LOCAL AREA FORECASTER'S HANDBOOK FOR NAVAL AIR STATION KEY WEST

PREPARED BY:
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SECTION I

BASIC DESCRIPTIONS

A. Naval Air Station and Naval Atlantic Meteorology and Oceanography Detachment, Key West, Florida

1. Location: The U.S. Naval Air Station Key West (NAS Key West), Florida is located five miles east northeast of the city of Key West on Boca Chica Key -- latitude 24 34' 45" North and longitude 810 41' 40" West (Figure (1-1)). The Key is bounded by the Atlantic Ocean on the east and southeast, the Gulf of Mexico to the north and west and the Florida Straits to the south.

The Naval Atlantic Meteorology and Oceanography Detachment (NAVLANTMETOCDET KEY WEST) is located at the NAS Key West Operations Building (A-244) in rooms 218-223. The office is staffed 24 hours a day with forecasting services available 7 days a week from 0600L to 1800L. After hours forecasting services are provided by the Sub-Regional Forecasting (SRF) center at the Naval Atlantic Meteorology and Oceanography Facility (NAVLANTMETOCFAC) in Jacksonville, Florida. Forecasting services do, however, become available around the clock upon the setting

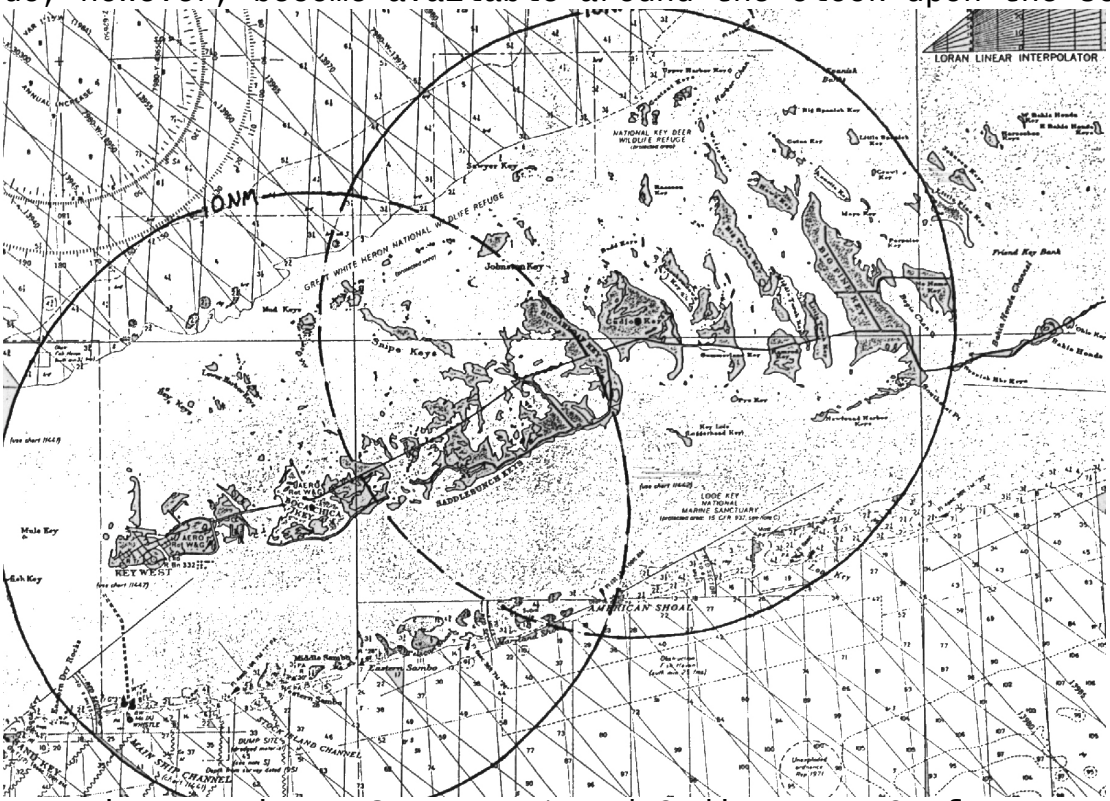

Figure I-i. NAS Key West and Cudjoe Key AOR for Forecasts and Wind Warnings.

of Tropical Cyclone Condition of Readiness III by NAS Key West and remain in effect until the Condition of Readiness reverts to IV or V.

2. Topography: The Florida Keys are a chain of islands extending southwesterly from the southeast coast of the Florida Peninsula. The closest point from Boca Chica Key to the Florida mainland is Cape Sable, approximately 55 miles to the northeast. Cuba is 90 miles to the south at its closest point.

Boca Chica Key is approximately three miles long and two and one-half miles wide. The Key is covered with a thin film of soil interspersed with tidal ponds. The sub-soil is limestone, freely mixed with coral and marl fill. Vegetation is limited to dense mangroves and scattered clusters of small trees; the exception being landscaped areas covered with grass and dotted with coconut palms.

3. Runway Description: The airfield consists of three asphalt runways with concrete turn-up areas. All runways are accessible by taxiways with a stabilized overrun area approximately 700-1000 feet. Runway 07 is the designated instrument/calm winds runway and will normally be used when surface winds are less than 10 knots, or at other times when it is operation ally advantageous. Field elevation is 6 feet above mean sea-level (MSL). Figure (1-2) depicts runway orientation at NAS Key West.

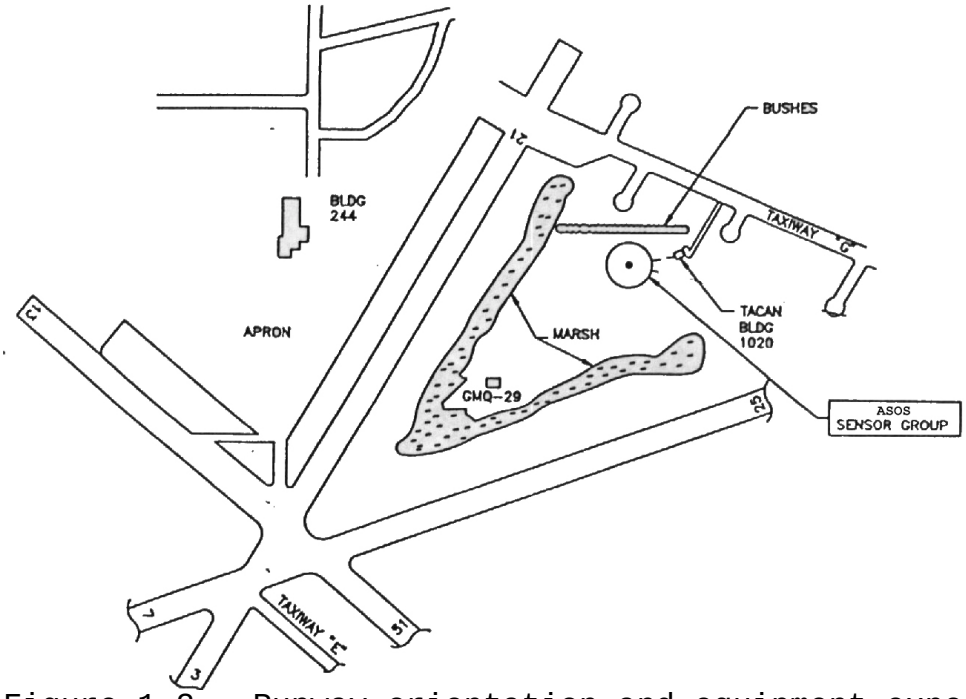

Figure 1-2. Runway orientation and equipment exposure.

The following are runway dimensions and headings:

RUNWAY	MAGNETIC HEADINGS	DIMENSIONS
07/25	073/253	10000' x 200'
03/21	031/211	7000' x 150'
13/31	131/311	7000' x 150'

As of 1993, the standard deviation for Key West is 2 degrees 45 minutes west with an annual increase of 8 minutes.

B. Meteorological Instrumentation: Figure (1-2) depicts the location and exposure of instruments outside the detachment.

1. Temperature and Dew Point Instrumentation:

a. The Automated Surface Observation System (ASOS) sensors are located approximately 2000 feet northeast of the intersection of the major runways, adjacent to the existing TACAN shelter.

b. An ML-450/UM Hand-held Electric Psychrometer is available.

2. Pressure Instruments: All equipment listed is located in the weather office, at an elevation of 28 feet above MSL.

a. A precision Aneroid Barometer ML-448/UM.

b. ASOS Sensors.

3. Wind Instruments:

a. The AN/UMQ-5C aerovane is located approximately 1400 feet northeast of the intersection of the major runways.

b. ID 586/UMQ-5 Wind indicators are located in the weather office, the Operations Duty Officer/Flight Planning area on the second deck, and in the Air Traffic Control Tower.

c. The ASOS aerovane is located in the open grass area between the approach ends of runways 250 and 210 near the Tacan Building #1020.

4. Rainfall Measuring Instruments: Due to the nature of air mass thunderstorms and rain showers, significant differences may be observed between the instruments listed below.

a. A tipping bucket rain gauge is located approximately 2000 feet northeast of the intersection of the major runways and is connected to the ASOS.

b. A standard 4 inch plastic rain gauge is located near the edge of the apron northwest of building A-244. This rain gauge is used in the event of ASOS failure and during periods of high winds.

C. Communications Equipment and Circuits.

1. Plain Language Data.

a. Contel Meteorologist Workstation (CMW) which has replaced teletype workstations, is used for the transmission and receipt of military observations, forecasts, and other alpha numerical data.

2. Products and Imagery.

a. The Meteorological Information Data Display System (MIDDS), is a dual Pentium processor which intigrates text data and graphic imagery providing analyses and prognosis products. Imagery sources include the GVAR link with NLMOC Norfolk, WSR-88D (NEXRAD) Doppler Radar, and the Lightening Position and Tracking System (LPATS).

b. A Plain Paper Laser Facsimile is used for rapid transmission of DD175-1's and weather warnings from NAVLANTMETOCFAC Jacksonville during evening hours and the routine transmission of environmental products to and from NAVLANTMETOCDET Key West.

3. Miscellaneous.

a. Pilot-to-Metro Service (344.6 MHZ). The Pilot-to-Metro Service provides direct voice communications between pilots and the Forecast Duty Officer (FDO).

b. Computer automated telephone information system (phone forecast ext. 2306). Provides a general environmental outlook to local users.

c. Intercom-NLMOD-Tower, GCI. Provides a direct link for rapid communications of weather information to the Air Traffic Control and Ground Control Intercept (GCI).

d. A PC to TV converter is utilized to produce and transmit local and Bingo Field conditions to various places around the base.program

e. NODDS/OPARS programs on MIDDS, provides a means of receiving mission specific data from Fleet Numerical Meteorology and Oceanography Center (FLENUMMETOCCEN) in Monterey, CA.

f. Various CPU's. Provides a means for completing numerous administrative functions to include receiving E-mail and ccMail messages.

g. An unclassified general access web page provides forecast products both text and graphic, satellite imagery, and tropical warnings and forecast tracks to a variety of commands and agencies in the lower Keys. The IP address is: http://205.67.213.10

D. Areas of Responsibility (AOR).

1. The area of responsibility for forecasts and wind warnings for NAS Key West is defined as a 10 nautical mile radius from the center of Boca Chica Key as depicted in Figure (1-1).

2. The area of responsibility for wind warnings for Cudjoe Key is defined as a 10 nautical mile radius from the center of Cudjoe Key as depicted in Figure (I-1).

3. The area of responsibility for recommending Thunderstorm Conditions of Readiness for the Key West area is broken down into two areas, both having a 5 nautical mile radius as depicted in Figure (1-3).

4. The area of responsibility for recommending Thunderstorm Conditions of Readiness for Cudjoe Key is 40 nautical miles for condition II and 20 nautical miles for condition I as depicted in Figure (1-4).

5. Key West Opareas. Includes W-174, W-465, and Key West Surface Oparea as depicted in Figure (1-5).

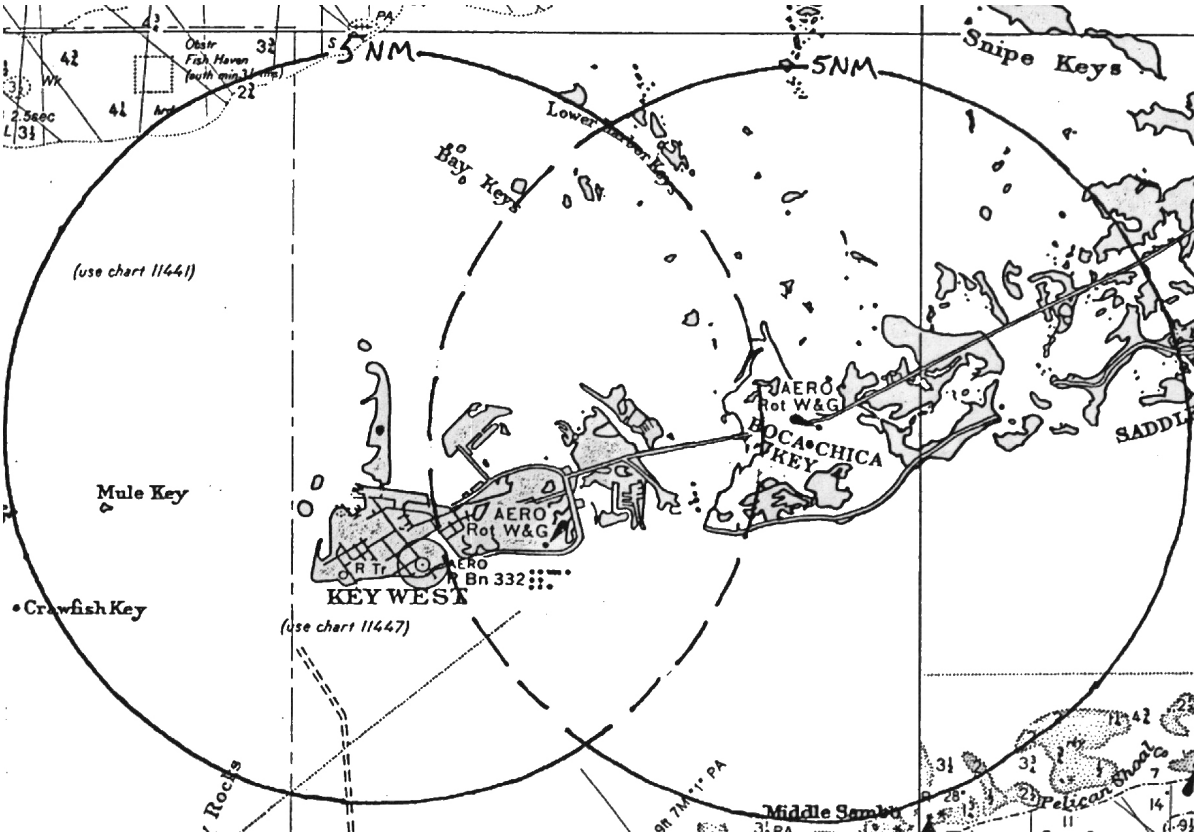

Figure 1-3. NAS Key West and Fleming Key AOR for Thunderstorm Conditions of Readiness.

6. COMNAVBASEJAX Area Bravo III. Area Bravo III is comprised of Dade and Monroe counties of south Florida as depicted in Figure (1-5).

E. Local Operating Areas.

1. Key West Local Flying Area. The NAS Key West local area is that airspace over the state of Florida within 350 NM of NAS Key West and airspace within W-174 and W-465 (Figure (1-5)).

2. W-174 and W-465. TARPON Key West controls these airspaces during weekday operation, and Miami ARTCC controls them after local operations secure. These warning areas are utilized by tenant squadrons and transient aircraft for training purposes.

3. R-2916. Restricted Area 2916 is located within a 2 statute mile radius of latitude 24 degrees 42 minutes north and longitude 81 degrees 30 minutes west (Cudjoe Key). This area contains two (2) 40' x 120' balloons moored at altitudes from the surface to 10,000 feet (Figure (1-4)).

4. Key West Surface Oparea. Depicted in Figure (1-5).

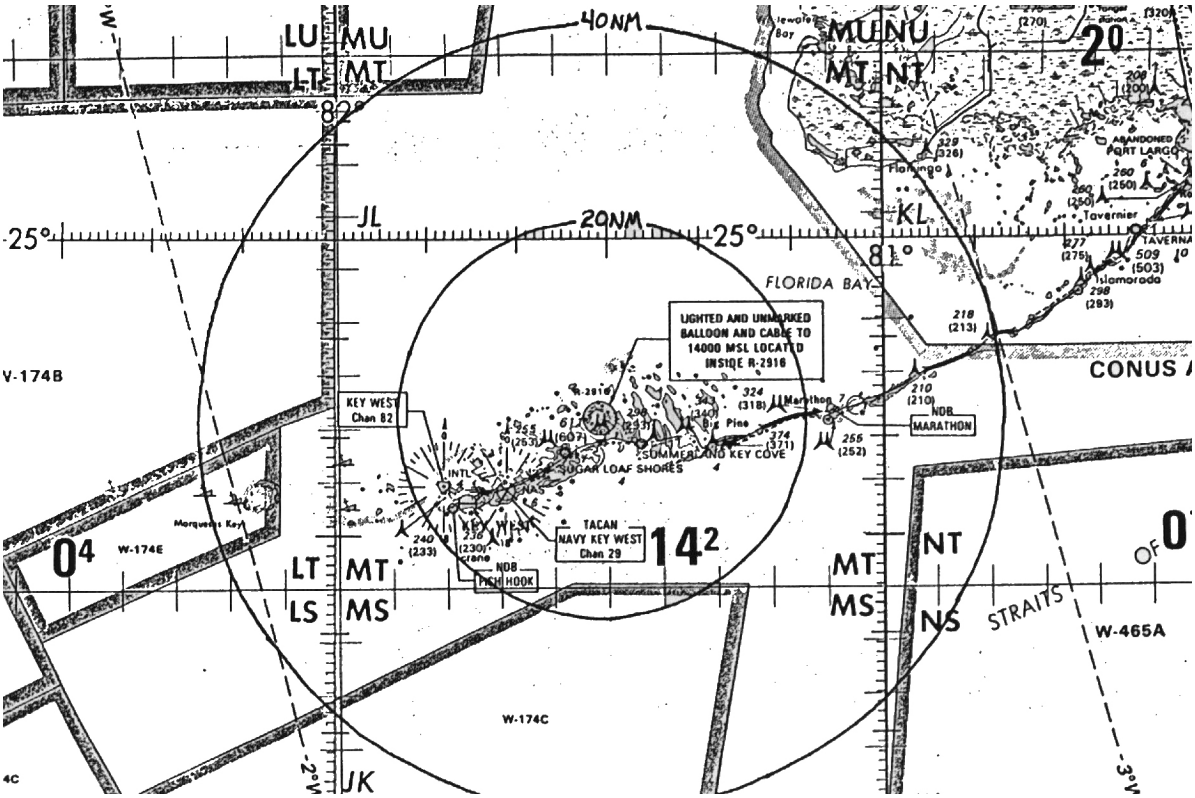

Figure 1-4. Cudjoe Key AOR for Thunderstorm Condition of Readiness.

F. Commands Supported

1. Commander, Joint Interagency Task Force - East (JIATF-East). A Joint Services/Agencies Command whose mission is to provide the necessary operations for detection, monitoring, and deterrence of drug smuggling operations.

2. Naval Air Station Key West. Maintains and operates facilities and provide service and materials to support operation of aviation activities as designated by the Chief of Naval Operations. Additionally, the Commanding Officer, NAS Key West, is the area coordinator for COMNAVBASEJAX Area Bravo III.

3. Caribbean Regional Operating Center (CARIBROC). Provides navigational assistance, radar advisories and communications control necessary for the tracking and correlation of air traffic of special interest to insure intelligence necessary for CINCLANT operations to protect the Atlantic Command.

4. Naval Air Warfare Center Detachment Key West. Supports the mission of the parent command in providing staging area, engineering support, and access to open ocean environments for

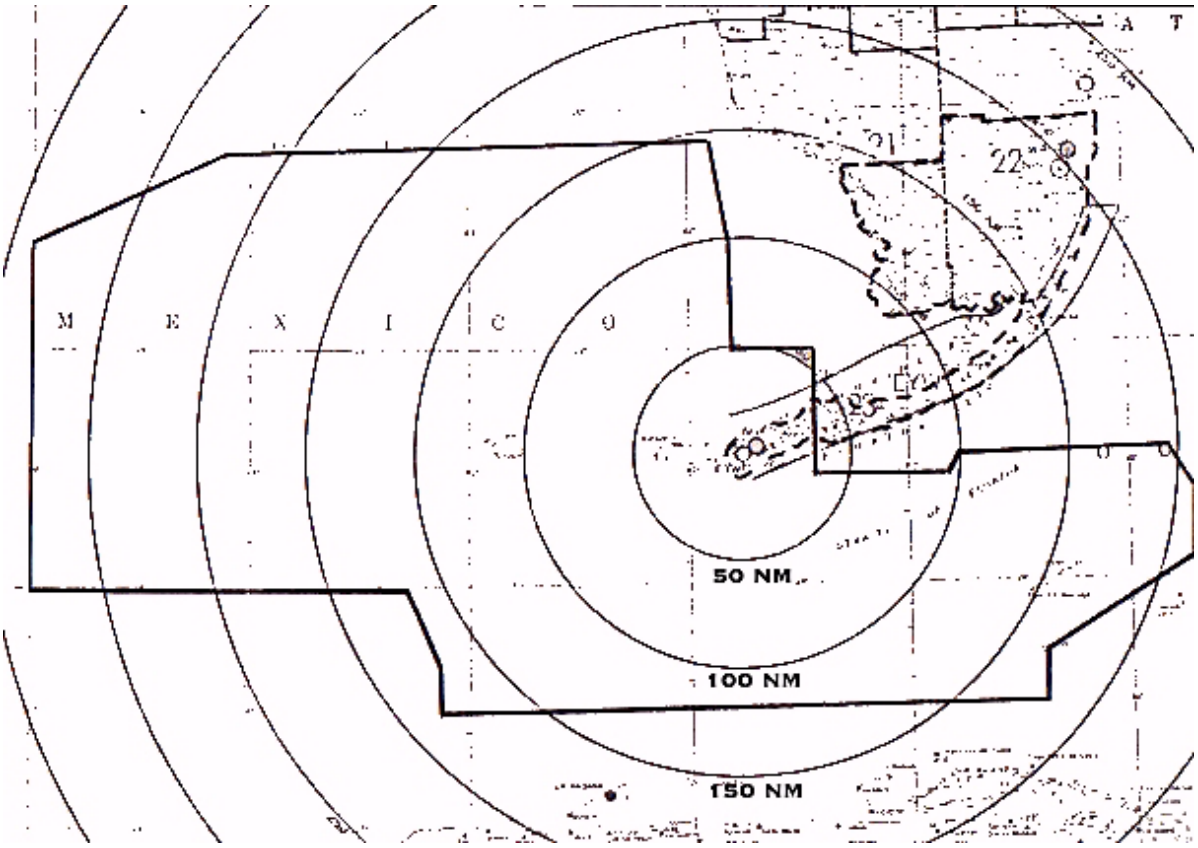

Figure 1-5. NAS Key West OPAREAS (Solid) and COMNAVBASEJAX Area Bravo III (Dashed).

development/engineering test and evaluation of prototype, anti-submarine, navigation and other pertinent system developments within the scope of the Naval Air Warfare Center Detachment.

5. Cudjoe Key AFS. Provides surveillance radar coverage of south Florida, the Keys, western Bahamas, Florida Straits, and southeastern Gulf of Mexico.

6. Fighter Squadron One Zero One (VF-1O1). Fighter Squadron One Zero One Detachemnt's mission is to train pilots, radar intercept officers, and enlisted maintenance personnel in the operation and employment of the supersonic F-14A and A-Plus Tomcat Fighters.

7. Other Key West Commands Receiving Routine Support

a. Boca Chica Key
   (1) NCTAMSLANT DET KEY WEST
   (2) Personnel Support Activity Detachment (PSD)
   (3) Naval Aviation Engineering Service Unit (NAESU)
   (4) Naval Investigative Services (NIS)

(5) Naval Medical Clinic (NMCL)
(6) Branch Medical Clinic (Dispensary)
(7) Branch Dental Clinic
(8) Resident Officer in Charge of Construction (ROICC)
(9) Navy Resale Activity (NEX)

b. Trumbo Point Annex
(1) U.S. Coast Guard Group Key West
(2) Naval Research Laboratory (NRL) (Fleming Key)
(3) Naval Legal Service Office Detachment (NLSOD)
(4) U.S. Army Special Forces Waterborne Operations Division (SFWOD)

c. Truman Annex
(1) Naval Security Group Activity Key West (NSGA)
(2) 6947th ESS (USAF)
(3) 749th Military Intelligence Company (USA)
(4) Foreign Broadcast Information Service (FBIS)

9. COMNAVBASE Jacksonville Area BRAVO III Naval and Marine Corps Activities Outside of Key West Receiving Severe Weather Warnings from NAVLANTMETOCDET Key West.

a. NAVOBSY SUBSTATION Richmond FL.
b. NAVCRUITDIST Miami FL.
c. Navy and Marine Corps Reserve Readiness Center, Miami, FL

G. Support Requirements provided on a Routine Basis.

1. Local Area Forecasts
2. Staff Weather Briefings
3. Aviation briefing services including OPARS Flight Planning to assigned and transient aircraft.
4. Notification of potential destructive weather phenomena including Small Craft/Gale/Storm Warnings and recommend appropriate conditions of readiness.
5. Tropical Cyclone Threat briefings and recommendations for the setting of the appropriate Tropical Storm/Hurricane Condition of Readiness.
6. Oceanographic Support for Planning/Operational Uses
7. Climatological/Astronomical/Tidal Data.
8. Sonic Boom Advisories
9. Refractivity Forecasts

H. Support Requirements provided on a Request Basis.

1. Specialized OPAREA Forecasts and Warnings
2. Climatological Studies
3. Seasonal Weather Briefings
4. Pre-Sail/Exercise Briefings
5. Presentations (Hurricane Preparedness, Hazards to Aviation, etc.)

I. References

1. CFADINST 5440.1 (Series), Commander Fleet Air Detachment Key West Manual
2. NASKWINST 3730.1 (Series), Aircraft Hurricane Evacuation
3. NASKWINST 3120.1 (Series), NAS Key West Deployment Manual
4. NASKWINST 3130.2 (Series), Search and Rescue
5. NASKWINST 3710.2 (Series), Air Operations Manual
6. NAVEASTOCEANCENINST 5450.1 (Series), Functions of Eastern Region Commands and Detachments
7. NASKWINST 3140.5 (Series), Hurricane and Destructive Weather Bill
8. CINCLANTFLTINST 3120.26 (Series), Atlantic Fleet Operating Areas and Warning Areas
9. COMHELWINGSLANT OPORD 2000, Annex F

SECTION II

CLIMATOLOGY

A. Narrative Climatological Summary

Key West has a notably mild tropical-maritime climate due in no small part to its proximity to the Florida Current located in the Straits of Florida approximately 12 miles to the south and southeast, and the tempering effects of the Gulf of Mexico to the west and north. The average temperature during the winter is

only 13 degrees lower than in the summer. There is no known record of frost, ice, sleet, or snow in Key West. Prevailing easterly trade winds suppress the usual summertime heating. Diurnal variations throughout the year average only about ten degrees.

Northeast to east winds dominate the autumn and winter months due to polar outbreaks reaching the Gulf of Mexico. East to southeast winds prevail during the spring and summer months due to the influence of the subtropical ridge and the Bermuda High. Wind speeds throughout the year average between 8 to 12 knots with a yearly mean speed of 10 knots.

There are two distinct and alternating seasons in Key West; dry and wet. The dry season extends from December through April during which NAS Key West receives abundant sunshine and approximately 22% of its annual rainfall (yearly average is slightly over 40 inches). This rainfall usually occurs in advance of cold fronts.

The rainy season is from May through October. During this period, the numerous showers and thunderstorms account for over three-quarters of the average annual rainfall, with early morning being the most favorable time for showers. Easterly waves are common during this season and bring an abundance of rainfall. The Hurricane season coincides with the rainy season and extends from 1 June through 30 November -- middle August to early October are the months with the highest probability of a tropical disturbance affecting the Key West area.

Flying weather is exceptionally good with marginal weather occurring less than one percent of the time. While humidity remains relatively high during the entire year, fog is quite rare, occurring only once or twice per year. Climatological for NAS Key West appears at the end of this section. More detailed information can be found in the references listed in paragraph D.

B. Synoptic Climatological Narrative.

1. JANUARY. By January the Bermuda High has receded eastward and the influence of the subtropical ridge on the Key West area is significantly lessened. Polar outbreaks reaching the Gulf of Mexico bring modified Continental Polar Air over south Florida and the Florida Keys with increasing frequency. Frontal passage occurs once every six to eight days. Fronts passing the Key West area with a Northeast-Southwest orientation usually have little weather, although they may be accompanied by prefrontal squall lines. On the other hand, fronts with an east-west orientation frequently develop waves in the Gulf of Mexico and bring light to

moderate rain and drizzle to the Key West area, and seldom persist for more than 18 to 24 hours.

2. FEBRUARY. The Bermuda High is near its extreme eastern position and the affects of the subtropical ridge on the Key West area are minimal. Polar outbreaks bringing Continental Polar Air into the Gulf of Mexico are quite frequent during the first part of this period, reaching into the Caribbean before halting their southward motion. There is usually little weather associated with these outbreaks during their passage over the local area; only an abrupt northerly wind component and cooler temperatures. It should be noted that some of these fronts may become stationary over the Florida Straits and the resultant bad weather will affect not only the Straits, but southeastern Florida as well. Furthermore, while stationary over the northern Gulf of Mexico, a large number of these fronts develop waves which move east-northeast as they pass over Key West and bring 12-18 hours of rain, showers, and drizzle. During the latter part of the month, this process becomes less frequent and frontal passage decreases to once every eight to 12 days. As the fronts enter the Gulf of Mexico, they become oriented east-northeast/west-southwest and become stationary over lower Florida prior to moving towards the east-northeast.

3. MARCH. Polar outbreaks affect the Key West area less frequently (only two to four frontal passages). Key West is partly under the influence of migratory high pressure systems moving over the southeastern United States and partly under the influence of the subtropical ridge which begins to re-establish itself over Florida later in the month. Skies are generally partly cloudy and precipitation is usually in the form of afternoon showers.

4. APRIL. The Bermuda High is returning to its normal position. The subtropical ridge re-establishes itself over Florida and the Gulf of Mexico. A few polar outbreaks occur in the Gulf of Mexico during April with an occasional cold frontal passage through the Key West area early in the month. Fronts that become stationary across Florida frequently develop waves in the eastern Gulf of Mexico that move eastward across Florida. During the latter part of the month, a few easterly waves may pass the Key West area; however, most will pass to the south.

5. MAY. May is considered the transition period into the rainy season as the subtropical ridge becomes well established over the Key West area. Fewer polar outbreaks affect the northern Gulf of Mexico, and frontal passage at Key West is rare. Weak stationary fronts across the southeastern United States that form waves in the northern Gulf of Mexico are fairly common; however, these waves seldom affect the local area. The frequency of easterly

waves that affect Key West increases and the incidence of waterspout activity increases in or near showers or thunderstorms.

6. JUNE. Unstable maritime tropical air from the Bermuda High dominates. Showers and thunderstorms increase in frequency through the month. Easterly waves and induced troughs affect this area three to four days during the month. Polar outbreaks seldom affect the Key West area during June, although weak fronts may extend into the extreme northern Gulf of Mexico. The Hurricane season begins on 1 June (and ends 30 November -- though tropical cyclones do occur outside this normal season) and tropical disturbances may develop in the Caribbean or Gulf of Mexico which may affect this area.

7. JULY. The westward extension of the Bermuda High dominates the area, although, the associated pressure gradient is usually flat and weak. Frequently, the ridge will split in the vicinity of Cuba, leaving a small bubble of high pressure in the Gulf of Mexico and inducing a trough over Cuba and the Bahamas. Easterly waves affect the Key West area six to eight days during the month. Tropical disturbances frequently develop in the Gulf of Mexico and may affect this area.

8. AUGUST. Key West remains under the influence of the westward extension of the Bermuda High. Warm, moist unstable air covers the area. Easterly wave passage occurs about every five to seven days. Tropical disturbances frequently form in the Caribbean, Western Atlantic, or in the Gulf of Mexico and may affect this area.

9. SEPTEMBER. The westward extension of the Bermuda High begins its slow regression eastward. The polar front occasionally lies over the southeastern United States and a few polar outbreaks reach into the Gulf of Mexico. Easterly wave passage occurs every five to seven days. Tidal flooding of extreme low lying areas may occur within two weeks of the Autumnal Equinox (22 September).

10. OCTOBER. The westward extension of the Bermuda High continues to recede eastward. Weak polar outbreaks occur in the Gulf of Mexico and one to two weak fronts may pass through the Key West area, though the majority of them dissipate prior to reaching the southeastern Gulf and Florida Keys. Those fronts that do continue through often become stationary over the Florida Straits and pass back to the north as warm fronts shortly thereafter. Easterly wave passages are not as common in October as in September, with only three to five affecting this area throughout the month. Tropical cyclones continue to form in the southern North Atlantic Ocean and the Western Caribbean. There

are two primary tracks for these systems; one that extends across Western Cuba while the other recurves approximately 600 miles east of Key West.

11. NOVEMBER. November is the transition to the dry season in the Key West area and precipitation decreases dramatically. The occurrence of polar outbreaks reaching the Gulf of Mexico is fairly frequent and three to four cold fronts may pass through the Key West area. Cold fronts that approach the area with a north-northeast to south-southwest orientation usually have little weather at the frontal boundary; however, they are often preceded by a squall line. On the other hand, fronts with an east-west orientation have a tendency to stall over the Florida Straits and progress northwards as a warm front. These fronts usually produce considerable precipitation and last for extended periods.

The Bermuda High is displaced eastward to its normal winter position and modified Continental Polar Air dominates the local area during most of the month. Migratory high pressure systems move eastward over the southeastern United States. Although very few easterly wave passages occur in November, some tropical cyclones do develop in the southern North Atlantic Ocean and the western Caribbean. The two primary cyclone tracks are; west of Key West, beginning from near the Yucatan Peninsula and continuing north-northeast through the Gulf of Mexico, and from the central Caribbean, tracking northeast into the Atlantic.

12. DECEMBER. Frequent polar outbreaks reach the Gulf of Mexico during December with cold fronts passing through the Key West area about every seven to ten days. Wave development along the cold fronts in the Northern Gulf of Mexico is common. Again, fronts with a north-northeast to south-southwest orientation usually have little or no associated weather at the front, but may be preceded by a squall line. Fronts with an east-west orientation usually have a considerable amount of precipitation in the form of rain and drizzle, with embedded showers in the frontal zone. The predominant air mass over Key West is modified Continental Polar. Easterly wave moving through the area are rare.

C. Special Features.

1. Temperature. The average yearly temperature is 78 degrees. During the summer months, the maximum temperatures are in the upper 80's during the day and the minimum temperatures are in the upper 70's at night. Normal maximum temperatures range from 90 plus during July and August to the middle 70's during January and February. During the winter months when polar outbreaks occur, temperatures may drop as low as the mid 40's, but this is rare.

The extreme maximum temperature recorded at NAS Key West was 95 degrees in both May and June of 1969. The extreme minimum temperature recorded was 43 degrees in January, 1981, and again in
December, 1989.

2. Humidity. The annual average relative humidity is near 73 percent, with a nighttime relative humidity average of 78 percent and a daytime relative humidity average of 67 percent. A relative humidity below 60 percent is rare.

3. Precipitation. Key West is the driest city in Florida. Its location and the position and intensity of the subtropical high place Key West far to the south of the average frontal position. Furthermore, the lack of a large land mass serves to deter convection. Between 1945 and 1993, the average annual precipitation at NAS Key West was 40.3 inches. During this period, September was the wettest month with an average monthly rainfall of 6.5 inches. March and April were the driest months with an average monthly rainfall of 1.7 and 1.6 inches, respectively. Coincidentally, these months also average the fewest number of days with precipitation, approximately eight while September averages the most, 21 (Figure II-1). The maximum *24*-hour rainfall total occurred in November 1980 when a total of 18.40 inches fell. Solid precipitation is essentially nonexistent in the Key West area, but hail is a possibility whenever thunderstorms occur.

4. Winds. Prevailing surface winds are from an easterly direction, East to Southeast during the summer and East to Northeast during the winter. Velocities average four to six knots 22 percent of the time, seven to ten knots 36 percent of the time and 11 to 16 knots 25 percent of the time. Lower average wind speeds occur during the late spring and early summer where approximately 75 percent of the measured wind speeds were less than ten knots (and 40 percent were less than six knots). Alternately, higher averages occur during late winter and early spring when 75 percent of the average wind speed were greater than 7 knots (40 percent greater than 11 knots). There also appears to be a slight diurnal change to wind speed in that shortly after sunset there is a nominal decrease in speed. in speed shortly after sunset. Finally, the indicated wind speed at NAS Key West is generally 5 to 7 knots less then that experienced over open water in the local area.

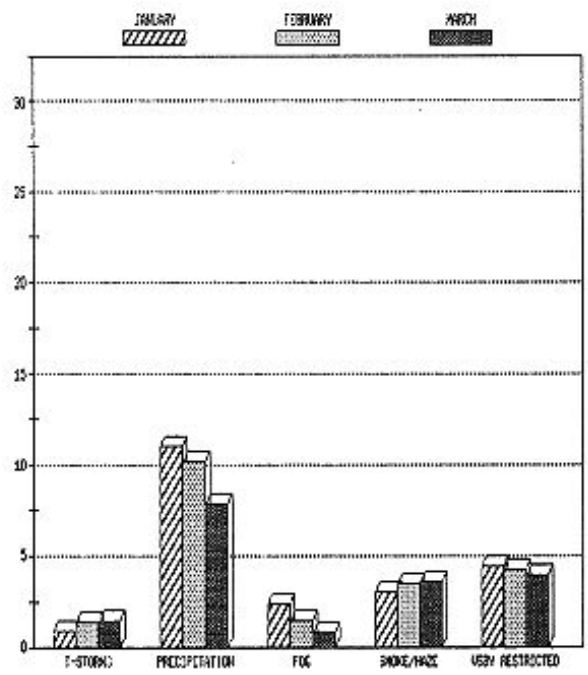

Figure II-1A. Winter weather (January - March).

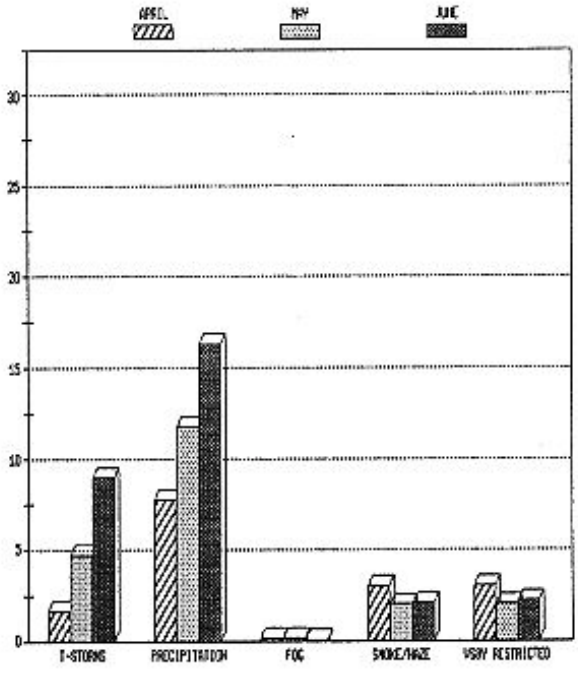

Figure II-1B. Spring weather (April - June).

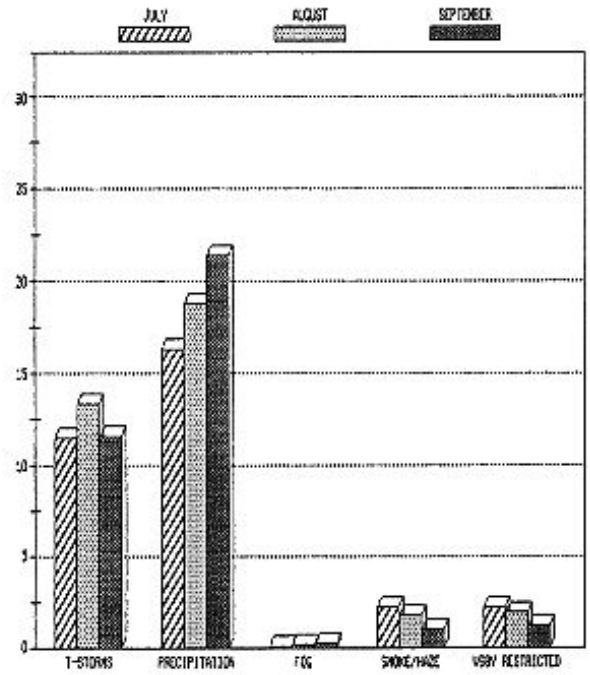

Figure II-1C. Summer weather (July - September).

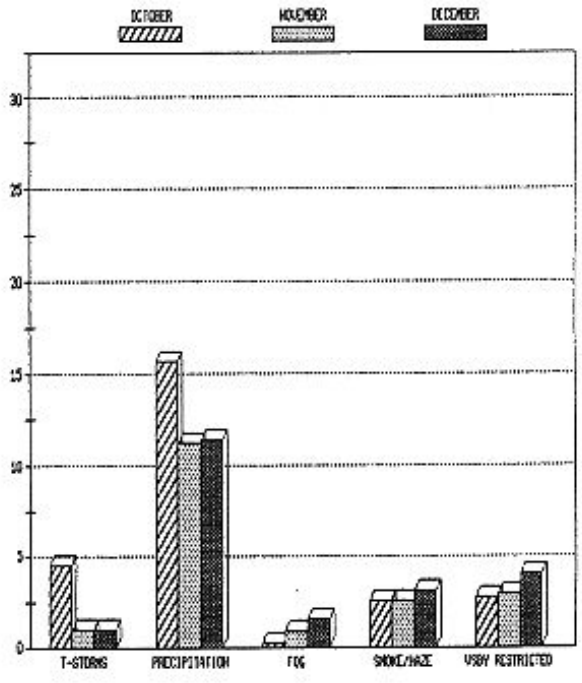

Figure II-1D. Autumn weather (October - December).

Figure II-1. Average number of days with selected atmospheric phenomena, by season, for period 2949 - 1993. Note that "t-Storms" include waterspouts and tornadoes.

5. Ceilings. Low ceilings are usually not a problem in the Key West area. Ceilings are above 1,000 feet 98 percent of the time. Low ceilings (below 1,000 feet) normally occur during frontal passage, easterly wave passage and in association with thunderstorms during the summer months.

6. Visibility. Visibility greater than six miles prevails over 98 percent of the time; however, as Figure (lI-i) shows, certain selected atmospheric phenomena do occur in the Key West area that serve to reduce visibility. The most common cause of reduced visibility is precipitation which generally lowers visibility to three to six miles in light to moderate rain showers, and occasionally to near
zero in heavy showers. Haze and smoke are the next most common causes and seldom reduce visibility to less than five miles. Fog is rare at Key West, averaging only seven days per year, but does occur during one or two days per year wherein reduced visibilities range from zero to three miles.

7. Cloudiness. Total sky cover in the Key West area averages 4 to 7 tenths; i.e., partly cloudy, with the higher averages from May through October (Figure 11-2). During late spring, summer and early fall the area is under the influence of a subtropical ridge of high pressure and most days begin as partly cloudy with cumulus congestus and thin

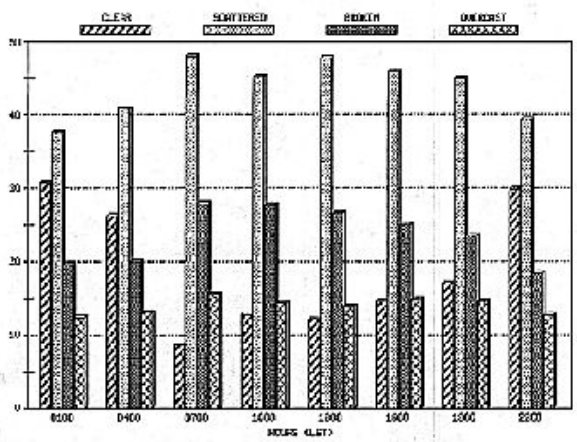

Figure II-2A. February sky cover.

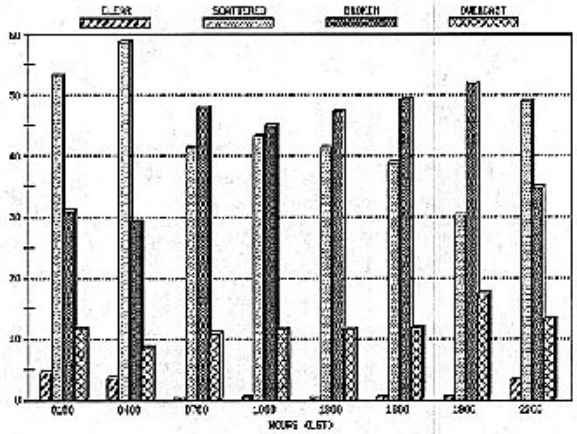

Figure II-2B. August sky cover.

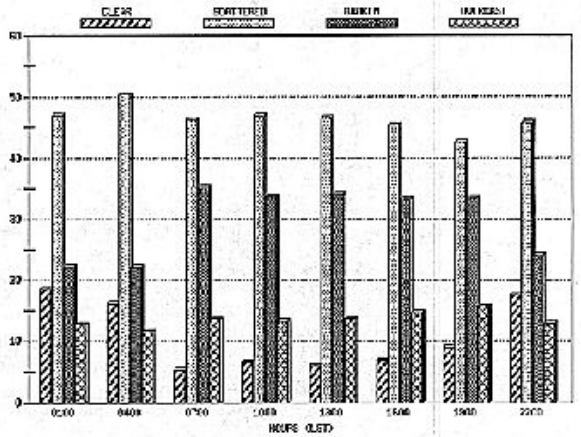

Figure II-2C. Annual sky cover.

cirrus as the predominant cloud types. By mid-afternoon to

Figure 11-2. Percent of time with total sky cover amounts at NAS Key West.

early evening, scattered (to occasionally broken) cumulonimbus clouds appear with associated altocumulus and altostratus clouds. During the winter, clear days will occur with an intensifying ridge over south Florida and from 12 to 24 hours after passage of a northeast to southwest oriented cold front. These fronts are usually accompanied by prefrontal squall lines with considerable shower and thunderstorm activity. Broken to overcast stratocumulus and altocumulus occur along and behind the front. Cloudy conditions, with broken to overcast multilayered clouds, occur with frontal wave formation in the Gulf of Mexico.

8. Thunderstorms. Thunderstorms occur in the Key West area every month of the year, but are most prominent during the months of July, August and September. The most prevalent type of thunderstorm is the air mass which occurs during the warmer months. In general, little thunderstorm activity takes place from dawn to mid-day. Air mass thunderstorms will normally begin development around mid afternoon and reach maximum intensity shortly after sunset when radiational cooling aloft allows for more convection. Thunderstorms activity can continue well into the evening and early morning hours. Additionally, isolated thunderstorms observed on the horizon may move through the Keys just prior to dawn. Wind gusts from 25 to 34 knots can be expected. Strong wind gusts (in excess of 50 knots) rarely accompany the summer thunderstorms. Frontal and prefrontal thunderstorms occur during late fall, winter and early spring when polar air masses are of such intensity to reach the Florida Keys. Frontal and prefrontal thunderstorms can and do reach severe limits but this type of activity is not frequent and is usually of short duration.

9. Fog. Fog in the Key West area is a rare phenomena and justifies the statement that Key West is the least foggiest location in the country. When fog does occur; however, it will usually be one of three types, advection, radiation, or frontal, and occur only during the colder months of the year (Figure II-1)

If sufficient moisture is present, the cooling of a clear night may produce Radiation fog in low lying areas. This fog normally dissipates shortly after sunrise. Advection fog, on the other hand, may occur within 18-36 hours after passage of a strong cold front. The temperature contrast between the dry cold air behind the front and the warmer sea surface results in an increase in moisture and the formation of fog, but not until the post frontal winds decrease to approximately 10 knots. At this time what appears to be haze starts to obstruct visibility and as the winds continue to decrease the fog thickens. During the daylight hours

under heavy clouds, the fog will dissipate over land yet will remain quite dense over the water and vary in intensity over the Keys. This type fog is extremely unpredictable as slight changes in wind speed or a momentary increase in cloud cover will cause the fog to move over land. Finally, frontal fog may occur when a cold front is moving extremely slow over the Keys or becomes stationary in the vicinity of Key West. This fog will usually form a few hours before sunrise and dissipate within two to three hours after sunrise, unless a heavy cloud layer is present in which case dissipation may be somewhat slower, three to five hours.

10. Waterspouts and Tornadoes. Florida Bay is considered the waterspout capital of the world as this area annually experiences from 50 to 500 waterspouts. Waterspouts are most common from May through October; although sightings have been reported during all months of the year. Waterspouts tend to from on days with high temperatures and humidity, and relatively calm wind. They most often develop from lines of cumulus congestus clouds that seemingly run parallel to the Keys though infrequent sightings have also occurred from small trade cumulus with tops less than 15,000 feet. There are two times for maximum formation; from around 1130 to 1330 and from 1630 to 1900. Most funnels are of short duration, lasting less than 20 minutes. It is not uncommon to observe two or three funnels at the same time or possibly out of the same cloud. Most waterspouts retreat back into the cloud when moving over land.

Tornadoes are extremely rare and, as a rule, are associated only with hurricanes or tropical storms.

11. Hurricanes. The National Weather Service has identified Key West as the most hurricane-prone area in the United States. Recent events, and the lack of hurricane activity within 150 nm of Key West, may lead one to believe otherwise. Nonetheless, hurricanes are of grave importance to the residence of the Keys; especially in view of the fact that the only land-based egress to a safe haven is the Overseas Highway (USl). The Florida State Emergency Management Agency indicates a minimum of 36 hours for residence to evacuate the Keys.

The Atlantic Basin experiences eight to ten tropical storms and hurricanes each year (the number varies with each source). Since 1886, approximately 78 hurricanes and half as many tropical storms have passed within 150 miles of Key West; an average of one "storm" per year. The actual percentage of storms affecting Key West, as it relates to the total number of storms over the Atlantic Basin is approximately 8.4 percent, or less than one storm per year.

Due to the protection offered by Cuba to the south, the reef, and the relatively shallow waters surrounding the Keys, hurricane damage to the Key West area has been minimal. The most severe hurricane affecting Key West was "Inez" which passed five miles

Radii		Jun	Jul	Aug	Sep	Oct	Nov	Total
150 NM	Storm	3	2	3	13	15	1	37
	Hurricane	5	4	20	24	22	3	78
100 NM	Storm	3	1	2	11	10	1	28
	Hurricane	5	1	13	18	15	3	55
50 NM	Storm	1	-	1	7	5	-	14
	Hurricane	3	-	7	9	9	2	30
Atlantic Basin		56	72	215	307	185	41	876

Table II-1. Number of tropical storms and hurricanaes to pass within a given radii of Key West for the period 1886 through 1995.

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to the north on 4-5 October 1966. The maximum observed wind during passage was 84 knots from the south-southeast. For the period of record 1886 through 1993, five hurricanes have passed within 100 NM of Key West during the months of June, July and August. Twelve hurricanes have passed within 100 NM during the month of September and 14 during the months of October and November. Some of the more notable hurricanes to pass through the area are presented in Table 11-2. More detailed information on tropical cyclone tracks can be found in the references listed at the end of this section.

Hurricanes are a feature of great interest due to the extremely low lying terrain of the Keys (averaging 4 to 5 feet above sea level) and the subsequent affects of storm surges which could result in extensive flooding of the Naval Air Station. A storm surge of eight feet would cover the runways at NAS with two feet of water.

NAME (Year)	Category	Date(s)	Max Wind (kts)	Mean SLP (in)	Max Surge(ft)
Great Labor Day (1935)	5	Aug 29 - Sep 10	> 200 (est)	26.35	20+
Key West (1919)	4	Sep 2-15	120	27.37	Unk
DONNA (1960)	4	Aug 29 -	140	27.46	13+

		Sep 13			
INEZ (1966)	3	Sep 21 - Oct 11	130	27.38	15~
BETSY (1965)	3	Aug 27 - Sep 13	135	27.82	9
Key West/Miami (1909)	2	Oct 6-13	115	28.55	Unk
FLOYD (1987)	1	Oct 9-14	72	29.32	Unk

Table II-2. Examples of (Saffir/Simpson) Category Hurricanes that have passed within 50 NM of Key West

Category	Description	Winds	MSL Pressure	Surge
1	Weak	65-82 kts	28.94 in	5 ft
2	Moderate	83-95 kts	28.50-28.91 in	6-8 ft
3	Strong	96-113 kts	27.91-28.47 in	9-12 ft
4	Very Strong	114-135 kts	27.17-27.88 in	13-18 ft
5	Devastating	> 135 kts	< 27.17 in	> 18 ft

Table 11-3. Saffir/Simpson Scale for Classifying Hurricanes.

D. References

1. NAVAIR 50-1C-550 U.S. Navy and Marine Corps Meteorological Station Climatic Summaries.
2. International Station Meteorological Station Climate Summary, Version 3.0, March 1995.
3. U. S. Navy Marine Climatic Atlas of the World March 1992.
4. Global Tropical/Extratropical Cyclone Climatic Atlas, Version 1.0, March 1994
5. Mariners Worldwide Climate Guide to Tropical Storms at Sea.
6. Tropical Cyclones of the North Atlantic Ocean.
7. The Climate and Weather of Florida
8. Florida Hurricanes and Tropical Storms - 1871-1993: An Historical Survey

Climate Summary for NAS Key West

Lat: 24° 35′ North				Elev: 6 Feet				Lon: 081° 42′ West					
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ann**
Temperature (°F)													
Mean Maximum	75	75	78	82	84	87	89	89	88	84	80	76	82
Mean	70	70	73	77	80	83	84	84	83	80	75	71	78
Mean Minimum	65	65	69	72	76	79	80	79	78	75	71	66	73
Extreme Maximum	85	86	88	90	93	95	95	94	93	91	89	89	95
Extreme Minimum	43	45	47	54	65	68	70	69	66	60	50	43	43
Mean Sea Surface Temp	71	72	74	78	82	85	87	87	85	82	76	72	79
Precipitation (Inches)													
Mean	2.0	2.0	1.7	1.6	3.9	5.3	3.7	4.9	6.5	4.3	2.5	1.8	40.2
Maximum	16.8	5.7	7.5	9.2	12.9	17.4	11.2	12.6	15.4	14.4	27.3	9.9	63.3
Minimum	T	T	T	T	0.2	0.3	0.7	1.1	1.5	0.6	T	T	19.6
24 Hour Maximum	7.2	4.5	2.5	6.3	5.7	6.8	4.6	3.8	5.5	6.1	18.4	5.7	18.4
Relative Humidity (%)													
AM 0700L	81	80	78	75	74	77	75	76	80	80	81	81	78
PM 1600L	69	67	65	63	64	67	65	66	69	69	69	69	67
Dew Point Temp (°F)	61	61	63	65	69	73	73	74	74	70	66	62	68

Table II-I. Climate Summary for NAS Key West from 1945-1993.

Climate Summary for NAS Key West													
Lat: 24° 35′ North				Elev: 6 Feet				Lon: 081° 42′ West					
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ann**
Sky Cover	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT	SCT
Prevailing Wind (Knots)													
Direction	NE	E	ESE	E	ESE	ESE	ESE	ESE	E	NE	NE	NE	ESE
Speed	9	11	11	12	10	9	8	8	9	9	9	9	10
Maximum Gust	62	46	63	53	52	72	48	48	80	84	55	55	84
Mean Number of Days with:													
Precipitation	11	10	8	8	12	16	17	19	21	16	11	12	161
Precipitation ≥ 0.01	6	6	5	4	8	11	11	14	16	11	6	6	104
Precipitation ≥ 0.05	1	1	1	1	2	3	2	3	4	3	1	1	23
Thunderstorms	1	1	2	2	5	9	12	14	12	5	1	1	65
Fog	2	1	1	-	-	-	-	-	-	-	1	2	7
Maximum Temperature ≥ 90°	-	-	-	>1	1	4	11	13	6	>1	-	-	35
Maximum Temperature ≥ 80°	8	8	15	23	30	30	31	31	30	28	18	10	261
Minimum Temperature ≤ 65°					-	-	-	-	-	-			
Minimum Temperature ≤ 55°				-	-	-	-	-	-	-	-		

Table II-I (Con't). Climate Summary for NAS Key West for 1945-1993.

SECTION III

FORECASTING

A. Local Area Environmental Parameters Associated with Typical Synoptic Developments.

1. Fronts. The Key West area is predominantly under the influence of a subtropical ridge. The exceptions are the occasional polar outbreaks that occur from late October through early April (Figure 111-1). These fronts normally pass through Key West when a deep trough exists east of the Rockies and extends southward to near 25 degrees north latitude. Fronts associated with a very weak trough will normally become stationary over mid-Florida and gradually dissipate.

During the first part of the period, cold frontal passages are of the slow moving variety with characteristic frontal weather in accompaniment. These fronts are usually weak and are modified by the warm waters of the Gulf of Mexico.

From December through February, fast moving cold fronts pass through the Key West area on the average of three to four times per month, or once every seven or eight days. The most significant weather accompanying these frontal passages is associated with the prefrontal squall line which may have severe thunderstorms and strong gusty surface winds.

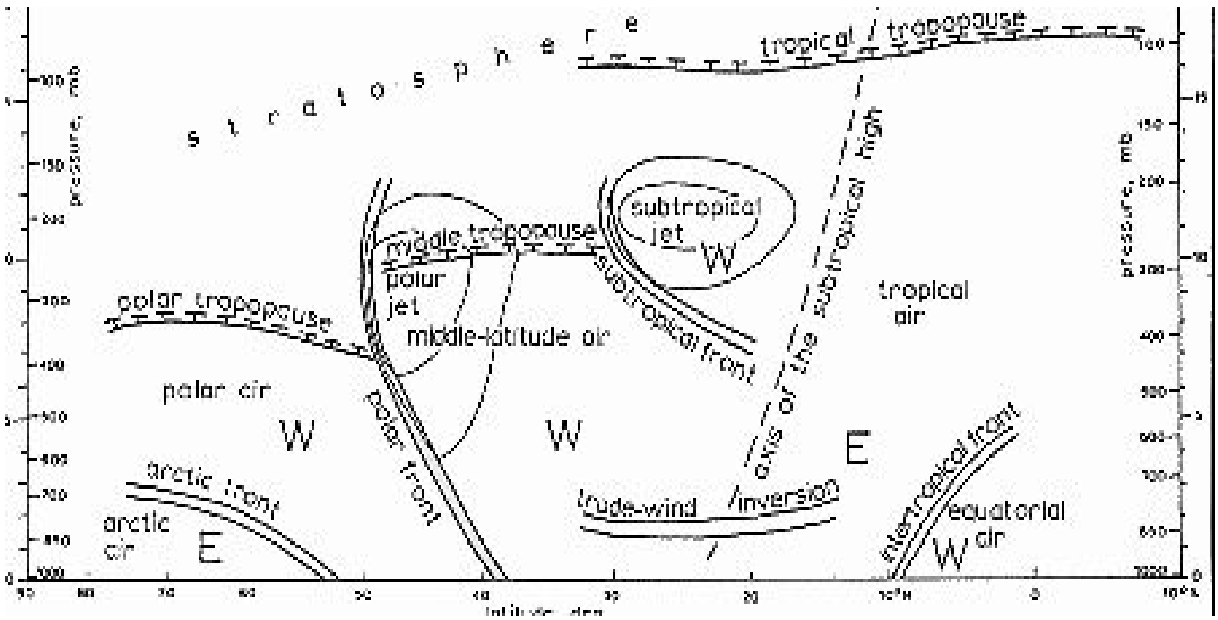
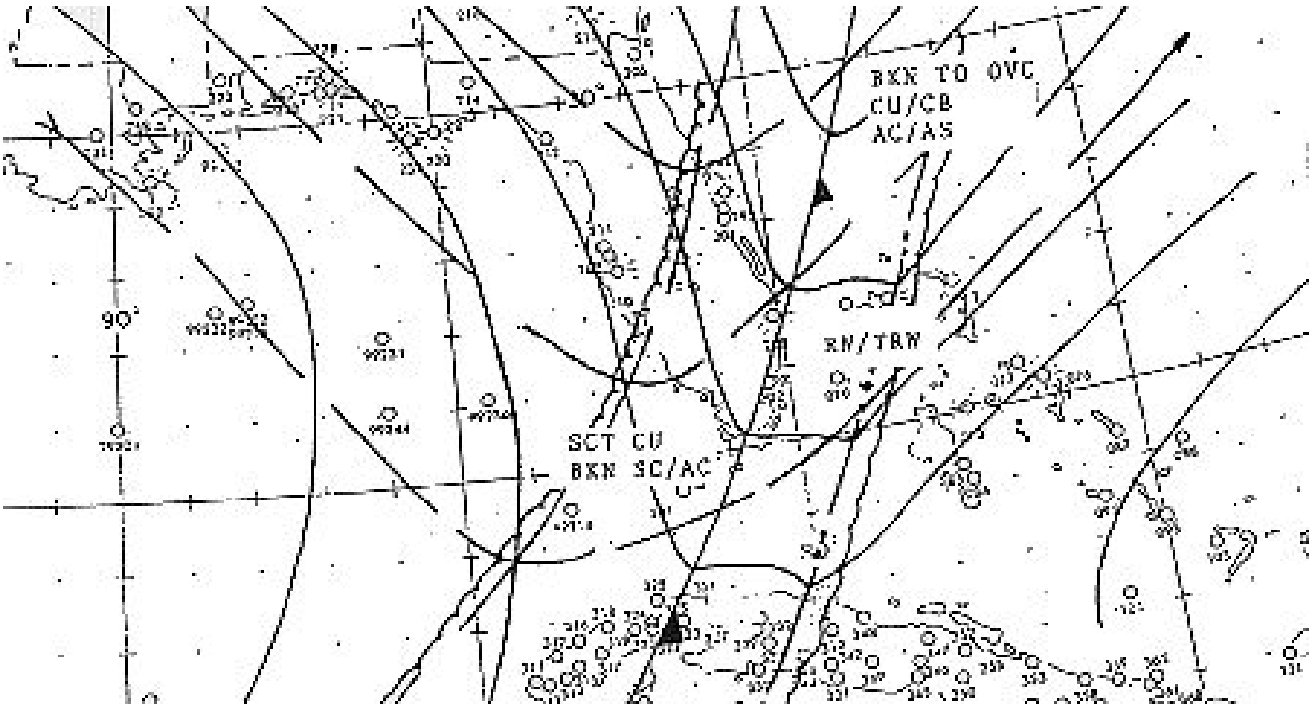


Figure III-1. Main structural parts of the atmosphere in a vertical meridional section (prevalent wind directions are indicated by E and W.

These fronts may move to the south of Key West and become quasi-stationary or form a weak wave and move back northward; their location dependent upon the position and strength of the subtropical high. Extensive cloudiness of the stratocumulus and stratus type with intermittent rain or drizzle occur and causes some of the worst flying weather encountered at NAS Key West. Once the cold front has passed, the cold, or cool, air mass usually remains in place for 24-48 hours; occasionally less than 24 hours, and only rarely longer than 72 hours.

Finally, warm frontal passage is rare. These fronts, originating over the Yucatan Peninsula, are modified by the Gulf of Mexico, as they approach the forecast area from the southwest. Also, cold fronts which have become quasistationary over the Florida Straits and northern Cuba may become modified warm fronts and pass through the area from the south.

a. Fast-moving colds fronts (Figure 111-2). Fast-moving cold fronts that transit the Key West area approach from the northwest and are generally oriented along a northeast to southwest axis. Moderate' to severe squall lines (with heavy rain and thunderstorms) are often well in advance of the surface front with little significant weather associated with the frontal passage itself. In fact, many such cold fronts may stagnate over the south Florida peninsula while only the squall line passes



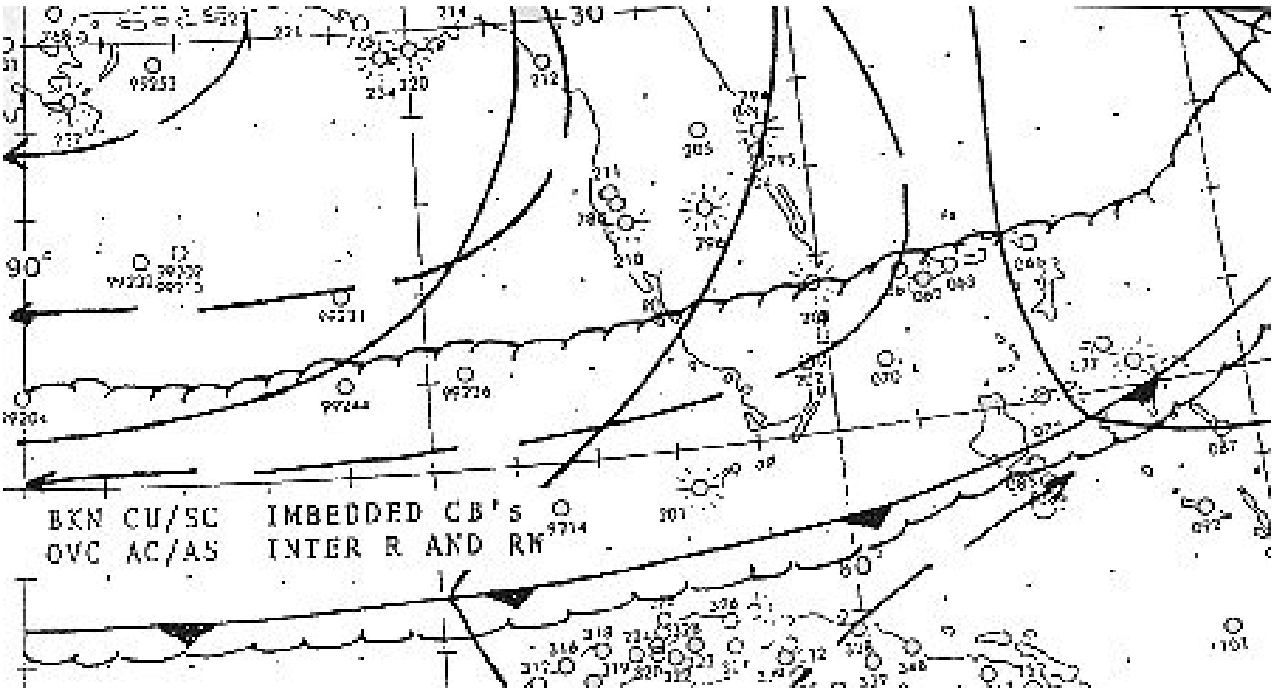
through the Keys.

Figure 111-2. Fast-moving cold front in Key West area, showing weather, surface Pressure distribution (solid lines) and 700 mb streamlines (dashed).

Multilayered cloudiness can be expected with rapid fluctuations in ceiling. A strong temperature contrast will produce a post-frontal broken stratocumulus layer with bases at 1500-3000 feet for six to eight hours after which mostly clear sky conditions can be expected. Surface maximum and minimum temperature decreases of approximately 6 degrees from the previous day are normal. Winds speeds of 14-22 knots with higher gusts are normal for this type of frontal passage, with a rapid wind shift occurring with the squall line passage.

b. Slow-moving cold fronts (Figure 111-3). Slow moving cold fronts generally approach the Key West area from the north and are usually oriented east to west. The timing of frontal passage is difficult to forecast because the speed of movement is highly dependent upon the position and strength of the subtropical high.

A broad band of multilayered cloudiness is normal for this type of front with ceilings at 1000-2000 feet. Areas of light rain or drizzle and embedded thunderstorms make this system hazardous to aviation. Surface maximum and minimum temperature decreases of approximately 6 degrees from the previous day are normal. A marked wind shift is not observed with this type front. Wind speeds usually increase to 10-15 knots 12-24 hours after frontal



passage.

Figure 111-3. Slow-moving cold front in Key West area, showing surface pressure distribution (700 mbs lines) and 700 mb streamlines (dashed lines) -

c. Warm fronts. Warm frontal type activity occurs only a few times during the winter season and is associated with a wave or low that has formed near the Yucatan Peninsula and moved northeastward across the Gulf of Mexico. Warm fronts may also be the result of a front moving back northward that had previously passed through the area as a cold front and became quasi-stationary over the Florida Straits. Cloudiness is quite extensive, occasionally including embedded thunderstorms. Winds veer from northeast to southeast with little change in velocity. A marked increase in temperature and humidity is evident. Precipitation is usually light rain and/or isolated to scattered rain showers.

d. Stationary fronts. Nearly identical conditions prevail with the stationary front as with the warm front.

2. Shear Lines (Figure 111-4). Shear lines usually occur during late fall to early spring and possess the same weather patterns as slow moving cold fronts. Typically, shear lines are the result of cold outbreaks invading the tropics with the associated cold front tending to become quasi-stationary through the Florida Straits.

3. Easterly Waves (Figure 111-5) - Troughs in the Easterlies (Easterly Waves) influence the local area frequently during late spring to early fall. These waves are an atmospheric low-pressure feature embedded in the trade wind belt and generally

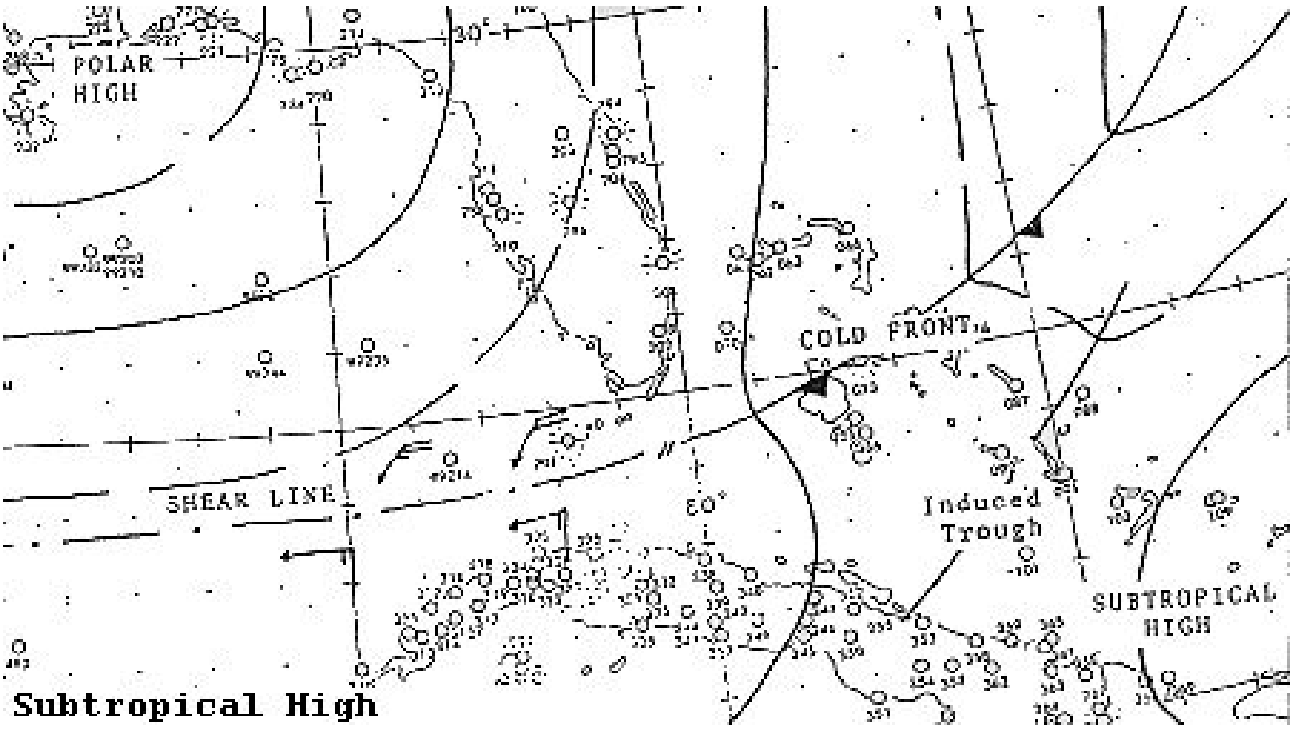


Figure 111-4. Shear line resulting when the Polar High invades the Tropics and reinforces the Subtropical High

form off the southern edge of the Sahara Desert. Their movement is somewhat erratic and frequency of passage varies pending the location and strength of the subtropical ridge. During the late summer, easterly wave passage becomes more consistent as this ridge becomes more developed over the local area.

Stronger, more intense, easterly waves can easily be tracked through satellite images. Furthermore, given the network of reporting stations east of the Key West area, including the tropical and subtropical Atlantic and the Caribbean Sea, less significant easterly waves can readily be detected as they migrate westward. The northern extent of significant weather; however, may not be fully realized until the wave reaches the Bahamas. An additional source of information of wave location is the Tropical Weather Discussion generated by the National Hurricane Center (NHC) in Miami, FL.

More often than not, easterly waves are of the stable or neutral type. The associated weather, including large clusters of convective clouds, forms along the eastern portion of the trough line. Multilayered cloudiness can be expected with ceilings generally 7000-9000 feet, frequently lowering in moderate to heavy showers and thunderstorms.

Periods of light rain are often observed. Surface winds in advance of the wave are northeasterly with an abrupt shift to east and southeast with wave passage. Wind speeds vary with each

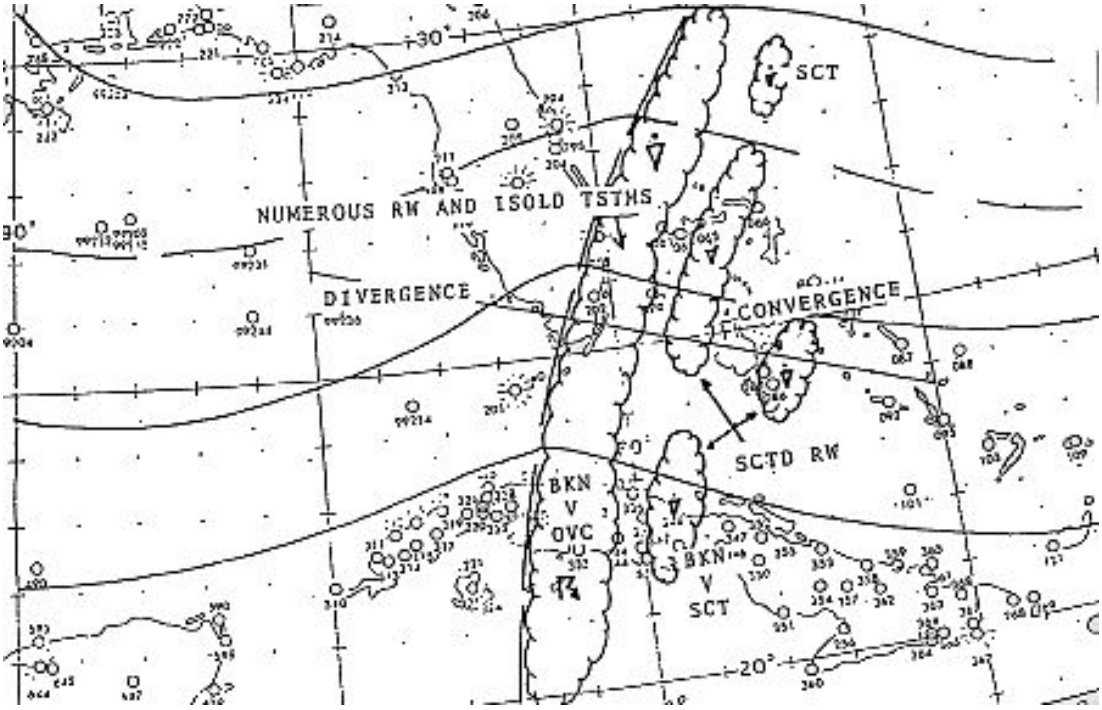


Figure 111-5. Diagram of surface pressure and typical weather pattern associated with a well developed stable easterly wave in the Northern Hemisphere.

wave but are generally 10-20 knots[1] with squall type winds in the heavier precipitation areas.

4. Induced Polar Troughs. Occasionally a polar front from the mid-latitudes invades the subtropics and becomes quasi-stationary over south Florida. During late spring through late fall, an increase in the westerlies above the front increases the relative vorticity south of the front, forming an induced trough. This trough will dissipate rapidly if the associated frontal system moves eastward. On the other hand, if the frontal system remains stationary for a time, the trough will intensify and produce multi-layered clouds with scattered rainshowers and isolated thunderstorms in the local area for two or more days--the period dependent upon the persistence of the trough.

5. Tropical Storms and Hurricanes. Tropical cyclone season runs from 1 June through 30 November, although storms may develop at anytime during the year. NAS Key West is considered to be in a high threat area, therefore, the air station remains at Hurricane

Condition of Readiness V for the entire season. The specific criteria for Hurricane Conditions of Readiness are listed in NASKWINST 3140.5(series)

The official tropical cyclone forecast is prepared and issued by the National Hurricane Center and is re-transmitted to the fleet by NAVLANTMETOCCEN Norfolk via CMW and their classified and unclassified web sites. Since the position and tracking of tropical cyclones are the responsibility of NHC, no attempt will be made to set forth techniques and forecast rules for these storms.

B. Thunderstorm Forecasting.

1. General. Florida, or more appropriately southwest Florida, is one of the primary thunderstorm regions of the world. Most thunderstorm activity at NAS Key West occurs during the late evening and early morning hours when instability is further enhanced by radiational cooling aloft. These thunderstorms usually move from the east or northeast. The occasional daytime thunderstorm will tend to move from the east-southeast or southeast.

An easterly flow, with wind speeds of 10 to 20 knots from the surface to 5,000 feet, will produce an excess amount of moisture over the Key West area. This leads to increased instability and the possibility of shower activity. If wind speeds at 20,000 feet and higher are greater than 20 knots; however, shearing will occur and only moderate showers will prevail.

A sharp increase in thunderstorm activity is likely to occur, especially at nighttime, if the flow aloft changes from easterly to southwesterly. On the other hand, if there is zonal flow aloft, thunderstorms or heavy showers will not develop because of the significant lack of moisture in the upper levels.

Winter thunderstorm activity is associated with frontal systems and usually occurs with prefrontal squall lines. Though typically strong, these thunderstorms tend to migrate out in advance of the squall line and last no more than one or two hours. A good indicator for these types of thunderstorms is the position of the 5820 meter isoheight (annotated as 582 on the FNMOC 500 ml, chart). The trend indicates passage of the prefrontal squall line when this isoheight is south of 250 N latitude. Additionally, severe thunderstorms may occur when related cloud tops develop to within 5,000 ft of, or actually penetrate, the tropopause.

2. Forecasting Techniques.

a. (In)Stability Indices and the Skew-T diagram. A generic summertime forecast for partly cloudy with isolated thunderstorms is not totally without merit and would verify most of the time. Nevertheless, forecast accuracy can be greatly improved through the use of the Skew-T diagram and selected (in) stability indices.

The upper air data used in construction of the Skew-T is taken from the sounding launched by the National Weather Service at neighboring Key West International Airport. These data are plotted and analyzed using *Skew-T Professional Ver 2.3.* Included amongst the various derived atmospheric parameters are several indices of (in)stability important to thunderstorm forecasting. Indices of instability—indices whose values increase in an unstable environment—include the K Index, SWEAT Index, and Totals-Totals, Vertical Totals and Cross Totals. Indices of a stable atmosphere include the Lifted Index and the Showalter Stability Index. These indices provide a good first guess for thunderstorm development, but do not reflect mid-level moisture or upper level instability. The addition of precipitable water, helicity, and CAP values help to overcome these weaknesses. This additional information is ascertained using *SHARP* (Skew-TiHodograph Analysis and Research Program). Nonetheless, the bottom line remains the same in that there is no one perfect, or preferred, index to forecasting thunderstorms. For example, stability indices generally require high moisture content at 850 mb; however, severe weather can occur even though the moisture does not quite reach that level. A combination of some, or all, of these indices plus the forecaster's own personal experience can increase the forecast accuracy.

3. K-Index: The K-Index is useful in forecasting airmass thunderstorm probability. It is a measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere, and the vertical extent of the moist layer. The temperature difference between 850 to 500 mb is used to parameterize the vertical temperature lapse rate. The 850 mb dew point temperature provides information on the moisture content of the lower atmosphere. The vertical extent of the moist layer is represented by the 700 mb dew point depression. Values less than 20 generally result in no

air-mass thunderstorms while values greater than 35 result in numerous thunderstorms. Subjective modification of these probabilities by consideration of the synoptic situation is recommended. A value of 33 has been found to be useful in forecasting thunderstorm development in the Key West area.

4. SWEAT Index: The Severe Weather Threat Index combines the effects of low-level moisture, convective instability, wind

speeds, and warm air advection. It is designed to discriminate between ordinary and severe convection by considering thermodynamic information with (low and mid-level) flow characteristics. Though the SWEAT Index is not used for ordinary thunderstorm forecasting, high values of SWEAT have been observed without subsequent severe weather. Look for consistently high values (in excess of 300).

5. Totals-Totals (TT), Vertical Totals (VT), and Cross Totals (CT): The TT Index combines the effects of the vertical temperature lapse rate between 850 and 500 mb (VT) with low-level moisture (CT). A value of 39 is sufficient to forecast isolated thunderstorms in the local area (with proportional increase related to increasing values in TT). In an ideal situation, a source of low level moisture and relatively cold 500 mb temperatures will yield high values of TT and, subsequently, the potential for severe convection. Though the TT Index may be numerically high, sufficient low level moisture is required for development.

6. Showalter Stability Index (SSI): This index is the algebraic difference between a parcel of air (lifted adiabatically from 850 mb) and the environmental temperature at 500 mb. SSI is useful when the moist layer extends beyond 850 mb, as is almost always the case with severe weather. Look for values of -3 or less. Keep in mind that the SSI does not reflect near surface conditions and that it will underestimate potential convection for cool layers extending above 850 mb.

7. Lifted Index: The Lifted Index is much the same as the SSI with the exception that it takes a representative low-level parcel of air vice one from the 850 mb level. This allows the LI to account for low-level moisture and provides for a more reliable measure of stability. As with the SSI, values of -3 or less imply strong possibility for thunderstorm development; however, an LI of zero can be sufficient for severe weather provided strong upper level divergence is present.

8. Precipitable Water: The indices described above all suffer from a disregard of the thickness of water vapor in the lower troposphere. On the other hand, thunderstorms develop more vigorously if there is an ample supply of water vapor—the more latent heat that can be released, the more precipitation generated. Precipitable water is defined as the mass of water vapor a square meter of earth's surface. Values of 1 inch or more generally sufficient to support showers and thunderstorms in southern United States, and values of 2 inches or greater increase the probability of thunderstorms over the Keys. Precipitable water values are available from SHARP or can be interpolated from the Stability Index-Moisture Chart (a 4-panel

graphic that displays the Lifted Index, precipitable water, relative humidity, and freezing level) produced by the National Meteorological Center.

9. Helicity and Hodographs: Helicity is proportional to thermal advection. As such, it can be an important signature to the development of thunderstorms. Warm air advection, especially in the lower layers of the atmosphere, tends to destabilize the atmosphere and enhance thermal instability. Thus, the greater the value for helicity values, the greater the warm air advection and, consequently, the greater the instability in the lower levels and the likelihood of thunderstorms.

The hodograph is a plot of the wind sounding. Knowing that winds tend to veer with warm air advection, the hodograph can be useful in estimating thermal advection. If the wind is equal at all levels; i.e., one point, then there is no change of wind with height and, thus, no advection. On the other hand, if the hodograph differs significantly from the radial; i.e., almost perpendicular to the thermal wind, then thermal advection is prominent. With warm air advection in the lower atmosphere and cold air advection aloft, destabilization of the atmosphere will occur and the likelihood of thunderstorms increase. This is especially true during late night and early morning hours when cooling aloft predominates.

10. Cap Strength: One last parameter to consider is the Cap Strength. Cap Strength is a measure of the ability of stable air aloft to inhibit the ascension of a parcel of air from the lower levels. The importance of the cap is that without one, convection may be widespread but will be less intense because the developing storms must compete for a limited amount of available moisture. A strong cap prevents overturning of the airmass by numerous, but ordinary convection. Thus, a strong cap will allow low-level heat and moisture to rise over a period of time. This, in turn, will increase the potential for thunderstorm development by limiting the number of cells able to surpass the cap to only a few. Watch for cap values in excess of 2. Furthermore, severe storms tend to form along the boundary between capped and uncapped regions—areas favorable to the release of latent heat.

11. Movement of Thunderstorms. The forecaster needs to be especially alert to thunderstorm activity occurring over Cuba during the daytime. This activity may begin to move over the coastal waters and the Florida Straits during the early evening hours in a general northwestward direction. In general, once these thunderstorms leave the land mass they must have a forward speed of movement of at least 20 to 25 knots in order to reach the Keys. At speeds less than 20 knots, the thunderstorms tend to dissipate over the Florida Straits.

Also, thunderstorms developing along the sea breeze front over the west coast of south Florida; i.e., the Everglades, can move southeast to impact the Keys. Again, intensity of the thunderstorm activity and its speed of movement is vital to the probability of thunderstorms reaching the Keys.

A most valuable tool to determine the movement of thunderstorms is radar. The Next Generation Weather Radar (NEXRAD) is a visual display of the meteorological data received by the weather surveillance radar (WSR-88D) located on the north side of U.S. Highway 1 at Boca Chica NAS. The variable color codes vary corresponding to the decibel intensity of electromagnetic return.

Thunderstorm movement can be readily distinguished by tracking individual cells through the image looping sequence on the NEXRAD. Other information derived from NEXRAD includes maximum cloud tops, cell movement and maximum intensity levels.

Complete coverage of south Florida and adjacent coastal waters can be obtained by using radar observations from Miami (AMX) and Tampa (TBW). Both of these are National Weather Service next generation radar facilities (NEXRAD - WSR-88D). In addition to providing a more complete radar picture, these two systems serve as backup systems during those periods when the WSR-88D in Key West is not operational.

4. Peak Gusts in Thunderstorms. The T2 Method, located in the *Aerographer's Mate 1 & C* Rate Training Manual, has been used with some degree of reliability in forecasting peak gusts associated with air mass thunderstorms. Note that (1) the results are more accurate when used with the OOOOZ sounding vice the 1200Z sounding; and (2) though the curve is theoretically accurate to within 8 knots, it has been observed to be more than 20 knots too high at NAS Key West.

An alternative to the T2 method involves the calculation of an upper level stability index (UI) and comparing it with the 700 mb dew point depression. The UI is determined by taking a parcel of air at 500 mb (T_{500}) and raising it along the dry adiabat to its lifting condensation level. From there, follow the saturation adiabat to the 300 mb (T_{300}) level, noting the temperature at 400 mb (T_{400}). UI is the sum of the difference between the ambient temperature and the temperature of the lifted parcel; or

$Ul = (T_{400} - T_{500}) + (T_{300} - T_{500})$
The following equation will calculate the convective gust potential (CGP):
$CGP = [3(T - Td)soo] - (T - Td)_{700}$.

If CGP is positive, there is no gust potential. On the other hand, if CGP is negative, then compare the 700 mb dew point depression with the previously calculated UI using Figure 111-7.

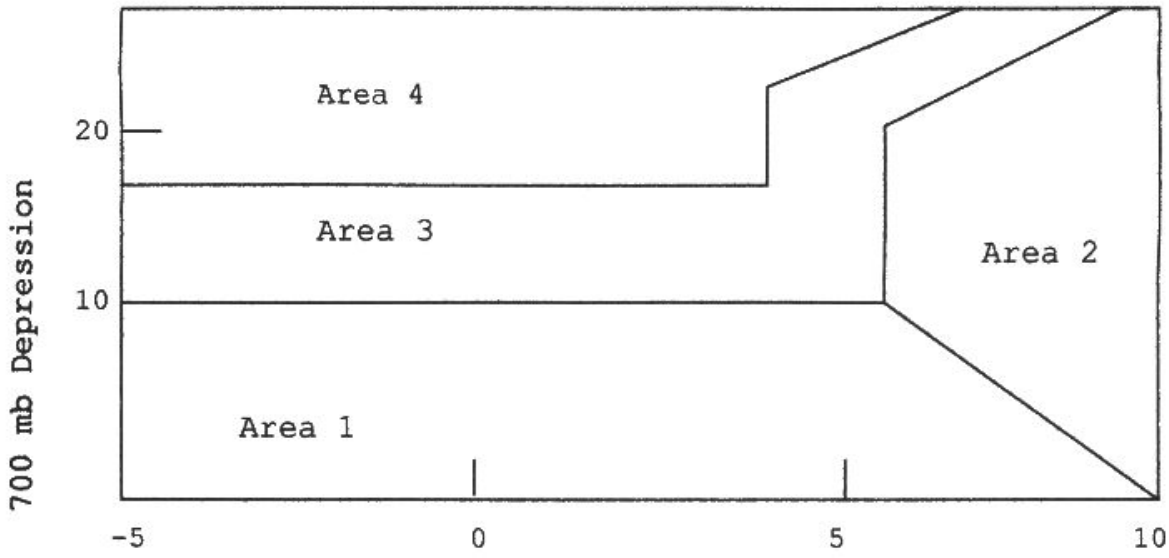


Figure 111-7. 700 mb Depression Upper Level Stability Index graph.

Area 1 - Too moist for strong convection gusts although thunderstorms may occur.
Area 2 - Too stable.
Area 3 - Potential for gusts greater than 30 knots exist for the period thunderstorms are expected.
Area 4 - Potential for gusts greater than 40 knots exist for the period thunderstorms are expected.

111-7 (Cont.). Area descriptions relative to gust potential.

C. Forecasting Rules. Due to the low lying terrain of Key West and vicinity (mean elevation approximately 4 feet) and small land masses, the weather types are nearly identical to conditions over tropical maritime conditions and no special forecasting techniques have been devised or are employed.

1. Surface Winds. If a pressure gradient of four or more millibars exists between Jacksonville and Key West, sustained winds of 12 to 18 knots can be expected.

Indicated wind speed at NQX is 5 to 7 knots less than that experienced over open water in the local area. Wind speed and direction along the reef can be obtained through Bookmarked WEB Sites, or by listening to NOAA Weather Radio (162.40 mHz)--rebroadcast on cable television TCI channels 5 and 19. Coastal and offshore wind guidance can be obtained by requesting product FZUS44 KWBC, in addition to using regularly produced NMC 12H Boundary Layer Wind charts.

2. Aircraft Icing. Aircraft icing poses no problems for the period of March through November, however severe icing can occur in cumulus congestus and cumulonimbus clouds, when aircraft fly through for extended periods of time. During the periods of December through February, incidence of aircraft icing increases particularly when an east-west cold front stalls in the local area. Moderate icing may be encountered from 12,000 feet to 20,000 feet in altostratus and nimbostratus type clouds.

3. Turbulence. Turbulence from late spring through early autumn normally is of the convective type$_1$ however light to moderate turbulence should be forecast when an easterly wave approaches the station. Mechanical turbulence becomes much more frequent from late autumn through early spring because of frontal activity over the local area. Light to occasionally moderate is frequent when surface winds are sustained 15 to 20 knots with higher gusts. The occurrence of clear air turbulence (CAT) is much less frequent in Key West except the period late autumn through early spring when the polar jet frequently swings south across the Florida peninsula.

4. Low Level Wind Shear (LLWS). Low level wind shear is an ever present danger in Key West during the rainy season of late spring through early autumn. Normally isolated air mass type thunderstorms pose no significant problem for flying operation. These storms are usually weak with gusts usually not exceeding 25 knots; however, when thunderstorms begin to merge together to form clusters stronger gusts will become more likely, with the resultant shear over the local field. During the winter months shears will occur behind slow moving cold fronts. When predicting turbulence, forecasters must consider the criteria established in NAVOCEANCOMINST 3140.4 (Atmospheric Turbulence and Icing Criteria)

5. Forecasting Sea Heights.

a. Forecast area. The forecast area is divided into two main areas; "Inside the reef" and "Outside the reef". Inside the reef the immediate reef area to the north and south of the Lower Keys.

Outside the reef refers to the Gulf of Mexico to the north and Straits of to the south.
The area from the northeast of Key West to the southwest tip of the Florida peninsula (Cape Sable) and encompassing the Florida Bay is referred to as the "Flats". Depth ranges from the surface to nearly 30 feet. Tidal influences vary the depth enough to make boating nearly impossible during low tide in some areas. North of the "Flats" lies the Gulf of Mexico where water depth increases significantly.
Southward of the Keys are the Straits of Florida. Between the Keys and the reef area to the south, the bottom depth increases to nearly 50 feet at Shark Channel. From there, the depths decrease upon approaching the reef. Interspersed amongst the reef are shoals which are exposed at the surface with an average water depth of 15 to 25 feet. Water depths increase rapidly south of the reef area.

b. Affecting Wave Heights. Wave height development is limited by the relatively shallow reef areas immediately surrounding the Keys. The reef disrupts any established wave pattern and limits wave action. Wave heights within the reef area rarely exceed five (5) feet.

c. Forecasting Techniques. Forecasting sea heights is a function of wind speed and direction, duration, and fetch. Of these functions, wind direction is perhaps the most important as because fetch, and depth, varies dramatically throughout the area. Table 111-1 depicts the fetch for sixteen compass points

		15 KTS		20 KTS		25 KTS	
Direction	Fetch (nm)	Height (ft)	Duration (hrs)	Height (ft)	Duration (hrs)	Height (ft)	Duration (hrs)
N	85	4½	13	7½	11	10½	10
NNE	70	4½	11½	7	10	10	9
NE	50	4	9	6½	7½	9	7
ENE	10 To 60	4½	10½	7	9	9	8
E	180+	5	22½	9	19½	13	18

ESE	600+	5½	42	11	42	15	43
SE	135	5	17	8	15	11½	14
SSE	85	4½	13	7½	13	10½	10
S	85	4½	13	7½	13	10½	10
55W	90	4½	14	6½	12	11	11
SW	150	5	20	8½	17½	12	15½
WSW	560+	5½	41	9½	40	15	40
W	900	5	52	10	52	15	52
WNW	720	5½	45	9½	47	15	47
NW	460	5½	37	9	37	15	35
NNW	360	5½	33	9	33	14	29

Table 111-1. Wave height characteristics for fully arisen seas at different wind speeds.

from Key West. Also included are values for fully arisen seas outside the reef at various wind speeds as well as the duration of wind required to reach that height.

D. References

1. NASKWINST 3140.5 (series) Hurricane and Destructive Weather Bill.
2. National Weather Service Forecaster's Handbook No. 1, Facsimile Products
3. NAVEDTRA 40501 (series), Forecasting in Mid-Latitudes
4. NAVEDTRA 10362-Bi, Aerographer's Mate 1 & C
5. NAVOCEANCOMINST 3140.4, Atmospheric Turbulence and Icing Criteria
6. NOAA Technical Memorandum NWS FCST-23, Low Level Wind Shear: A Critical Review
7. U.S. Navy Hydrographic Office, Observing and Forecasting Ocean Waves, H.O. Pub No. 603.

SECTION IV

SPECIALIZED FORECASTS AND SERVICES

A. OPARS. Reference (a) provides procedures to obtain OPARS flight plans. Forecasters verify OPARS winds with an alternate data source before releasing the flight plan to the requester. The detachment SOP contains procedures to ensure that OPARS will not route aircraft over Cuba. Because NAS Key West supports primarily attack and fighter aircraft, a thorough knowledge of input items for external loads and SPERF is required.

B. Atmospheric Refractivity. FNMOC produces an N-profile bulletin, FXUS 28 KNWC, using the sounding from Key West International Airport. Since the balloon is released over land, the sounding does not accurately depict refractivity conditions over the water. Extended propagation ranges for higher frequency emitters are usually present because of the height of the evaporative duct. M-Profiles are produced on a PC using the Geophysics Fleet Mission Program Library (GFMPL) program; with Refractive Layers and Evaporation Duct Height also calculated. For refractive effects specifically tailored to the parameters of individual emitters, NAVLANTMETOC DET Key West can provide IREPS products computed using GFMPL.

C. Electro-Optical Forecasts. Forecasts or analyses of the atmospheric effects upon electro-optical sensors may be required on occasion. Reference (b) provides information in support of such services. Also, certain sensors require absolute humidity values. Forecasters can obtain absolute humidity values by substituting dew point temperatures for the "Temp, C^{11} values and reading the corresponding value in the column labeled "Saturated vapor density, grams/m^{31}' using reference (c).

D. Sound Focusing. The exceptional VFR conditions bring supersonic aircraft to Key West for Air Combat Maneuver (ACM) Training. Coincidentally, these same atmospheric conditions are also conducive to sound focusing. The intensification and extended propagation of sonic booms is present especially during the winter months. Unfortunately, the city of Key West is downwind from the primary ACM area and may be affected by sonic booms.

To aid in the issuance of sonic boom advisories, FLENUMMETOCCEN provides a sound focusing bulletin, FXUS 29 KNWC, that depict, if present, the 114 decibel sound level at more than 30 nautical miles from an aircraft (noise level minimums). If the bulletin is not available, an automated processing request (APR) for sound focusing (SNDFO) should be made to FLENUMMETOCCEN. To account for possible 30% increase in intensities because of diurnal temperature effects, the 112 DB level is used to identify the extent of the 114 DB level. The synoptic thumb rule is to expect intensified and extended sonic boom propagation when the winds at 30,000 feet are 90 knots or greater.

E. Other Tactical Support Products. Forecasters can provide the following tactical support products by requesting those products from FLENUMMETOCCEN using the APR format (For more information, consult references (b) through (h)):

- Ballistic Winds and Densities

- RADFO
- CHAFF
- D-VALUES
- Currents or SAR

F. Condensation Trails. Provided using the methods outlined in references (f) and (g), or using a Skew-T, Log-P diagram with CONTRAIL probability overprints.

G. HF Propagation Conditions. Forecasters can provide information regarding solar effects upon HF propagation by consulting the AWN bulletins listed in reference (h).

H. Climatology. Climatology reports and products are available upon request.

I. Astronomical and Tidal Data. The detachment issues Key West Astronomical and Tidal data annually and maintains such information for the current calendar year. For other locations, the detachment has onboard publications containing tide and tidal current information for the east and west coast of the America's and the Nautical and Air Almanacs containing the data to calculate astronomical data for any location on the globe.

J. Oceanographic Support Services and Products. The primary oceanographic products that the detachment provides are sea surface conditions - temperature, sea state and location of the Gulf Stream. The detachment receives current sea surface condition via NODDS charts, the NAVO, and NLMOC classified and unclassified homepages products. Oceanographic products in support of ASW operations are available - consult references (d), and (e).

K. Support to the Tethered Aerostat Radar System (TARS) Program, Cudjoe Key AFS. Daily, the forecasters provide 36 hour forecasts and current winds aloft to the Flight Controllers at Cudjoe Key AFS. Forecasters provide weather advisories via telephone as follows:

PHENOMENA	DESIRED LEAD TIME
Thunderstorms Severe	60 minutes
Thunderstorm/Tornado Watch	6 hours
Severe Thunderstorm/Tornado	Warning 20 minutes
Waterspouts/Funnel Clouds	ASAP after sighting
Surface Winds > 35 knots	60 minutes
Tropical Cyclones	ASAP after receipt of warning

L. Shark Drop Zone Forecast. At the request of Army or Air Force elements, forecasts for the Shark Drop Zone located between Fleming Key and Sigsbee Island (Figure IV-l) is provided. This forecast consists of; valid TAF, wind and temperature up to and including 12,000 feet, sea state and surface temperature tidal and astronomical data, and any warning in effect.

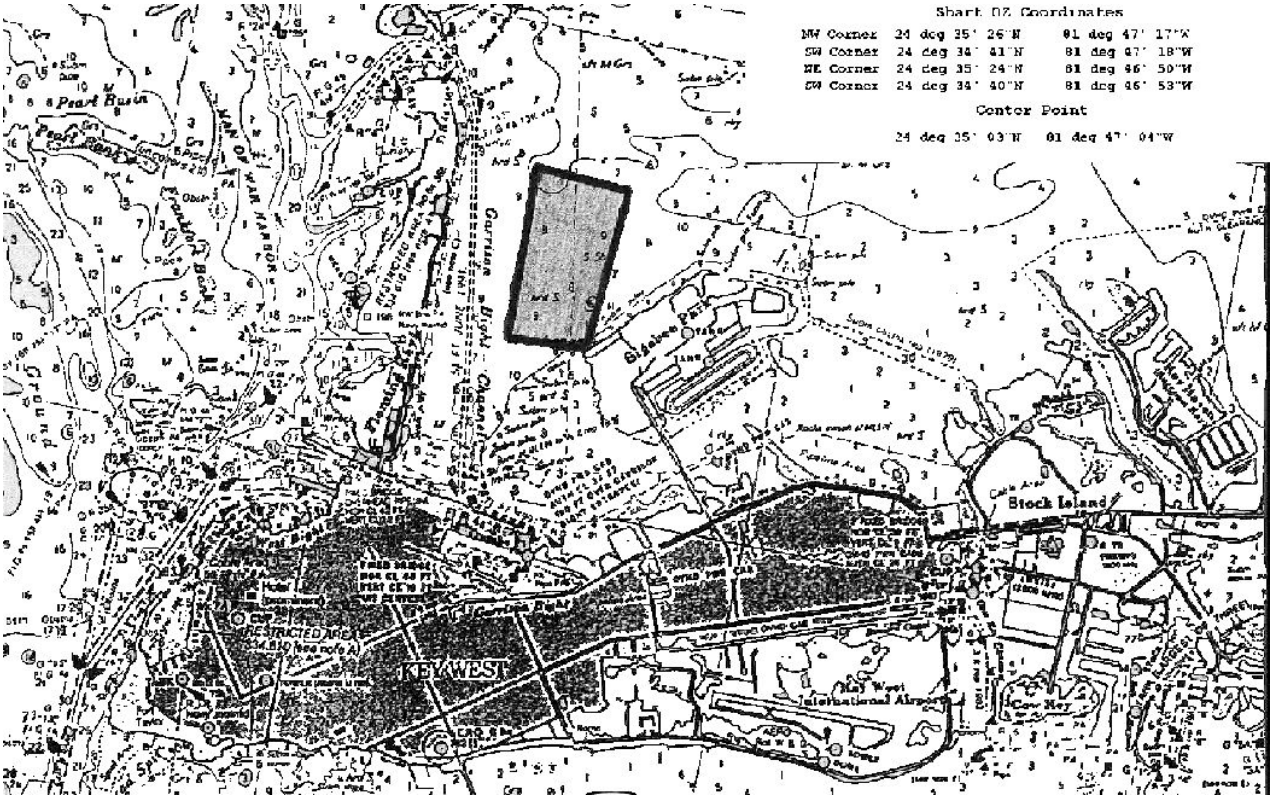


Figure IV-1. Location of Shark Drop Zone.

M. References

a. FLENUMOCEANCENINST 3710.1 (Series) OPARS User's Manual
b. ELECTRO-OPTICAL Handbook (AWS/TR-79/002)
c. Handbook of Meteorology (NAVWEPS 50-lB-503) p.70, tab 68
d. NAVOCEANCOMINST C3140.22 Tactical Support Products Manual
e. FLENUMOCEANCENINST 3140.3 APR User's Manual
f. Geophysics Fleet Mission Program Library (GFMPL)
g. Forecasting of Aircraft Condensation Trails (NAVAIR 50-lP-6)
h. Space Environmental Effects (AFSFC PAMPHLET 105-3)
i. IREPS Revision 2.2 User's Manual (NOSC TD 659)

SECTION V

ENVIRONMENTAL EFFECTS

A. Minimum Meteorological Conditions For Airfield Operations.

1. Takeoff Minimums: None.

2. Approach Minimums:

a. Precision Approach Radar (PAR)

Runway #	Ceiling/Visibility
030	200 ft / ¾ mi
070	100 ft / ¼ mi
130	No PAR
210	No PAR
250	100 ft / ½ mi
310	200 ft / ¾ mi

b. Airport Surveillance Radar (ASR)

Runway #	Ceiling/Visibi1iy

030	400 ft / 1 mi	CAT E	400 ft / 1¾ mi
070	400 ft / ½ mi	CAT E	400 ft / ¾ mi
130 (CAT C)	400 ft / 1 mi	CAT D/E	400 ft / 1 ¼ mi
210 (CAT C)	400 ft / 1 mi	CAT D/E	400 ft / 1 ¼ mi
250	400 ft / 1 mi	CAT E	400 ft / 1 ¼ mi
310	400 ft / 1 mi	CAT E	400 ft / 1 ¼ mi

3. CIRCLING-MINIMUMS: Dependent on the type of aircraft involved$_1$ the lowest circling minimum is 500 feet and ½ mile. The highest circling minimum is 600 feet and 2 miles.

Note: There is no recovery bill for wet runways at NAS Key West. A-4's and A-6's use the arresting gear when there is standing water on the runway as determined by the approach controller.

B. Thunderstorm Conditions of Readiness.

1. NAVLANTMETOC DET Key West sets thunderstorm Conditions of Readiness for NAS Key West, which includes Boca Chica Key and Fleming Key, the Cudjoe Key Aerostat Site, and for Area BRAVO III.

II. The Forecast Duty Officer (FDO) will notify the NAS Key West OOD. NAVLANTMETOC DET Key West Standard Operating Procedures provides more complete information, however, when Condition TWO is set, no special action is taken on the part of the activities supported by this Command. The lone exception is Cudjoe Key AFS which positions the aerostat for rapid in-haul, and, subsequently, reducing its surveillance area. The setting of Condition ONE, on the other hand, will result in changes to the following operations:

1. Effects upon Aircraft Operations.
(a) Emergency generator to the GCA Radar activated
(b) Aircraft fueling ceases
LOX transfer ceases
(d) Use of GSE equipment limited
(e) Aircraft electrical starting power secured
(f) Aircraft external air conditioning secure
(g) Transportation of ordnance ceases
(h) Weapons magazines secured

2. Ship Operations.
(a) Fuel and ordnance transfers cease
(b) Cease work aloft

3. Ground Operations.
(a) Cease work aloft

(b) Swimmers vacate pools

4. Aerostat Operations: Lightning, updrafts and down drafts associated with thunderstorms pose the greatest environmental dangers to the aerostat and its tether. When thunderstorms are imminent, the aerostat is retrieved and secured to its mooring mast, terminating surveillance.

C. Severe Thunderstorms.

1. A Condition of Readiness for severe thunderstorms will be set when any of the following occur within our AOR and/or Area BRAVO III (See Figures 1-2, 1-3, and 1-5).

a. A thunderstorm producing wind gusts of 50 knots or greater, and/or hail of a diameter of ¾ inches or greater is occurring or is expected to occur.

b. When max tops of thunderstorms exceed the tropopause.
c. When the National Weather Service in Key West has issued a severe weather watch or warning that includes our AOR, Area ECHO, or portions thereof.

2. There is no additional action required in preparing for severe thunderstorms than that which is normally required for standard Thunderstorm Conditions of Readiness.

D. Wind Warnings.

1. Aircraft Operations. When sustained winds exceed 30 kts, aircraft are secured using 6 point tiedown. With gale force winds, aircraft are positioned nose into the wind and secured with a minimum point tiedown. For storm force winds, aircraft are placed in available hangar space and the remaining aircraft depart if feasible. Finally, in hurricane force winds, some aircraft are hangared, though most aircraft will be evacuated.

2. Ship Operation. When Small Craft Warnings are in effect, NAS boat operations cease and the NAS Marina secures rental boats. Because of the limited navigational space that Key West harbor provides, near Gale Force winds can prevent ships with large sail areas from safely entering or leaving the harbor. When gale force winds occur, ships in port will double-up the mooring lines. Lastly, with storm or hurricane force winds, the senior officer present afloat (SOPA) considers the sortie of all capable ships in port.

3. Aerostat Operation. Aerostats are designed to withstand winds up to 90 knots while secured to the mooring pad while winds up to 55 kts do not affect aerostat operations aloft. The threat created by strong winds, however, occurs during launch and recovery operations and special care must be taken.