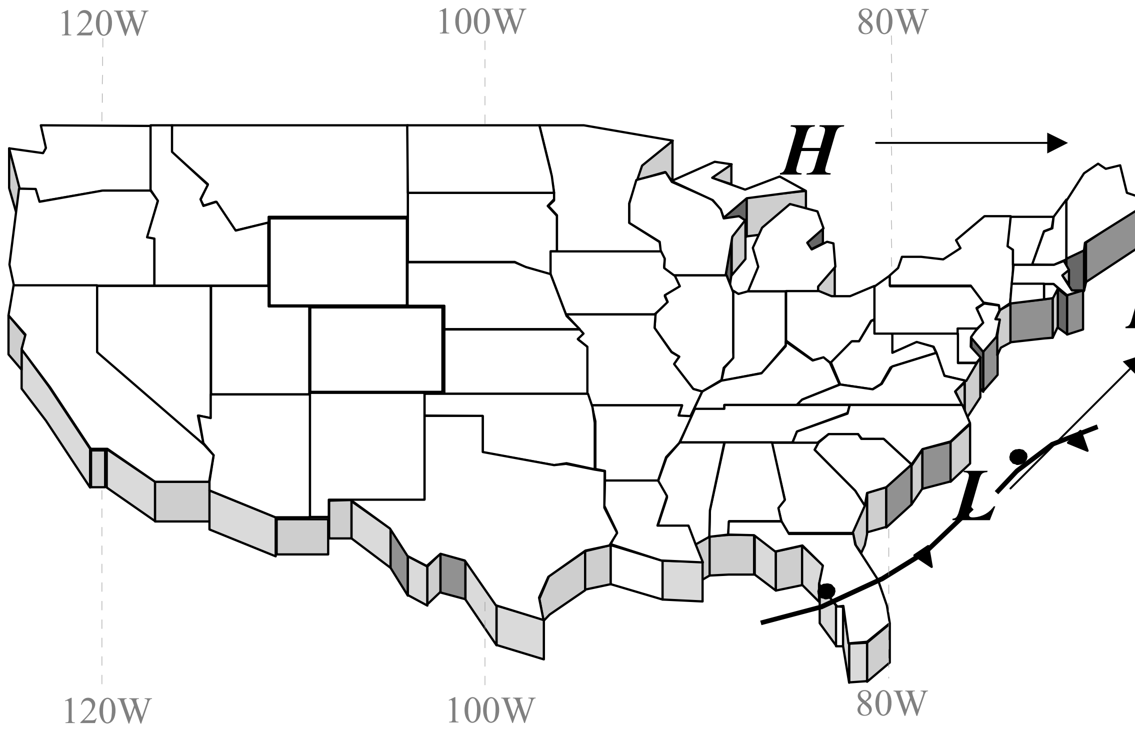


Type GB

H. <u>South Atlantic Type (Hatteras Low)</u>. With the exception of tropical lows that first appear in the South Atlantic, Practically all storms that form in this area are South Atlantic or Hatteras Lows and usually form in one of the following ways:

1). When the Bermuda High is stationary and well developed or intensifying, and approaching low pressure trough and associated cold front from the west will be blocked by the Bermuda High giving rise to ideal conditions for the formation of a Hatteras Low.

2). When the Bermuda High is well developed and a weak stationary front extends across Cape Hatteras then a secondary low develops along the warm front. It is necessary to have mP or cP air in the region ahead of the warm front with a narrow wedge of high pressure east of the Appalachian Mountains. This type of formation usually occur between 15 October and 15 April when the conditions are most prevalent



Hatteras Low (Development)

I. <u>Back-Door Cold Front</u>. A back-door cold front is a name used in the Eastern United States for fronts which move south and southwest from the Canadian Maritimes along the Atlantic Coastal States and contrary to the normal west or northwest approach of cold fronts moving in the westerlies. These fronts are usually rather shallow (5000 to 8000 ft) and the Appalachian Mountain Chain effectively blocks their westward movement. They are most commonly a result of a ridge that builds westward rather than eastward. As these fronts move south and southwest along the coastal plains and plateau, a warm front or quasi-stationary front forms adjacent to the Appalachian Mountains. Although most common in the New England Area, these fronts have penetrated as far south as Central Florida. After achieving their southernmost penetration, the fronts usually return northward along the coast as warm fronts.

Back-door cold fronts are most frequent in the warmer seasons with maximum occurrence in May and June and again in late summer and early fall. The farthest southern movement of back-door cold fronts occurs during June.

The main feature of the 500MB pattern is a pronounced cold core ridge extending from the Ohio Valley northward to Western Quebec with a warm core Bermuda High to the south and retrograding. A short wave trough moves across the cold ridge through the Canadian Maritime Provinces southeastward into the Atlantic. At the surface a high pressure center of mP air moves southeastward under and behind the short-wave trough from the vicinity of Hudson Bay toward Northern New England and/or the Canadian Maritimes. The result is that a quasi-stationary front oriented North - South from 40N to 48N latitude is pushed southward and southwestward over the Atlantic Coastal States. The surface high moves with the 500MB flow.

The movement of the surface high and the back-door cold front are closely related to the strength of the combined 500MB ridge. A more intense ridge implies a stronger surface high and a more southerly direction to its movement. This in turn results in increased southerly penetration of the back-door cold front. The front moves southward until there is an eastward movement off the coast of the surface high center behind the front or the front becomes parallel to the 500MB flow.

The speed of frontal movement varies with the time of day and time of year. Back-door cold fronts tend to move faster during the night with maximum speed during the late night. Fastest speeds are historically during the spring and fall. Average speed is 8 to 12 knots.

Passage of a back-door front brings about substantial changes in the local weather. On the average, the following occur with frontal passage:

1) Average change in daily maximum temperature 15^{o}F.
2) Average change in daily minimum temperature 10^{o}F.
3) Average dewpoint change across the front 10^{o}F.
4) The winds are affected by shifting to the northeast and increasing to 15 to 20 knots.
5) Precipitation will be in the form of rainshowers.

J. **Cyclogenesis:** The following information is based on a manuscript by James E. Miller New York University, entitled "Cyclogenesis in the Atlantic Coastal Region of the United States", in which the characteristics of cyclones originating in the Atlantic Coastal region of the United States are discussed and classified into two types as determined from a study of 208 cyclones that occurred in the area over a ten-year period. The methods of detecting these cyclones in the early stages are described in illustrated in the Manuscript that was published in the Journal of Meteorology, Vol. 3, No. 2, of June 1946.

The forecasting of cyclonic development along the Atlantic Coast of the United States is always a difficult problem, as the development of the storm is sometimes so rapid that it may change a situation in which the forecaster would be inclined to anticipate fairly good weather into one where a severe cyclonic storm develops within the forecast period.

The forecasting of cyclogenesis is complex and cannot be done satisfactorily by empirical methods alone. The causes of cyclogenesis and the physical processes involved must be thoroughly understood by the forecaster, as failure in the forecasting of cyclone formation and development has been attributed in a large number of cases to the fact that the forecaster had no sure knowledge of the subject.

There are two distinct types of cyclones which can be recognized in the Atlantic Coastal Region of the United States. The distinguishing features of the two types are noted by their difference in pressure field patterns and motion and also in the frontal picture of the surface weather map at the time the new cyclone originates. The characteristics of the two are usually quite apparent but sometimes there is a difference in detail from one cyclone to another. It has been found in this study that when the surface weather chart does not exhibit the characteristics of one of the two types, a new cyclone formation in the area is unlikely.

TYPE A This type appears as a wave along the cold front. It is a common occurrence in regions where cold outbreaks occur frequently, but it is often observed along the East Coast during the colder part of the year. This type occurs in the Atlantic Coastal Region then the surface weather map has the following characteristics:

(1) A cold anti-cyclone covers most of the United States east of the Rocky Mountains.

(2) A cold, continental airmass is flowing off of the continent.

(3) A current of warm, maritime air from a southerly or southeasterly direction is in the Western Atlantic associated with a more or less well-developed warm anti-cyclone, and opposed to the offshore flow of cold air.

(4) A retardation of a portion of the cold front in such a way that it is distorted into a wave form.

(5) A spreading of middle clouds and precipitation over the retarded portion of the cold wedge.

Type A cyclones generally originate over the ocean and move northeasterly so that in many cases they do not have much effect on the weather at the coastal stations.

TYPE B. This type originates near the coastline to the southwest and along the warm front, or what appears to be a warm front, of the older storm. This type is not as common to any other part of the world as it is to the eastern coast of North America.

It is necessary to study closely all station observations in order to identify this type, as it is not easily recognized at times. Sometimes it is hard to distinguish between the primary cyclone and the secondary, which forms near it. The characteristics of Type B are as follows:

(1) An occluding or occluded primary cyclone in the Great Lakes Region, which is nearly stationary or moving northeastward.

(2) A shallow wedge of cold, high pressure air lying between the Appalachian Mountains and the Gulf Stream, the wedge line oriented southwestward from a cold anti-cyclone centered in Eastern Canada or over the Grand Banks and crossing the 45th parallel near 68 degrees West. The shallow, cold airmass is sluggish and tends to remain along the coast during cyclogenesis.

(3) A frontal discontinuity must be maintained, so it is necessary for warm maritime air from the south to be flowing north over the cold sluggish wedge.

(4) A spreading of precipitation and stable type clouds is noted over the cold wedge, partially separated from the cloud and precipitation area of the primary cyclone.

(5) An area of falling pressure separate from the isallobaric minimum preceding the primary cyclone but associated with the front of the cold wedge in the region is where the air mass contrast and convergence is greatest. The cyclone develops in this area.

Type B affects the coastal weather more than Type A since it develops nearer to the coast line and usually moves in a northeasterly direction.

In rare cases the features of a Type B cyclone may appear soon after a cold outbreak, with the primary cyclone being west or southwest of it usual position over the Great Lakes and still in the early stages of development. This new cyclone which forms along the coast under the above circumstances may be classified as an intermediate type, either A or B.

It is sometimes possible to anticipate the development of a cyclone two or three days in advance on the basis of these characteristics although there is no assurance cyclogenesis will take place. When the East Coast weather is not characteristic of either type and a trend toward one type or the other is noted, the forecaster can estimate the length of time required for the cyclogenetic system to set in. In view of the type of system, the forecaster can locate the approximate region where cyclogenesis can occur.

Monthly Frequency

a. Type A is most frequent in November, dropping to a minimum in January.

b. Type B rises to a maximum frequency in January, drops to a minimum in February, and then rises to a secondary maximum in March.

Geographic Frequency

a. Type A - In tracking a cyclone and studying the distribution of elements about it, the point of minimum pressure is taken as its center. The mean point of origin of Type A is slightly east of the temperature axis of the Gulf Stream near 32 degrees North Latitude. There is some indication that the land area east of the Appalachians and the water area north of the axis of the Gulf Stream, where it swings eastward, are also favored areas of cyclogenesis.

b. Type B - Type B shows two concentrations, the primary one near Norfolk and the other south of Cape Cod.

The most notable difference between Type A and Type B cyclones is the presence of an older cyclone in the eastern half of the United states with the Type
B. The secondary cyclones originate almost exclusively in the southeastern
C. quadrant of the primary cyclone.

Premonitory Signs of Cyclogenesis

Since new cyclones develop rapidly along the Coastal Region, often reaching maturity in less that 24 hours, it is highly desirable that the inception of the cyclone be detected at the earliest possible moment.

One of the earliest signs of cyclogenesis is the appearance of middle clouds and precipitation over the Coastal Regions. These clouds are the typical warm front type in the form of altostratus and altocumulus, which gradually thicken and finally become nimbostratus. These middle clouds are often hidden by stratocumulus.

The Coastal Region will have experienced a cold frontal passage within the past day or two before Type A cyclogenesis occurs, and the warm front cloud sequence is a significant indication of the Type A cyclone development.

The Type B is not readily identified by the cloud sequence because one would expect the same cloud sequence to appear ahead of the approaching primary cyclone. The forecaster must examine the synoptic pattern of middle clouds very carefully, looking for a partial separation between the middle clouds of the primary and the developing secondary cyclone in the Coastal Region. The separation of the cloud systems is not noticeable when the secondary cyclone develops close to the primary cyclone. Sometimes there are two distinct precipitation areas when the type B is developing. Sometimes these two precipitation areas may not be observed, but the spread of precipitation is so great or rapid over the Coastal Region that it could not be due to the movement of the primary cyclone.

The isallobaric pattern should be carefully noted for any relation to the movement and development of pressure systems. A point of line of maximum pressure fall is a sure sign that a new system is forming. A situation of this kind does not mean a new system will mature, but only that one has been forming.

The process of cyclogenesis can proceed for several hours without any drop in air pressure; depending upon both the isallobaric pattern and pressure gradient. In regards to the Type B cyclone, if the primary cyclone continues to deepen or to move toward the area of normal secondary cyclogenesis, there is less probability that the secondary pressure fall will reverse the pressure gradient and form a separate center of low pressure.

D. NARRAGANSETT BAY OPERATING AREA

<u>General</u>

The Narragansett Bay OPAREA is a square/rectangular area that is utilized by Naval Air, Surface, and Sub-surface units of the Atlantic Fleet for scheduled exercises

1. Significant features of this area indicate a variety of oceanographic and bathymetric features. The Continental Shelf extends southward from Long Island and the Southern New England Coast for approximately 60 NM. Water depths average 20-40 fathoms. Bottom composition is a mixture of brown sand and mud with shells. In addition, numerous wrecks and unexploded ordnance litter the area. The Continental Slope extends from the middle of the OPAREA south into the southern portion and contains several significant bathymetric features. The Hudson Canyon in the center and the Atlantic Canyon on the eastern side with depths that average 50-100 fathoms and varies in slope. Bottom composition is primarily gray mud in the western areas and green mud in the eastern areas with scattered reports of shipwrecks. Deep water continues at the edge of the slope and averages between 1000 and 1700 fathoms. In the southern portion of the OPAREA, gray mud makes up the bottom composition.

2. The Gulf Stream transits through the southern portions of the OPAREA year round. Frequently observed between 37 and 40 degrees North, the core of the stream sets east-northeast between 1-3 knots. As water transits from the Cape Hatteras area it slows and begins to meander. When meanders are cut off from the main stream, eddies are formed. The eddies affect the southern half

of the OPAREA are warm core and normally average one within the area at any one time. In addition, the Gulf Stream presents a strong oceanographic front within this area year round. Analysis of the Gulf Stream, including eddy location, is received posted twice weekly by NAVLANTMETOCCEN Norfolk via their web site.

3. OPAREA FORECAST: NAVLANTMETOCCEN Norfolk prepares a Narragansett Bay OPAREA forecast (FOXX02 KGNU) once per day (or every twelve hours if weather conditions require it). The forecast is transmitted via AUTODIN. The message includes a synoptic situation, a twelve, and a twenty-four hour forecast.

E. TROPICAL STORMS AND HURRICANES

1. The term "hurricane" comes from the Spanish "hurricane" which in turn is thought to have originated from the Mayan storm god "Huraken". It is neither the largest nor the most intense of all storms. Temperate zone storms are usually larger and the concentrated fury of tornadoes is more violent than that of hurricanes. However, because of the hurricane's combination of considerable size and intensity, it is the most dangerous and destructive of all storms. In total damage, hurricanes have exceeded any other natural catastrophe.

2. The term "tropical cyclone" indicates a warm-core, non-frontal cyclone of synoptic scale, developing over tropical or sub-tropical waters, and having a definite, organized circulation. In the course of their existence, tropical cyclones like other atmospheric circulation systems, pass through varying stages of development, intensification, maturity and decay or modification. Weather satellites also have confirmed that some tropical cyclones may develop in connection with polar troughs or upper level cold lows and have initial cold-core circulation.

3. Further classification of tropical cyclones depends upon the wind speed near the center of the system. The terms tropical depression, tropical storm, or hurricane are assigned depending upon the speed of the sustained surface winds near the center of the system. Tropical cyclones are not named unless they reach at least tropical storm strength. The term "sustained wind" refers to wind average over one minute. Shorter period gusts are lulls may be considerable higher of lower that the sustained wind. The intensity of these storms may vary from the 200 mph winds of "Gilbert" in 1988, to the weakest of disturbances. The following definitions according to intensity are used:

a. **Tropical Disturbance.** The weakest recognizable stage of a tropical cyclone in which rotary circulation is slight or absent at the surface, but possibly better developed aloft. There is either one closed isobar or none at all, and no significant winds.

b. **Tropical Depression.** The weak stage of tropical cyclone with a definite closed surface circulation, one or more closed isobars, and highest wind speeds less than 34 knots.

c. **Tropical Storm.** A tropical cyclone with closed isobars and highest wind speeds of 34-63 knots.

d. **Hurricane.** A large revolving storm originating over tropical or sub-tropical waters with winds of 64 knots or greater.

4. Some of the world's heaviest rainfalls have occurred in connection with hurricanes. The rainfall is always heavy, probable 3 to 6 inches on the average.

5. When a tropical cyclone or an intense extratropical storm approaches a coastline, there is the resulting rise in the water level which may permit surf to penetrate far inland of the normal high water mark. This abnormal rise in the water level is defined a "storm surge" and is a function of storm speed, direction or storm movement with respect to orientation of the coastline, the radius of winds, the storm's central pressure, and the bathymetry of coastal waters. The total water height is a combination of tides, storm surge, waves and rainfall. Predictions of storm surge are available through National Hurricane Center's warning messages.

6. From past performance of storms of tropical origin, there is little likelihood of local occurrence before August or after October, although the hurricane season extends from June through November. Also, early September is the most likely time of year to have a hurricane brewing somewhere in the Atlantic.

7. The average tracks of tropical storms and hurricanes are for August through September.

8. NAVLANTMETOCCEN constantly monitors all tropical development in the Atlantic during each hurricane season (01 June to 30 November). In the event of a tropical development reaching Tropical Depression intensity, NAVLANTMETOCCEN issues six hourly warnings at 0400, 1000, 1600, and 2200Z. Each warning consists of a present fix, sustained wind speed/gusts and direction of movement, followed by forecast location, and wind speed/ gusts out to 72 hours.

9. **HURRICANE CONDITIONS**

Hurricane conditions of readiness are based on the onset of 50 kt winds unless ships are present. If Ships are present 35 kts is used to guide the setting of the following conditions of readiness. The forecaster should consider both 35/50 kts of wind when ships are present. (Further guidance is available in the Naval Station Newport Disaster Preparedness Plan and Detachment SOP.)

a. **Hurricane condition V.** Hurricane Condition V is a normal condition of alertness consistent with sound precautionary measures to be exercised during the annual hurricane season which is considered to be 1 June to 30 November. Condition V will be effective through the hurricane season. Forecasters will assure themselves that hurricane plans are up to date. In the event that Hurricane condition IV, III, II or I has been ordered, upon elimination of danger and passage of the storm, Hurricane Condition V will be resumed.

b. **Hurricane Condition IV.** Hurricane Condition IV will be placed in effect when a tropical disturbance approaching hurricane strength has established a trend making it reasonable to predict that it is in a position to strike the New England area within seventy-two hours. The purpose of setting Hurricane Condition IV is to alert all ships in Narragansett Bay and to orient future plans and thinking toward a possible sortie to emergency berths/anchorages. It must be remembered that a hurricane's predicted track are extremely variable. Therefore, preparations for ships' movements must be expeditiously carried out in Hurricane Condition IV. Speeds of hurricanes heading north may average 33 knots or more after passing abeam of the Carolina Coast. The most advantageous time to sortie to their emergency berths is obviously prior to the arrival of predicted high winds. As a general rule, heavies will be ordered to move to their hurricane dispersal berths prior to the arrival of winds in excess of 35/50 knots. All or a portion of the smaller ships may be ordered to move to their hurricane dispersal berths. SOPA NARRABAY will keep ships informed of intentions.

c. **Hurricane Condition III.** Hurricane Condition III will be placed in effect when a tropical disturbance approaching hurricane strength has established a trend making it reasonable to predict that it is in a position to strike the New England area within forty-eight hours. As a general rule, heavies will be ordered to their hurricane dispersal berths prior to the arrival of winds in excess of 35/50 knots. All remaining ships will be ordered to move to their hurricane dispersal berths in Hurricane Condition III in the interest of taking advantage of the remaining good weather. SOPA NARRABAY will keep ships informed of intentions.

d. **Hurricane Condition II.** Hurricane condition II will be placed in effect when a hurricane continues to approach the New England area, and winds of 35/50 knots or greater are expected within twenty-four hours.

e. **Hurricane Condition I.** Hurricane Condition I will be ordered when winds of hurricane force are expected within 12 hours and the track of the storm indicates that it definitely constitutes a threat to New England. Hurricane Condition I is the ultimate in preparation for a hurricane. At the time Hurricane Condition I is set, dispersal of ships to their emergency berths normally would have been carried out in either Condition IV or III.

SECTION III

FORECASTING

A. THUNDERSTORMS

1. Thunderstorms are a threat to the Narragansett Bay area during all months of the year. They are rare from late December through February and most frequent during the period June through August.

2. Maritime tropical air is normally required for air mass thunderstorm occurrence.

3. Air mass thunderstorms often develop at night, reach maximum intensity in the early morning and dissipate after sunrise. Occasionally, air mass thunderstorms may develop over land and drift eastward out to sea in the late afternoon and dissipate in the early morning. Air mass storms are not common to Rhode Island.

4. Thunderstorms are usually associated with prefrontal instability or passing fronts.

a. Thunderstorms associated with rapidly moving cold fronts may be violent along the coast, intensify over the Gulf Stream and persist well into the night.

b. Frontal thunderstorms are usually of the more violent type and tend to approach from the west or northwest.

c. Warm frontal thunderstorms are associated with warm air overrunning a colder air mass.

d. Early signs to look for:

(1) Convective clouds developing along the front on the preceding day.

(2) Marked temperature contrasts (20-25^{o} F) across the front with high dewpoint temperatures (>60 - 65^{o} F) in the warm air.

(3) Crashing static on commercial AM radio frequencies.

(4) Strong upper level dynamics and instability.

e. Signs to look for:

(1) A slight trough or "kink" in the isobars about 100-150 miles ahead of the front.

(2) Weak pressure tendency falls ahead of the squall line.
(3) Weak pressure tendency rises behind the squall line.

B. LOCAL WINDS

1. Limitations on Small Craft. When smallcraft warnings are issued, boating operations are suspended. Small craft are sensitive to wind due primarily to a shallow draft, flat bottom and low freeboard. At the NETC Marina there are 27 sailing craft which are used for recreation. The boats and their recall criteria are listed below.

# boats	TYPE	RECALL CRITERIA
6	30 foot Shields	22KTS sustained and/or gusts to 27KTS
2	22 foot Ensigns	18KTS sustained and/or gusts to 25KTS
10	19 foot Rhodes	18KTS sustained and/or gusts to 25KTS
9	15 foot Mercuries	15KTS sustained and/or gusts to 22KTS

a. As can be seen by the numbers of sailing craft and small craft, warnings for small craft, gale, and thunderstorms have a significant effect on operations in the area. The responsibility for receiving and setting various conditions rests with NETC Operations. NAVTRAMETOC DET Newport acts as an advisor to Commander, NETC on conditions. NTMOD will call and recommend appropriate action to NAVLANTMETOC DET Brunswick as conditions develop during normal working hours.

2. Strong Northwest winds (25-35 knots) may occur for a period of several days when a deep, stagnating low is centered near Newfoundland and a large high pressure system is centered over the Central U.S. The resultant strong gradient is quite noticeable at the surface, 850MB, and 700MB levels. Offshore winds vary little from those along the coast except they tend to be 20% to 25% higher.

3. **Alberta and North Pacific lows** - NLMOD Brunswick normally issues warnings to cover the cold front passage and post-frontal winds.

a. Forecast S to SW 10-20 knots prior to warm FROPA.

b. Forecast increasing southwesterly winds after warm FROPA reaching SW 15-20 knots gusting to 30 knots just prior to cold FROPA.

c. Forecast a shift W to NW 20 knots gusting to 35 knots with North Pacific low, cold FROPA and diminishing to 10-15 knots with gusts to 25 knots after 24 hours.

d. With cold FROPA forecast the following wind (coastal waters):

(1) NW to N 25 knots gusting to 50 knots on the first day.

(2) NW to N 20 knots gusting to 35 knots on the second day with a decrease to 15-20 knots at night.

(3) N 15-20 knots on the third day.

4. **<u>Colorado and Texas lows</u>** on a track west of station - warnings normally issued by NLMOD Brunswick for warm sector winds and for cold FROPA.

a. Forecast S to SSW 10-20 knots prior to warm FROPA.

b. Forecast increasing southwesterly winds after warm FROPA, reaching SW 20-25 knots gusting to 40 knots prior to cold FROPA.

c. Forecast a shift of W to NW 20 knots gusting to 35 knots following cold FROPA.

5. **<u>Gulf and South Atlantic lows and Colorado and Texas lows</u>** on a track east of the station - warnings normally issued when the low center is between latitudes 40°N-42°N with a possibility of storm warnings to be issued.

a. Forecast E 10-15 knots with center near coastal VA (0 hrs).

b. Forecast E 15-20 knots with center near 38°N (0 + 4 hrs).

c. Forecast NE 20 knots gusting to 35 knots with center near 39°N (0 + 6 hrs).

d. Forecast NE 25 knots gusting to 40 knots with center near 40°N (0 + 8 hrs).

e. Forecast N 30 knots gusting to 45 knots with center near 41°N (0 +10 hrs).

f. Forecast NW 35 knots gusting to 50 knots in extreme cases when the low center is 992MB or deeper as it passes near 42°N (0 + 12 hrs).

g. Forecast diminishing winds W 15-20 knots within 8 hours after the passage of the low center.
<u>NOTE</u> With blocking action present, the maximum winds do not occur as the center passes through the area, but occur during the first 24 hours of the block with the center just south of Long Island.

As the block recedes and the center moves slowly northward to pass the station the winds tend to gradually diminish.

6. **Sea Breeze.**

a. This phenomenon becomes an important feature in coastal weather by late April and persists until mid October. This effect is found largely in the coastal areas from 12-15 miles out to sea and within 25-50 miles inland, dependent upon local topography.

b. A sea breeze usually sets in between 1000-1200L, reaches its peak intensity by 1400-1500L, and decreases markedly by sunset. Periods where there is little gradient wind and little or no cloud cover result in an earlier time of onset although the time of cessation varies little. Cloud cover will greatly diminish the sea breeze effect.

c. In general, the sea breeze component is from the southeast to south at 8-16 knots. The sea breeze must be vectorially added to the gradient wind to obtain the resultant wind. With little or no gradient wind, the sea breeze may reach a maximum force of 20-25 knots and occasionally reaches 30 knots, although a southerly vector wind of 10-15 knots is more common.

d. Gradient winds from the NW to NE usually result in a no wind condition or in a light sea breeze late in the day since the wind components tend to cancel each other out. Under such conditions the sea breeze normally sets in as a sudden hard gust from the southeast before settling down to the resultant.

NOTE Resultant wind computations

(1) Gradient Wind	NW	10 knots
Sea Breeze Vector	SE	12-16 knots
Resultant	SE	2 knots -- forecast light/variable, occasionally SE at 6 knots
(2) Gradient wind	W	15 knots
Sea Breeze	SE	8-16 knots
Resultant	WSW	11 knots S-SSW 12 knots -- forecast S-WSW 10-14 knots

C. FOG AND STRATUS

1. Fog over Narragansett Bay presents a difficult forecasting problem. A major factor in fog development is the offshore ocean current structure. A

southwestward running extension of the Labrador Current dominates the coastal waters to the south and east, while the Gulf Stream moves eastward just seaward of the southern extremity of the Labrador Current.

2. Climatology indicates fog may be persistent in any month of the year. From late Fall to late Spring, extensive fog areas are seldom destroyed except by frontal passage.

a. Prefrontal fog. This is a common occurrence. When occlusions, associated with deep low pressure cells, pass near the station be on the alert for advection fog.

c. Cloud cover strongly influences radiation fog development. As cloud cover reduces incoming insolation, it helps maintain lower daytime temperatures and higher humidity. As incoming insolation is reduced, fog is more likely to be adverted inland if the wind is favorable.

d. Coastal advection fog prediction requires warm air advection in the lower levels which may extend up to 850MB.

(1) Advection fog is generally associated with mT air moving into the area.

(2) The most reliable parameter appears to be a comparison of the 0700L dewpoint temperature along the Maryland and Delaware coast with coastal sea water temperatures.

(a) During winter, when 0700L dewpoint temperatures are 5-10 degrees higher than SST, the development of sea fog during the late afternoon is very probable.

(b) During summer an 8-10 degree difference is required.

e. Winds from 210 to 160 advect fog into Narragansett Bay.

(1) A flattening of the pressure gradient on the back of a high or within at least 5MB of the center is a good area for fog formation.

(2) It has been noted that if afternoon upper air soundings indicate a more westerly than 210 flow, then no local area fog is expected.

(3) Advection fog moving from 160 eastward to 030 approaches as low stratus (i.e. 800-1500 feet broken clouds). This condition slowly lowers during the early morning hours (0400-0800).

(4) Fog from the northeast is generally restricted to the late fall through spring.

f. Forecasting dissipation of fog and low stratus is as difficult as forecasting its onset.

(1) If the fog-producing phenomena are forecasted to be destroyed during the morning it is reasonable to expect the fog to "burn off".

(2) The existence of a higher overcast extends the period of low ceilings until noon or early afternoon, visibility usually improves slowly.

(3) With clear skies, fog and stratus ceilings and visibility improve rapidly.

(4) If rapid, steadily increasing temperature occurs after sunrise, fog dissipation is expected early (0800L).

g. Southerly flow causes advection of warmer air over cooler water producing fog or low stratus clouds especially in the warm sector of cyclonic systems.

h. SE-SW flow is associated with sea fog.

(1) In the spring, periods of fog are of short duration (a day or two). Fog tends to form early in the morning and usually lifts by noon even over coastal waters.

(2) Sea fog is likely whenever a southerly flow persists.

(3) A low stratus deck is likely if surface winds are sufficiently strong to produce lifting and mixing (in excess of 15 knots).

i. By late spring, periods of maritime tropical air tend to persist for a week or two with a prolonged period of SW winds. Either fog with visibility less than 2 miles or haze with 4-6 miles occurs. Incidence of haze is greatest in the extreme southern portion of Narragansett OPAREA, while fog is more likely to the north.

j. In the summer, the Bermuda High becomes the predominant weather feature. Warm, moist maritime tropical area flowing northward causes large areas of coastal fog which persists up to 50-100 miles off the coast.

k. Coastal fog is common during the summer and occurs primarily from midnight to 0900L over land but persists at sea with a southerly flow.

l. Fog almost always accompanies precipitation during the summer, except with thunderstorms.

m. The offshore limit of fog varies considerably, depending upon the fluctuation in the Gulf Stream and Labrador Current and the associated SST's.

(1) The extreme southern portions of the Narragansett Bay OPAREA and waters to the south rarely experience fog in summer.

(2) In general, the seaward limit of the fog bank will extend SE from a point 60-80 miles south of Block Island.

D. SNOW VS. RAIN

1. One of the most significant forecasting problems to the Newport Area is whether or not precipitation will occur as snow, rain or an intermediate form. No one method, when used alone, can be taken for gospel. A good analysis and a combination of different thermal parameters will yield the best forecast.

a. The period between mid October to mid May is considered the snow season for the local area.

b. Upper air conditions are of primary interest in forecasting whether precipitation will be rain only, snow only, or mixed rain and snow.

(1) Since no radiosonde observations are taken in the immediate area, the forecaster is required to use available upper air analyses and prognosis from the National Weather Service and Naval Environmental Data Network.

(2) These products coupled with the latest soundings from Chatham, MA (74494), Albany, NY (72518), Atlantic City, NJ (72407), Washington DC (72403), as well as pilot reports should provide sufficient data for an intelligent evaluation of the atmospheric conditions.

3. **Precipitation - Winter.**

a. Alberta or North Pacific lows and Texas or Colorado lows with a track west of the station.

(1) Cold Front (begins with front in Western Massachusetts.)

(a) Forecast light rain/snowshowers, except moderate showers in the frontal area.

(b) Forecast a TRACE-1/2 inch water equivalent or a TRACE of snow accumulation as applicable.

(c) With a deep cyclone north of the area and cold polar flow over the area, forecast moderate-heavy snow showers for 30 hours following cold frontal passage.

(2) No Front.

(a) If the frontal zone does not extend far enough to the south, expect a trough passage with precipitation at the station beginning one hour prior to passage.

(b) Forecast a TRACE of water accumulation and zero to a TRACE of snow accumulation.

(3) Warm Front - associated with an Alberta or North Pacific low, precipitation beginning 2-3 hours prior to the frontal passage.

(a) Forecast intermittent light to very light intensity precipitation.

(b) Forecast a TRACE of water equivalent and/or a TRACE of snow accumulation as appropriate.

(4) Warm Front - associated with a Colorado or Texas low, precipitation beginning with the front in the southern portion of Chesapeake Bay.

a) Forecast continuous light intensity precipitation.

(b) Forecast a TRACE-1/4 inch water equivalent of the appropriate type.

(5) Occluded Front - usually associated with an Alberta or North Pacific low, precipitation beginning when the front is in the Hudson River Valley.

(a) Forecast continuous very light to light intensity precipitation with occasional intermittent periods.

(b) Forecast a TRACE-1/4 inch water equivalent of the appropriate type.

b. Gulf and Southern North Atlantic lows or Colorado and Texas lows with a track to the east of the station.

(1) Forecast precipitation beginning at the time the center reaches LAT 36^{o}N and continuing until the center passes LAT 43^{o}N.

(2) With no blocking action present, forecast light-moderate intensity precipitation, except moderate-heavy precipitation from the time the center passes the station to the time it passes Lat 43^{o}N. (An average time interval of 16-20 hours.)

(a) If the low is a Colorado or Texas low (originally), forecast 1/2 to 1 1/2 inches water equivalent or a TRACE-6 inches of snow as appropriate.

(b) If the low is a Gulf or Southern North Atlantic type low (originally), forecast 1-2 inches water equivalent or a minimum of 3 inches of snow as appropriate.

(3) With blocking action present, forecast moderate-heavy intensity precipitation for the first 24 hours of the block and light-moderate precipitation thereafter as the block recedes. (An average time interval of 60 hours).

(a) Forecast 2-4 inches water equivalent of the appropriate type.

c. **General Guidelines.**

(1) **Snow.**

(a) If the surface temperature at Mt. Washington is 15^{o}F or lower, precipitation normally begins as snow.

(b) If winds are light and the temperature is near 10^{o}F at Mt. Washington, heavy snow can be expected.

(c) When the 700MB temperature is -8^{o} C or colder, the 850MB temperature is -3^{o} C or colder, and the surface temperature is below 40^{o} F, snow is the most likely form to occur.

(d) Look for the 5540 contour at 500MB to be south of Newport.

(e) If the 1000-500MB thickness is forecast to be #5340m, snow is likely.

(f) If the 1000-700MB thickness is forecast to be #2835m, snow is likely.

(g) A freezing level less than 1200 feet will bring snow.

(h) Heavy snow normally results when low level winds are from the northeast with a trajectory over the ocean from the east and southeast.

(i) NAVSTA will put the plows on alert when 4 inches of snow is forecasted.

(2) **<u>Snow Mixed with Rain or Changing to Rain</u>.**

(a) When the 700MB temperature is between $-4^{o}C$ and $-8^{o}C$ and the 850MB temperature is between -1^{o} C and -3^{o} C, snow mixed with rain is likely.

(b) If the winds aloft are from the southwest, snow or snow changing to rain is likely.

(c) When a cold high pressure cell is east of the station, warm advection will occur and snow will probably change to rain.

(d) During a snowstorm when the surface wind at Nantucket shifts to the southeast, the snow is likely to change to rain within 2 hours.

(e) 1000-500mb thickness between 5340m and 5400m will bring mixed precipitation.

(3) **<u>Freezing Rain</u>.** With southwesterly flow aloft and 850MB temperatures forecasted to rise above $-2^{o}C$, freezing rain is likely to occur if the surface temperature (and a shallow layer above) remain below freezing.

(4) **<u>Sleet</u>.** If the cold layer of air above the surface extends for several thousand feet or more, the raindrops are likely to freeze and fall to the ground as sleet.

(5) **<u>Rain</u>.** Rain occurs when the

(a) 700MB temperature is -4^{o} C or warmer.
(b) 850MB temperature is 0^{o} C or warmer.
(c) surface temperature is above $38^{o}f$
(d) 1000-500mb thickness is >5400m
(e) 1000-700mb thickness is >2835m

Rain may result when low level winds are from the east with a trajectory over the ocean from the south.

SECTION IV

SPECIALIZED FORECASTS

A. NAVTRAMETOC DET Newport can provide any meteorological and oceanographic data in accordance with NAVMETOCCOMINST 3140.1(Series).

SECTION V

ENVIRONMENTAL EFFECTS

The Officer in Charge functions in an advisory capacity to commands in the Narragansett Bay Area. Particular attention is afforded to the following phenomena in order to provide optimum METOC services to the commands supported by NAVTRAMETOC DET Newport:

A. **WARNINGS** – The FDO will monitor and if necessary discuss with the NLMOD Brunswick FDO to ensure that Brunswick is aware of current or forecasted conditions that meet the following criteria:

1. Thunderstorm Warning - when thunderstorms are within 30 miles.

2. Smallcraft Warning - sustained winds of 15 knots or more.

3. Gale Warning - sustained winds of 35 knots or more.

4. Storm warning - sustained winds greater than 50 knots.

B. SNOW CONDITIONS AND SEVERE WEATHER

1. The Duty Forecaster will contact Commander NAVSTA and offer advice and recommendations concerning the setting of snow or severe weather conditions.

C. ICE STORMS

1. One of the more dangerous winter storms is one that produces freezing rain. While the effect of a snowstorm can be relatively gradual, freezing rain can quickly paralyze power, communications, and transportation systems. Fortunately, the occurrence of severe ice storms is infrequent.

2. The most dangerous ice storms occur when precipitation begins as rain with surface temperatures below freezing or when surface temperatures are slightly above freezing and the underlying surface is frozen due to a recent cold spell. Ice storm occurrence is enhanced by the following conditions:

a. Pronounced surface inversion with below freezing temperatures at the surface.
b. Below freezing temperatures within several (2-3) thousand feet of the surface.
c. Warm overrunning air at the precipitation producing level and/or a few thousand feet below it.

3. The above requirements are necessary in order for the precipitation to commence as rain or possibly snow, which is warmed sufficiently to liquefy into droplets and then enters a sub-freezing layer sufficiently thick to allow the droplets to freeze. It must be emphasized that if the droplets are not frozen as they reach the surface, the accumulated precipitation may freeze at the surface if the underlying surface is frozen.

D. FORECASTING ICE ACCRETION ON SHIPS

1. Topside icing has long been recognized as a serious hazard to ships. Thick layers of ice can form on decks, sides, superstructure, hatches, masts, rigging, deck mounted machinery, antennas, and combat systems. Fishing boats have reported ice accumulations 3 feet thick on decks with the guard rail covered completely to form a closed bulwark.

2. The presence of topside ice increases the ship's displacement, decreases freeboard, obstructs operation of deck machinery, impedes personnel movement on deck, may obstruct air intakes, restricts helo operations, disrupts operation of radio and radars and hampers the deployment of underwater sensors. The greatest danger of topside icing, however, is the loss of ship's stability.

3. Spray icing is the most commonly encountered form of topside icing. It occurs at air temperatures below freezing when the spray of water hitting the ship's surfaces freeze and creates a shell of ice. Spray icing merits the forecasters attention because the ice can form on the highest parts of the ship - the masts, antennas, and rigging - where it can immediately and very substantially raise the center of gravity and lower a ship's stability.

4. Wind also is important in producing spray ice. The wind drives the waves, creating a cloud of spray that will strike the ship's hull. The rate of spray icing depends on the wind velocity and height of the waves. Spray can rise to the upper regions of the superstructure. Spray icing will appear at air temperatures below 32F. Forecasters should keep a close watch on superstructure icing criteria in order for the timely notification of conditions to visiting ships.

E. HURRICANES

1. Passages to the west or over the station present the most hazardous situations.
   a. Under the above conditions, the northeast quadrant (area of strongest wind) will pass over Narragansett Bay.

b. Wind force will depend on proximity of the passage as well as hurricane intensity and forward speed.
c. Record or near record rainfall should be expected.
d. The fully arisen sea is swept forward by the hurricane and the heavy rain run-off in the bay presents an ominous threat to lives and property in the vicinity of Narragansett Bay.

2. A hurricane passing to the east, or over Cape Cod, is a dangerous storm but does not create hazards as extreme as one passing directly over or to the west of the station.

   a. A northward-moving hurricane passing to the east will produce northerly winds.
   b. NAVSTA is exposed to a relatively large fetch area and unprotected areas can experience a 10 to 15 knot stronger wind. The western shore of Coasters Harbor Island is an example of such an exposed point.
   c. Hurricanes passing to the east of Narragansett Bay have not created serious flooding problems in the past.
   d. The proximity of the storms path will determine the amount of rainfall. Generally, rainfall will be less than that of a hurricane passing over or to the west of the station.

3. With the passage of a fully developed storm over Newport or within 100 miles to the west, a storm surge is possible.

   a. The average surge above normal tide at Newport is about 7 feet, Quonset Point is 10 feet, and Providence is 15 feet.
   b. The most dangerous conditions will exist when the storms passage and normal high tide coincide.
   c. Areas of NAVSTA that are most susceptible to flooding are Coddington Cove, the southern tip of Coasters Harbor Island (marina and O'club), and the area around K-61.
   d. Storms passing to the east of the area have increased the height of water in the bay, but this increase is usually not enough to create serious flooding on the Naval installation.

SECTION VI

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