II. GULF OF LION – WEST CENTRAL MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Gulf of Lion-West Central Mediterranean Area* shown in Figure II-1 encompasses the Gulf of Lion, western Ligurian Sea, and that part of the Mediterranean Sea between the Balearic Islands to the west and the islands of Sardinia and Corsica to the east. For purposes of this discussion, the Strait of Bonifacio is included both in this area and in the Tyrrhenian Sea-Central Mediterranean Area addressed in Section III.

A complex coastal topography characterizes the north and the south coasts of this area (see Figure II-1). There are three major mountain barriers to the north -- the Pyrenees, the Massif Central, and the Alps -- and three major valley openings to the sea -- the Carcassonne Gap, the Rhone Valley and the Durance Valley. Such topographical features frequently combine to create channeling of the air flow in the valleys, prominent corner effects, and/or obstacle effects to air flow over the mountain barriers.

Along the southern coastal boundary area, the Atlas Mountains are dominant with the Tellien Atlas to the west and Massif De L'Aures to the east. The Bishra Gap between these latter two ranges can promote strong channeling of the air flow.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Gulf of Lion-West Central Mediterranean Area are dominated by the major influxes of cold air into the Mediterranean that usually occur along the northern boundary of the area, creating the cold outbreaks with associated northwesterlies known as mistrals (see Para. 2.1).

During the winter season (November through February), when the upper-level westerlies and associated storm track are positioned over the area, unsettled and stormy weather, alternating with strong to gale force mistrals, is common. During the summer season (June through September), when the upper-level westerlies and associated storm track retreat to the north, settled and warm, dry weather is much more the rule. However, mistral conditions associated with cold outbreaks are still common near the coast of southern France.

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*Comprises British forecast sea areas Lions, Unicorn, Bougie; see Figure 1b in the Introduction.

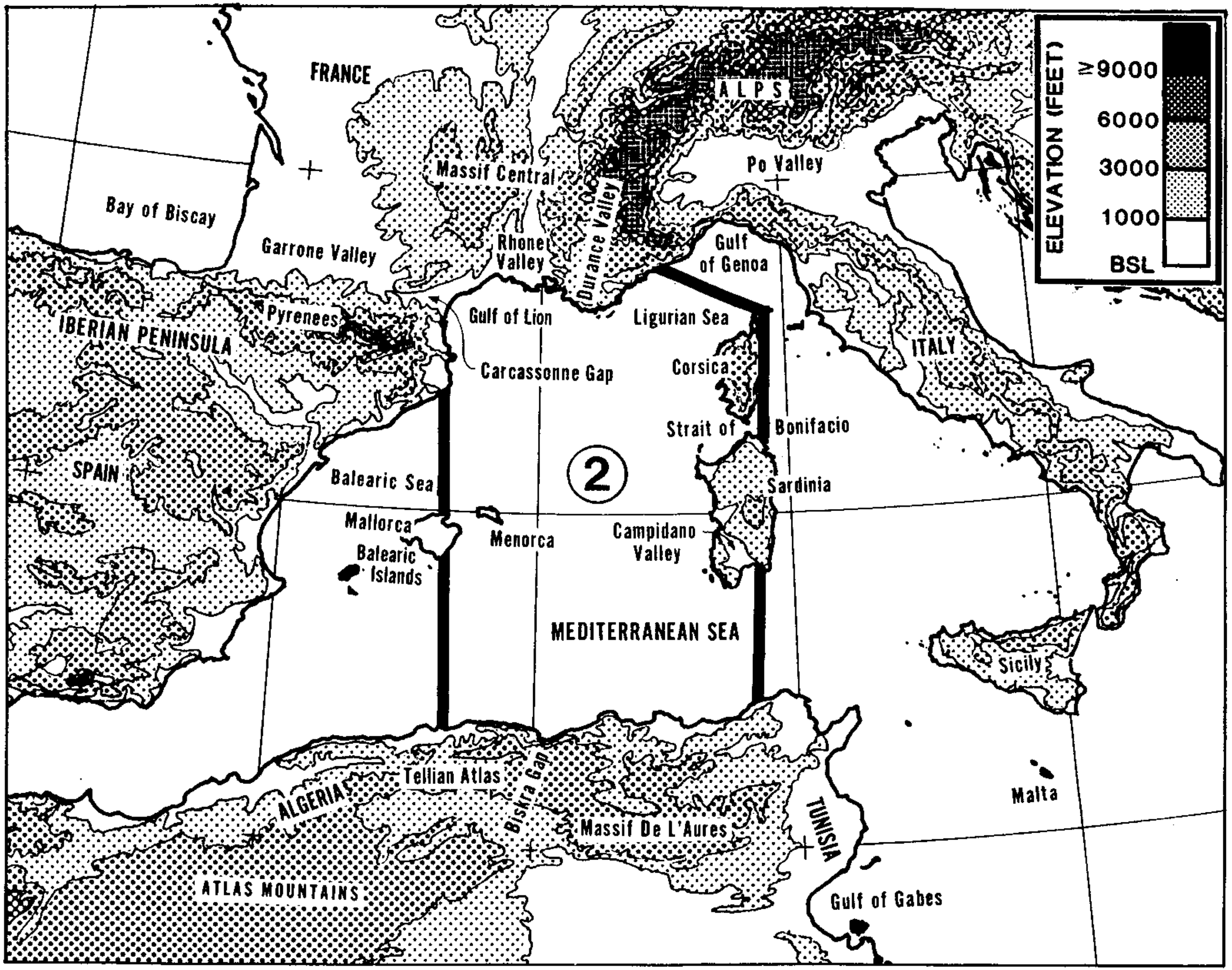

Figure II-1. Topographical map of Gulf of Lion - West Central Mediterranean Area.

The transitional seasons, spring and autumn, are of very different length. The relatively long spring season (March through September) is noted for periods of stormy weather with mistral conditions that alternate with a number of false starts of settled summer-type weather. Autumn lasts only about one month (October), and is characterized by an abrupt change to winter-type weather.

2. REGIONAL WEATHER PHENOMENA

2.1 MISTRAL

2.1.1 Introduction

The mistral is a cold, strong northwesterly to north-northeasterly offshore wind along part or all of the coast of the Gulf of Lion. Its influence occasionally extends beyond the Gulf of Lion to affect the weather of the entire Mediterranean basin.

The mistral is the result of a combination of the following factors:

(1) The basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

Mistrals are observed in association with three particular upper level (500 mb) large-scale flow patterns. These flow patterns are classified as types A, B, and C (British Air Ministry, 1962; see Introduction).

Type A. A blocking ridge in the eastern Atlantic and a long-wave trough over Europe produces a strong northwesterly flow over western France (see Figure II-2). This is a meridional flow situation.

Type B. A blocking ridge extends northeastward from the eastern Atlantic over northern Europe and a low pressure belt covers the Mediterranean (see Figure II-3). Meridional flow predominates.

Type C. A series of depressions dominates the European mid-latitudes, and westerly winds prevail over the Mediterranean (see Figure II-4). This is a zonal-flow situation.

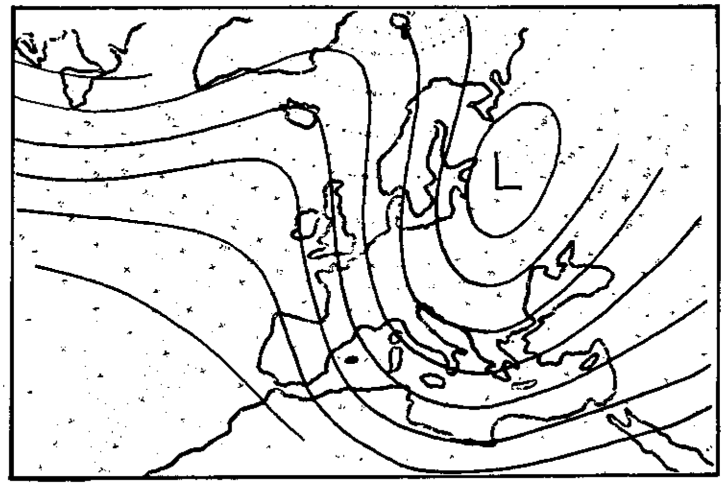

Figure II-2. Upper-level flow pattern showing the British Air Ministry Type A.

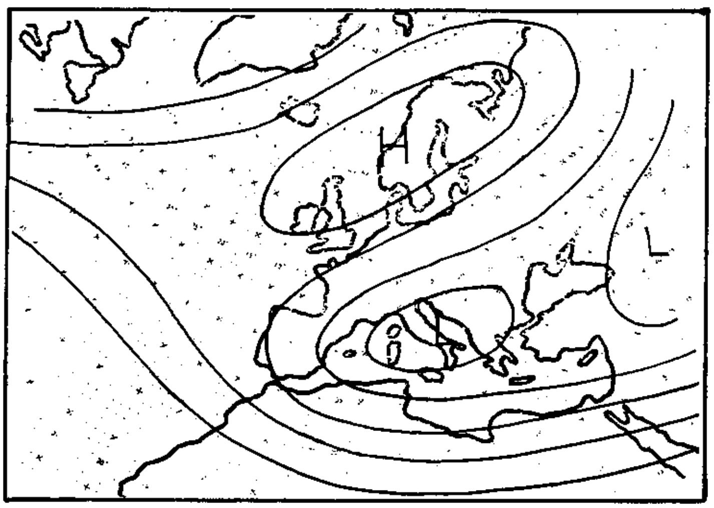

Figure II-3. Upper-level flow pattern showing the British Air Ministry Type B.

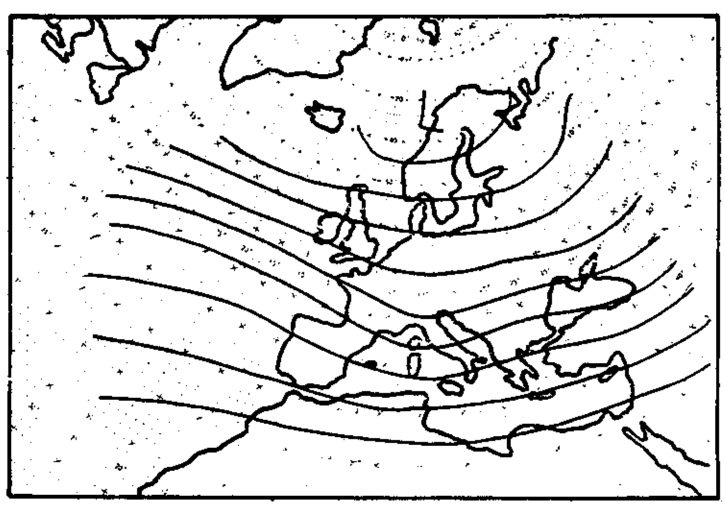

Figure II-4. Upper-level flow pattern showing the British Air Ministry Type C.

It should be noted by users of the British Air Ministry classification system that the three types often merge from one to the other or form combinations which can make classification extremely difficult.

2.1.2 Climatological Properties

Strength. Mistral wind speeds often exceed 40 kt and occasionally have reached 100 kt in gusts along the coastal region from Marseille to Toulon. Over the open water in the Gulf of Lion, at the French buoy TOQD (see Figure II-9 for location), mistral wind speeds locally greater than 40 kt occurred in nearly 8% of total observations.

Direction. Wind direction along the shore is primarily a function of the orientation of the valleys. Over the open water in the Gulf of Lion, the predominant direction is 320°-340° (data from French buoy TOQD).

Horizontal Extent. The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing southeastward. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as North Africa, Sicily and Malta, as well as very strong westerly winds in the Bonifacio Strait.

The lateral extent of the mistral over the sea is related to the sheltering effect of the Pyrenees and Alps. Sharp shear lines between the high and low wind speeds are found downstream from the edges of these mountain chains. The boundary from the northeast corner of Spain to Menorca is usually well marked.

Seasonal and Diurnal Variation. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. Figure II-5, for example, shows that at Marignane the greatest number of mistrals of 30 kt or greater occur during the months of February through April.

The diurnal variation in the intensity of the mistral appears quite different between coastal stations and observations over the open sea. At coastal stations the maximum mistral winds tend to occur in the afternoon, while over the sea (data from French buoy TOQD) they tend to occur during the night, as shown in Figure II-6.

Sea Conditions. Seas increase rapidly with the onset of mistral conditions. Significant sea heights of up to 24 ft have been reported during storm force mistral conditions in the Gulf of Lion (data from French buoy TOQD); significant sea heights of up to 30 ft can be expected farther from the coast. More typical values of sea heights are 15-20 ft.

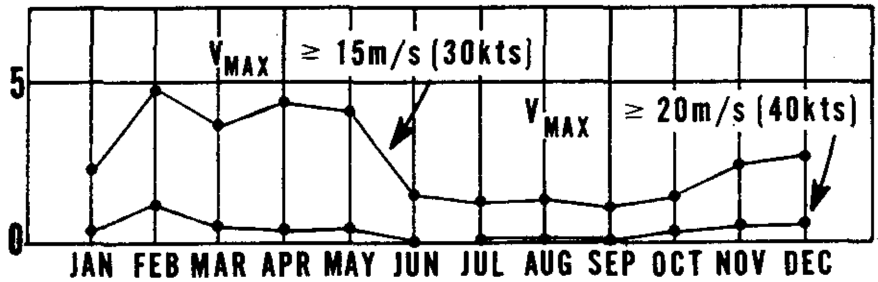

Figure II-5. Mean monthly frequency of mistrals at Marignane (1957-1966) for different threshold values of wind speed.

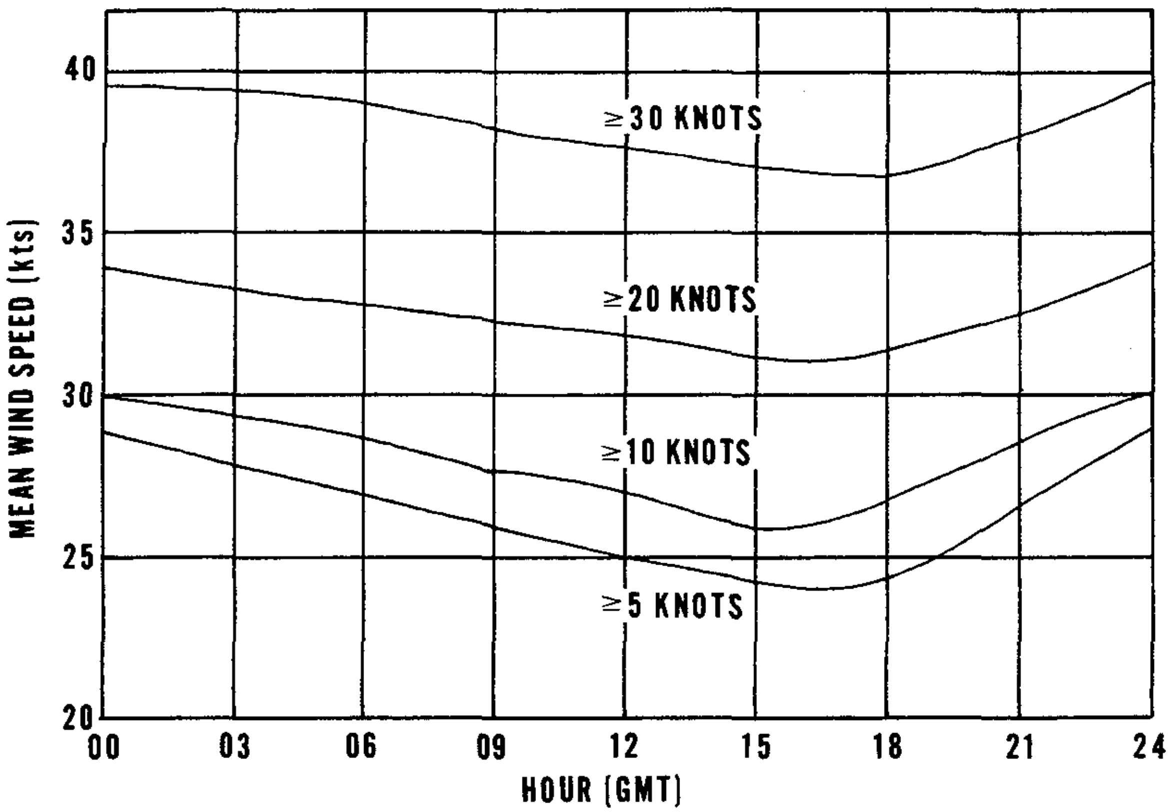

Figure II-6. Diurnal variation of mean mistral winds beyond indicated speed thresholds at *TOQD*.

Clouds and Weather. The mistral is a katabatic wind, characterized by the sinking and spreading of cold air. Skies along the coast are usually clear. Precipitation is uncommon, except when the mistral is shallow with a southerly flow of mid-levels that causes middle cloudiness and rain. Other exceptions are at the cold front associated with the onset of the mistral and at secondary cold fronts associated with reintensification of mistral conditions. However, as the cold air moves out over the warmer water, convective cloudiness does increase. (See Figure II-7 for a typical case.) Very poor atmospheric visibilities also have been reported up to a height of 30 m during cases of extremely strong mistrals because of a layer of spray that extends above the water surface.

2.2 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean originating over North Africa. Because the air's source regions are deserts, the sirocco is extremely dry at its source, warm in winter, and hot in spring and summer. Its influence occasionally extends over the entire Mediterranean basin, but it is most pronounced in the Gulf of Gabes east of the Atlas Mountains.

In the Gulf of Lion-West Central Mediterranean Area, the sirocco usually occurs in the warm sector of cyclones moving across the area. In the vicinity of the Gulf of Lion, the sirocco is known as the "marin." The direction of the marin is southeasterly, the reverse direction of the mistral in the Gulf of Lion. Over the Ligurian Sea the direction is southerly, but at times gale force easterlies also are associated with the sirocco.

Sirocco weather can vary from severe dust storms to heavy fog and rain. Skies normally can be expected to be relatively clear along the north coast of Africa, but visibilities will be reduced because of dust/sand picked up by the winds from the desert regions to the south. To the north, low stratus and fog occur as the air picks up moisture in the lowest levels from the relatively cool water surface. Given the volumes of dust in the air, visibilities in these situations can be very low.

2.3 CYCLONE OCCURRENCES

Cyclones affecting the Gulf of Lion-West Central Mediterranean Area usually originate in three regions (see Figure II-8):

(1) North Africa, south of the Atlas Mountains (North African cyclones).

(2) Gulf of Genoa, Ligurian Sea, Po Valley and, in a broader sense, south of the Alps (Genoa cyclones).

(3) Balearic Sea, off the east coast of Spain.

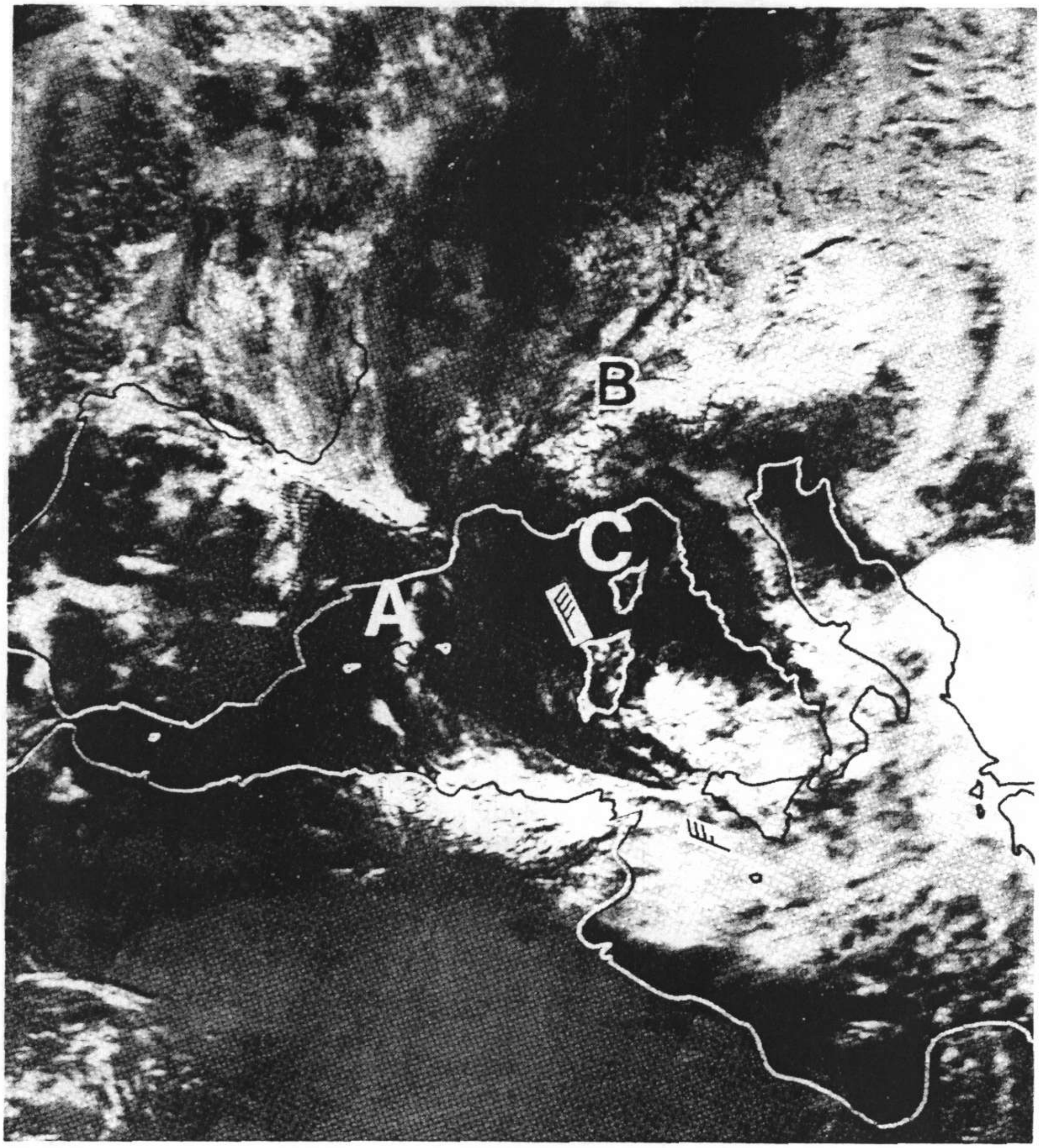

Figure II-7. DMSP high-resolution visual image, 1122 GMT, 28 January 1973.

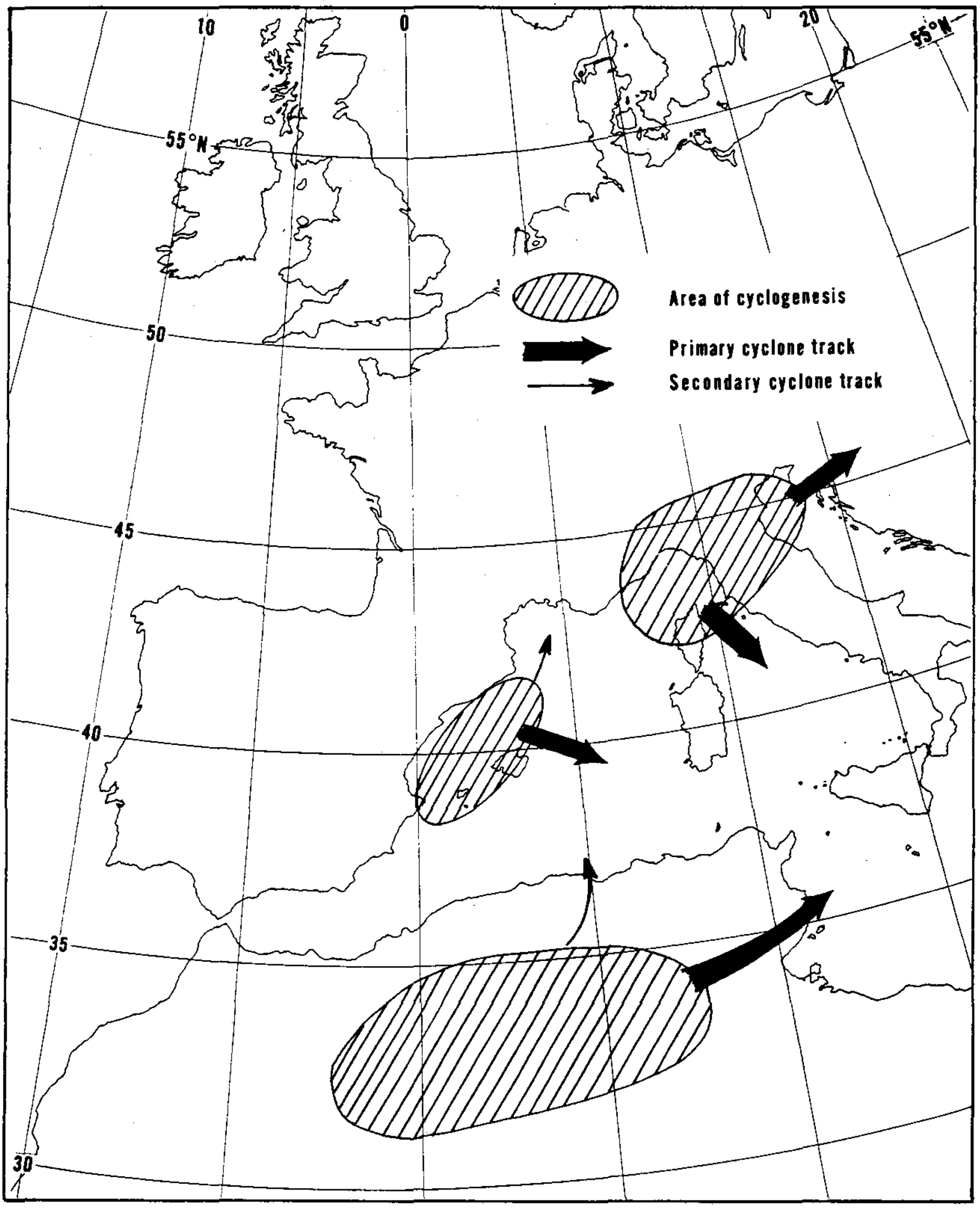

Figure II-8. Areas of cyclogenesis and tracks of cyclones which affect the Gulf of Lion - West Central Mediterranean Area.

The North African cyclone (of the type described in detail in Section V, Para. 2.5.1) is most common during the winter and spring. It generally moves eastward south of the Atlas Mountains, recurving northeastward over the Mediterranean only after reaching the Gulf of Gabes. It is only when the cyclone moves northward across the Atlas Mountains (a rare event) that it directly affects this area. During cases of strong upper-level southwesterlies across the Atlas, however, lee cyclogenesis does occur over the water. These secondary systems can be quite intense, but usually decay as soon as the parent low moves off to the east.

The Genoa cyclone (of the type described in Section III, Para. 2.3.1) affects weather conditions in this area although it generally develops and remains in the east. Its major effect is the intensification of the east-west pressure gradient and thus the strength and extent of the mistral wind regime.

Cyclogenesis off the east coast of Spain is of major importance in the Gulf of Lion-West Central Mediterranean Area during winter. These cyclones usually develop as secondaries to cyclones moving eastward across the Iberian Peninsula and appear to develop in a lee trough over the Balearic Sea. Although they generally move southeastward across the area, at times they drift northward over the Gulf of Lion.

3. FORECASTING RULES

Tables II-1 through II-4 provide quick reference to the 68 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure II-9, and listed in Table II-5.

Table II-1. Forecasting rules for the mistral.

Onset	48 hr lead time	Rules 1,2
	24 hr lead time	Rules 3-5
	Unspecified lead time	Rules 6-12
	Lead time dependent on other factors*	Rules 13-19
	≤6 hr lead time	Rules 20-23
Intensity	General	Rules 24-27
	Gulf of Lion	Rules 28-32
Horizontal Extent		Rules 33-36
Cessation		Rules 37-39
Other		Rules 40,41

*The Fleet Numerical Oceanography Center (FNOC) prog package can be expected to give useful information concerning the occurrence or nonoccurrence of mistral conditions. The best results are seen when the FNOC 500 mb analysis accurately depicts the sharpness of approaching short wave troughs along with positions and extent of the polar jet. These conditions can be checked by comparing the FNOC analysis with wind, height and temperature data from the radiosonde stations at Bordeaux, Brest, Valentia, Camborne, and Long Kesh.

Table II-2. Forecasting rules for cyclonic activity.

North African	Secondary development	Rule 42
	Maximum wind	Rules 43, 44
	Movement	Rule 45
Other		Rules 46-48

Table II-3. Other forecasting rules.

Frontal Movement/Placement	Rules 49,50
Channeling	Rules 51,52
Low-Level Jet	Rule 53
Southwesterly Gales	Rule 54
Station Reports	Rule 55
Fog	Rule 56
Haze	Rules 57-59

Table II-4. Forecasting rules for ports and anchorages.

Villefranche, Beaulieu, Monaco, Cannes	Rules 60-67
Marseille	Rule 68

Table II-5. List of observing stations.

Name of Station	Block No. (Lat., Long.)	Index No.
Beaulieu	43°43'N 7°18'E	
Bordeaux	07	510
Bougie	60	402
Brest	07	110
Camborne	03	808
Cannes	07	684
Capo Della Frasca	16	539
Istres	07	647
Long Kesh	03	920
Lus La Cruix Haute	07	587
Mahon	08	314
Marseille/Marignane	07	650
Monte Carlo	43°44'N 7°25'E	
Montpellier	07	643
Nice	07	690
Nimes	07	646
Orange	07	579
Palma	08	302
Perpignan	07	747
Sanremo	43°48'N 7°46'E	
TOQD	42°13'N 5°34'E	
Toulon	07	660
Valentia	03	953
Villefranche	43°42'N 7°18'E	

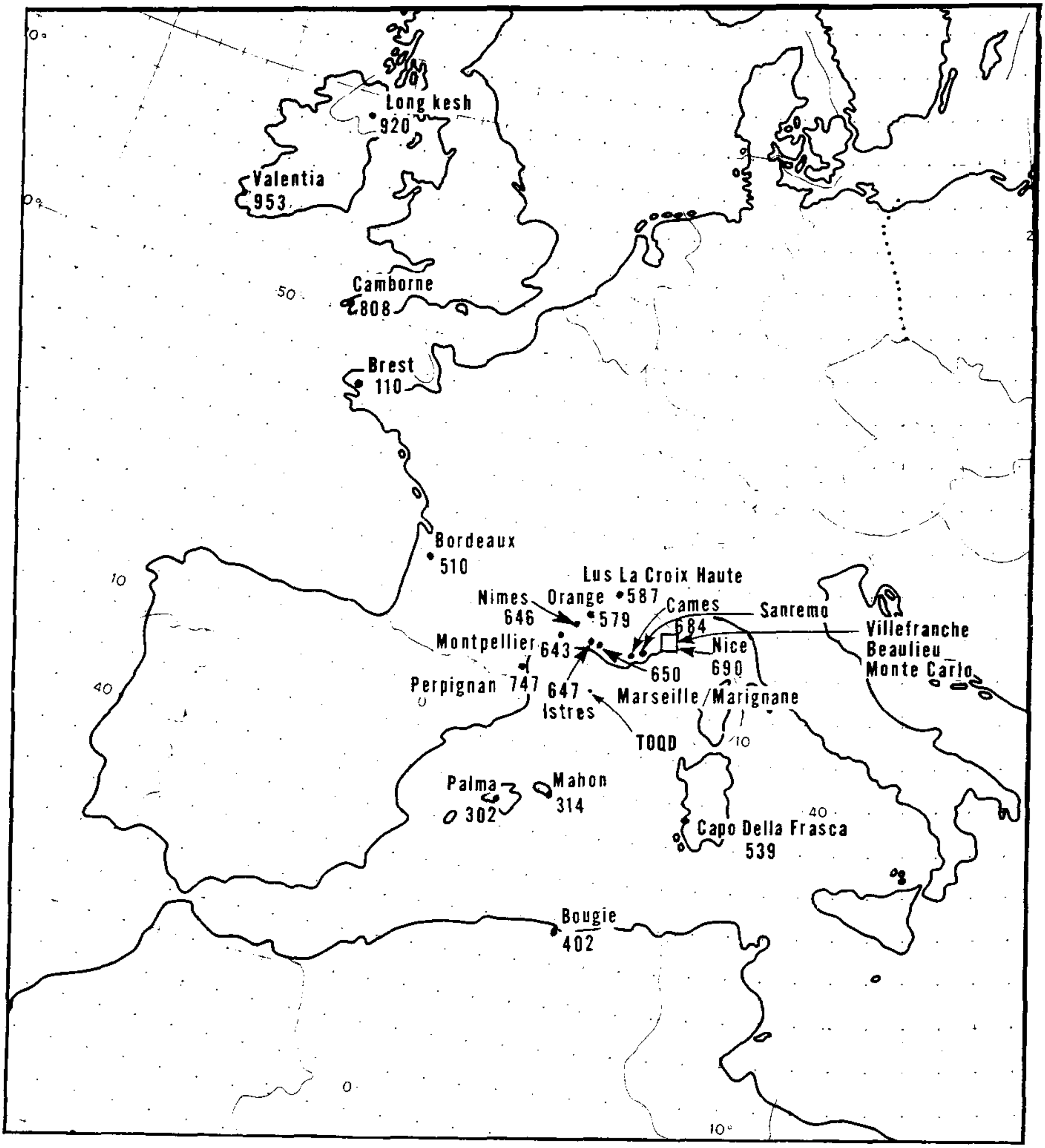

Figure II-9. Station locator map for the Gulf of Lion - West Central Mediterranean Area.

MISTRAL, ONSET, RULES 1-23

1. In association with a Type A* large-scale flow pattern as shown in Figure II-2, forecast the start of a mistral within 48 hr when a surface frontal trough is located just south of Iceland and is backed by an extremely strong surge of cold air to the east of Greenland. (Note: The longwave ridge axis is west of Iceland; this rule is biased toward established rather than developing patterns.)

2. In association with a Type C large-scale flow pattern as shown in Figure II-4, forecast the start of a mistral within 48 hr when (1) a surface frontal trough and upper short-wave trough are 24° of longitude to the west of the Gulf of Lion, (2) the short-wave ridge is 12° west, and (3) both are progressing at a speed of 12° per day. (Note: The "rule of thumb" in this case is that these short-wave ridges and troughs replace each other in 24 hr, i.e., there is a tendency toward a 48 hr periodicity of frontal systems moving into France as long as the high-index circulation is maintained. Mistrals in this situation must be short-lived.

3. In association with a Type A large-scale flow pattern (Figure II-2), forecast the start of a mistral within 24 hr when the frontal and 500 mb short-wave troughs extend across southern (or southeastern) England and the Bay of Biscay, and the short-wave ridge is located over Spain and France. (Note: The long-wave ridge axis is west of Iceland. This rule is biased toward established rather than developing patterns.)

4. In association with a Type C large-scale flow pattern (Figure II-4), forecast the start of a mistral within 24 hr when the surface and 500 mb short-wave troughs extend from the Irish Sea southward over Portugal, and the short-wave ridge is over southern France. (Note: This pattern is poorly defined in this high-index situation.)

5. In association with a Type B large-scale flow pattern as shown in Figure II-3, forecast the start of a mistral within 24 hr when: (1) the 500 mb trough moves over or just south of the south coast of France; and (2) the associated surface low appears in or near the Gulf of Genoa.

6. The probability of mistral occurrence is greatest (correlation coefficient, r = 0.62) if the 500 mb wind direction at Bordeaux is 330°-340° or 040°-050°, when the 500 mb trough reaches Nimes. The probability decreases rapidly as direction changes either to the west or east from the 330°-050° band.

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*Mistral types A, B and C (British Air Ministry classifications) are defined in Para. 2.1.1.

7. The probability of mistral occurrence with a blocking pattern is greatest (r = 0.30) if, at the time the trough reaches Nimes, the Nimes height deviation from normal is about +200 m. For progressive systems, the probability increases from r = 0.26 for deviations of +75 m to r = 0.98 for deviations of -350 m.

8. A mistral is likely to occur with a Type A situation (Figure II-2) when: (1) the long-wave trough is over or just past the south coast of France; and (2) a northwesterly (west through north-northeast) current with maximum speed of at least 50 kt at 500 mb is so oriented that it points toward the Gulf of Lion.

9. The probability of mistral occurrence is greatest (r = 0.58) when the 850 mb wind direction over Nimes is from 350°; it decreases with winds east or west of 350°, reaching near zero for winds from 240° and 090°.

10. The probability of mistral occurrence increases with the north component of the 850 mb wind at Nimes, reaching r = 0.93 for 50 kt.

11. In association with a Type A large-scale flow pattern (Figure II-2), a mistral will occur if the 500 mb winds over England or Ireland are northwesterly 50 kt or more.

12. If a cutoff low as seen at 500 mb forms over northeast France and produces a northwesterly flow at 500 mb over the south coast, a mistral may occur even though 500 mb wind speeds do not reach 50 kt and the jet axis is located far to the west and south.

13. A mistral generally sets in when the surface front or trough passes Perpignan, or the 500 mb trough passes Bordeaux. (Note: These two events are expected to occur nearly simultaneously.)

14. In association with a Type C large-scale flow pattern (Figure II-4), a mistral will occur if a deepening 500 mb trough moves over the south coast of France and is followed by a 500 mb ridge building at about the longitude of Ireland and Spain.

15. Genoa lows occur almost simultaneously with the onset of the mistral in the Gulf of Lion, and they invariably form when conditions are right for a mistral to occur. (See rules on forecasting Genoa cyclogenesis in Section III.)

16. In association with a Type A large-scale flow pattern (Figure II-2), a mistral will start when the 500 mb short-wave arrives over Perpignan.

17. In association with a Type C large-scale flow pattern (Figure II-4), a mistral will start when a northwesterly jet stream arrives over the Bay of Biscay.

18. If a 500 mb trough extends from Central Europe southward over North Africa, a surface low from Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a mistral (see rules on forecasting movement of North African lows in Section V.)

19. The mistral will start when one of three differences is achieved: Perpignan-Marignane, 3 mb; Marignane-Nice, 3 mb; or Perpignan-Nice, 6 mb. A difference usually occurs from 0 to 24 hr after a closed Genoa low appears, but it occasionally occurs earlier.

20. Wave clouds, such as observed on high-resolution Defense Meteorological Satellite Program (DMSP) satellite imagery, are observed over the Massif Central of Southern France approximately 6 hr before the start of a mistral (see Figure II-10).

21. Lus La Croix Haute will provide a 2-3 hr advance notice of mistral onset. This wind speed report will closely approximate the wind speed in the Gulf. (Note: Usefulness of this station limited by the fact it only reports every 3 hr.)

22. Orange gives a good 3-4 hr warning of a gale force mistral when winds at this station increase to 25 kt northwesterly. Hourly reports are available from this station.

23. By observing changes in the normally strong afternoon sea breeze (east-southeasterly direction) at Perpignan, it is possible to forecast the beginning of a mistral in the Gulf of Lion. If, at this station, the wind shifts northerly with speeds increasing to 25-30 kt and the temperature drops at least 3°F, a strong mistral (40-50 kt) will be blowing in the Gulf of Lion within 6 hr.

MISTRAL, INTENSITY, RULES 24-32

24. Strongest winds associated with a mistral do not occur until after the passage of the upper-level (500 mb) trough. This occurs well after the surface cold frontal passage.

25. Forecast mistral winds to increase during a Type A large-scale flow pattern (Figure II-2) in about 24 hr after a new cold front or minor trough appears in the northwest current over southern England, and the maximum speed at 500 mb in the current increases at least 10 kt while the inflection point (IP) retrogrades or remains stationary; or with the passage of the new cold front or minor trough.

26. Satellite observations indicating a strong mistral will exhibit the following features: cloudy over France and clear over the water area south of the 1000' water depth contour; clear over the Gulf of Lion but a cloud mass, parallel to the coast, lying 75-150 n mi offshore; wispy cloud streaks extending from 315° to 360° into offshore clouds (see Figure II-11).

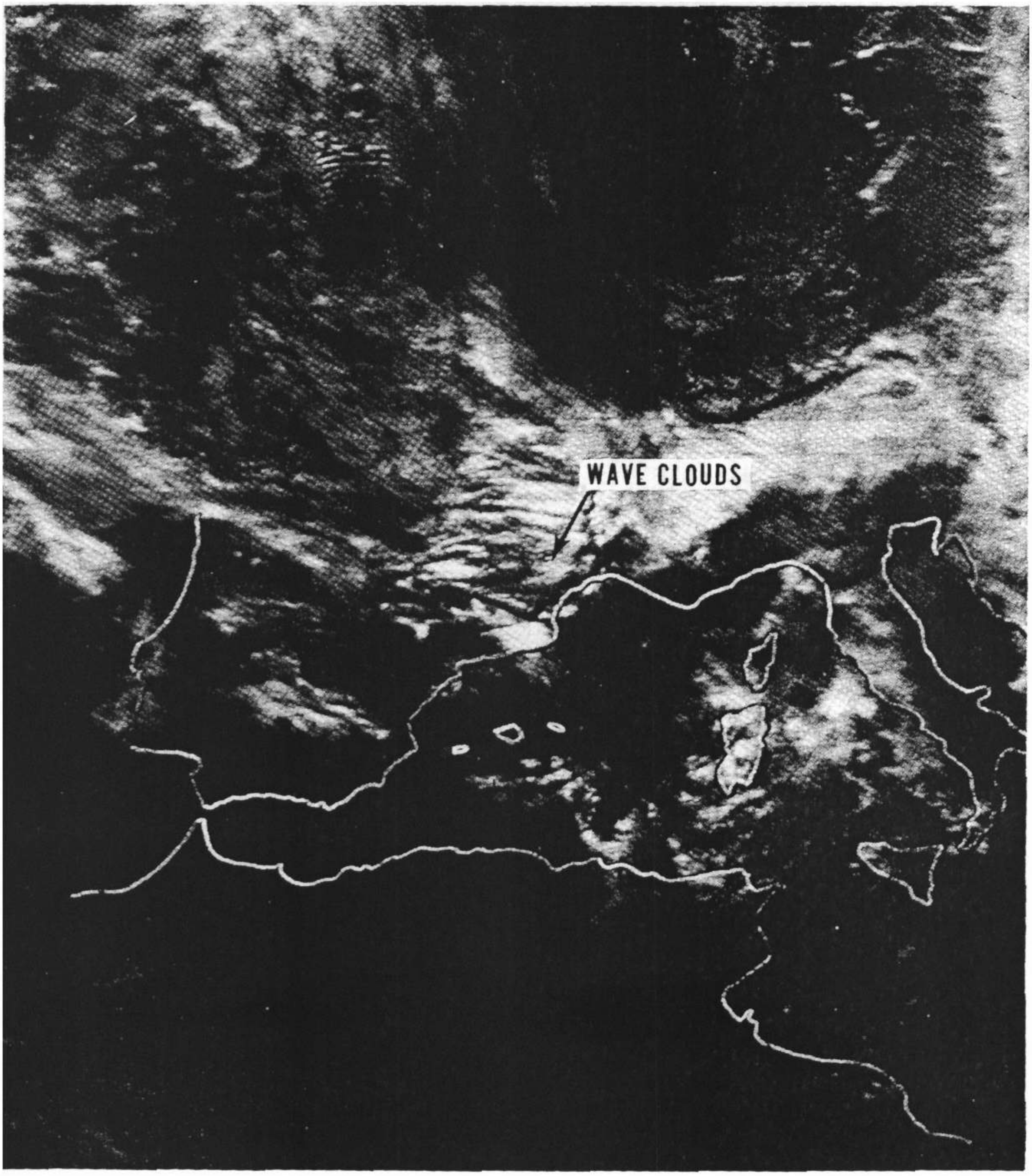

Figure II-10. DMSP high-resolution visual image, 1136 GMT, 27 January 1973.

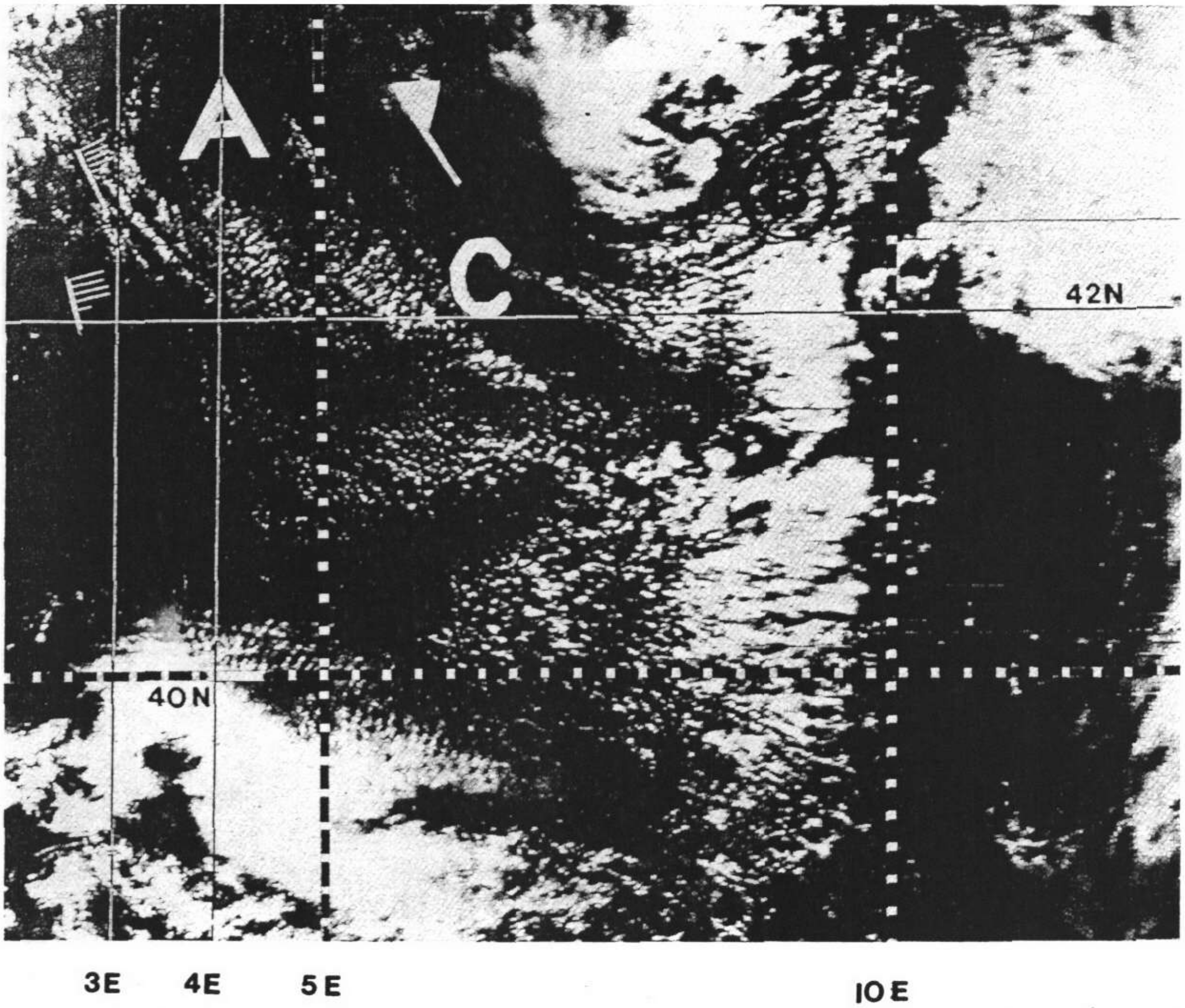

Figure II-11. DMSP satellite photo of storm force mistral winds in the Gulf of Lion and west Mediterranean during April 1975 verified by the four attendant 45 kt land and ship reports.

A. Shows typical clear coastal area with increasing cloudiness down wind.

B. Shows southwest flow north of Corsica typical of 80% of mistral situations.

C. Shows area of strongest winds with sharp definition indicated in cloud patterns.

27. Wave clouds extending from Sardinia to Tunisia, viewed on satellite imagery, are generally associated with gale force mistral situations (shown in Figure II-7).

28. Use the table below to estimate wind speed associated with a mistral in the Gulf of Lion.

Pressure Difference* (mb)	Perpignan (station 07747) and Nice (station 07690)	Perpignan and Marignane (station 07650)	Marignane and Nice
3		30-35 kt	30-35 kt
4		40	40
5		45-50	45-50
6	30-35 kt		
8	40		
10	45-50		

*Highest pressure at Perpignan.

29. Wind speeds over open water during a mistral will be approximately double those measured at Perpignan or Marignane except in storm conditions, when the ratio will be lower.

30. A good indication of the intensity of a mistral in the Gulf of Lion can be obtained by adding 10 kt to the wind speed reported by either Montpellier or Istres.

31. If the 500 mb winds reported at either Bordeaux or Brest are northwesterly at 65 kt or greater, storm warnings instead of gale warnings are indicated for the Gulf of Lion.

32. Maximum mistral winds occur when the surface isobars are at an angle of 30° to the valleys of either the Garonne, the Rhone or the Durance with low pressure to the southeast.

<u>MISTRAL, HORIZONTAL EXTENT, RULES 33-36</u>

33. The eastern boundary of the mistral extends downwind from the western edge of the Alps through Sanremo.

34. The western boundary of the mistral has the following characteristics:

(1) The boundary is generally narrow, 2-20 n mi wide.

(2) Large changes in wind and sea conditions are observed across the boundary: winds generally are 8-16 kt to the west and 35-45 kt to the east of the boundary, while seas are 3-5 ft to the west and 14-20 ft to the east.

(3) The boundary defining the limit of the mistral appears to move generally from east to west especially in the region of the Balearic Islands. At times it oscillates from southwest Mallorca to northeast Menorca.

(4) The boundary occasionally is marked by a line of low clouds; at other times it is clear and can only be observed by the different effects of the wind on the surface of the sea.

(5) A relatively accurate location of the boundary is a line drawn to the North African coast through the stations at Perpignan, Mahon and Bougie.

35. The strong mistral winds which occur on the cyclonic side of and underneath the jet axis, will extend as far south or southeast as do the trough and jet stream.

36. Rule 35 applies primarily to Type A large-scale flow patterns (Figure II-2). If a deep trough extends to Sicily or Algeria, the mistral usually extends into the region of Sicily and Malta or, in extreme cases, to Algeria.

MISTRAL, CESSATION, RULES 37-39

37. *In association with a Type A large-scale flow pattern (Figure II-2),* surface winds usually decrease, i.e., the mistral ceases when the jet axis moves eastward and an anticyclonic regime is established. This rule reflects the *control on the surface pattern that is exercised by the upper air pattern.*

38. The mistral will cease when the cyclonic regime at the surface gives way to an anticyclonic regime. Indications of this change are:

(1) The surface wind direction becomes north to northeast.

(2) The 500 mb ridge begins to move over the area.

(3) High pressure at the surface begins to move into the western basin of the Mediterranean.

(4) There is a change that reduces the pressure difference between France and the western basin.

39. *Cold advection on the western flank of a blocking ridge over the* eastern Atlantic may herald the breakdown of the long-wave pattern and, hence of the mistral. This rule applies to Types A and B large-scale flow patterns where breakdown of the ridge, rather than eastward movement, results in cessation of the mistral.

MISTRAL, MISCELLANEOUS, RULES 40, 41

40. During strong mistral conditions in the Gulf of Lion, a strong diurnal wind variation in the sea area north of Mallorca has been observed, possibly the result of oscillation of the shear line described in Rule 34. Daytime wind speeds appear to be more than twice as strong as those at night; in one actual case, 10-20 kt daytime winds decreased to 4-6 kt at night.

41. Mistrals during late autumn and early winter may occur when air-sea temperature differences (water warmer than air) reach 6°C or more. At these times there is poor visibility in the lowest 30 m of the atmosphere because of a layer of spray. These mistral situations are also associated with damage to harbor installations along the Algerian and Tunisian coasts because of the unusually high sea and swell.

CYCLONIC ACTIVITY, NORTH AFRICAN, RULES 42-45

42. A frequent development, which occurs in conjunction with the appearance of a depression to the south of the Atlas range, is the generation of a low to the north of the Atlas range (Figure II-12). Such lows are usually formed when the upper flow over northwest Africa is between southwest and south; a lee effect is thought to be the initiating factor in this case.

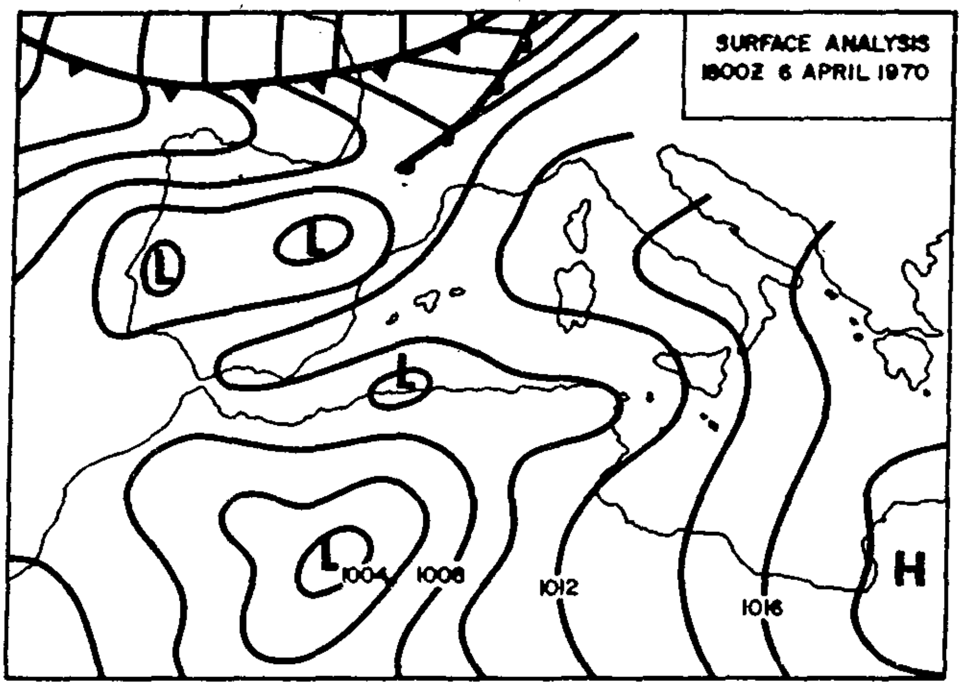

Figure II-12. Surface analysis, 1800 GMT 6 April 1970, example of a secondary depression north of the Atlas Mountains.

The two lows generally move eastward together, the parent to the south of the Atlas range and the subsidiary along the coast of Algeria and Tunisia. Should the upper flow over the Atlas back to southeasterly, the subsidiary low may remain stationary or even drift westward for a time. A close watch must be kept for the formation of the subsidiary lows; they are often small features that are difficult to see on a synoptic chart, but they can cause unexpected increases in wind and thundery outbreaks along the coast of Algeria and Tunisia. Occasionally they develop into major depressions, particularly on the arrival of a cold front from the north, and thereafter may move independently of the parent low.

43. Strongest winds associated with North African lows occur west of the centers when an incursion of cold air aloft arrives (seen at 500 mb).

44. It has been noted that the strongest winds associated with deepening North African lows, after moving out over the Mediterranean, occur in the northwest sector of the system rather than in the eastern sector.

45. Past numerical models sometimes have tended, incorrectly, to move developing North African lows northeastward across the Atlas Mountains. The actual course of these lows was usually first to the east, south of the Atlas Mountains, then northeastward after they reach the Gulf of Gabes.

CYCLONIC ACTIVITY, MISCELLANEOUS, RULES 46-48

46. Remnants of old cold fronts should be followed closely. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with these fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

47. Cold fronts approaching the central Mediterranean become very active when they slow down. Multiple low centers with heavy rain are very common. This pattern remains stationary until the upper trough either moves eastward or fills.

48. Complex low pressure systems with multiple centers at the surface are a common event in the western Mediterranean basin. One center usually can be found in the Gulf of Genoa, and another over North Africa; a weak pressure gradient exists between the two systems. Which of those lows will develop depends greatly on the movement of an upper-level (500 mb) shortwave trough (SD minimum). If, for example, the SD minimum moves to the North African coast, the low center in that region will develop; this rapidly increases the pressure gradient, and causes easterly gales over the southern and central portions of the Mediterranean.

MISCELLANEOUS RULES, FRONTAL MOVEMENT, RULES 49, 50

49. Shallow cold fronts approaching the Mediterranean basin are greatly retarded by the mountain barriers. Deep cold fronts (those detectable at the 700 mb level) are not hindered by terrain features, and at times even accelerate. Movement of troughs at the 400 mb level appears to be useful in forecasting this acceleration.

50. Correct placement of fronts is very difficult in the western Mediterranean basin, particularly in summer when fronts are weakest, due to the lack of ship reports and to terrain effects. One of the worst such areas is over the Iberian Peninsula and Balearic Sea. Observers should be alert to the lee trough that develops along the east coast of Spain during periods of northwesterly flow: there is a tendency to designate this trough as frontal, instead of correctly moving the front eastward across the region.

MISCELLANEOUS RULES, CHANNELING EFFECTS LOW LEVEL JET, RULES 51, 52, 53

51. Winds with an east or west component are funneled through the Strait of Bonifacio in a "V" pattern. Rough seas are experienced within the "V", with wave heights often doubled on the eastern side of the Strait during mistral conditions.

52. High winds caused by channeling are observed in the Campidano Valley across Sardinia. With southeasterly winds normally associated with a sirocco, wind speeds at Capo Della Frasca, on the northwest end of the valley, can be triple those at nearby stations.

53. During periods of sirocco over the Mediterranean, there probably will be a low-level jet just below the top of the very marked temperature inversion common during sirocco conditions. Wind speeds reaching 70-80 kt, as well as heavy turbulence associated with strong vertical wind shear, have been observed in this jet.

MISCELLANEOUS RULES, SOUTHWESTERLY GALES, STATION REPORTS, FOG, HAZE, RULES 54-59

54. Strong southwesterly winds at 30-40 kt, associated with the early stages of lee cyclogenesis south of the Alps, are common in the region between the southern French coast and Corsica.

55. Some confusion has arisen in the past over the pressure tendency reported at Palma in the Balearic Islands. During the period from late winter through spring, large pressure falls of approximately 2 mb/3 hr at the 0300 GMT observation at Palma have been misleading. Apparently these pressure falls were a local effect, not indications of cyclogenesis. Mahon appeared to give more reliable information at these times.

56. Likely areas for the occurrence of fog during the summer are along the coasts of Corsica and Sardinia and between Sardinia and the North African coast.

57. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.

(2) Its color is bluish white, as opposed to the brown of dust haze.

(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) It is sometimes thicker aloft than at the surface.

(7) It is less of a problem after sunset since the poor visibility is caused partially by scattering and reflection.

58. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing due to the presence of a strong ridge present at the surface and aloft.

59. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

PORTS AND ANCHORAGES, SOUTHERN FRANCE, RULES 60-68

60. The carrier anchorage at Cannes is well protected from all but a southwesterly direction.

61. Cannes is not normally affected by the mistral, although white caps and rough seas can be observed just to the west of the harbor.

62. The most hazardous weather conditions at Cannes -- high winds, rough seas, thundershowers/storms and continuous rain -- are associated with depressions moving from the south towards the Gulf of Lion or the Ligurian Sea.

63. Depressions moving into the Ligurian Sea or across Corsica into Italy create a southerly swell (approximately 160° to 220° depending on the track) that enters the harbor at Cannes. This swell can be as high as 8-10 ft and persist for 2-3 days. The biggest problem with the swell is that the winds in the local area are usually from a different direction than the swell, which causes the swell to approach ships at anchor at critical angles of 45-90°.

64. Wind conditions at Cannes will vary considerably from those at Villefranche, Beaulieu and Monte Carlo.

65. The harbor at Villefranche is considered one of the safest in the Mediterranean. About the only time a mooring problem might arise is when a southerly swell enters the harbor (see Rule 63 for synoptic conditions producing a southerly swell). The swell can also cause an increase in water depth, raising the water level at the boat landing.

66. A strong pressure gradient in the vicinity of Villefranche and Beaulieu (high pressure to the north) will cause almost continuous high northerly winds at Beaulieu. At Villefranche, on the other hand, strong northerly winds of 20-40 kt will usually last only 1-2 hr.

67. Depressions forming in the Gulf of Genoa affect Monaco and Beaulieu with high winds, high seas, and occasionally severe thundershowers/storms. Since Villefranche is better protected from the east and northeast, the winds and seas there are much reduced.

68. During a mistral at Marseille there is a strong diurnal wind variation at the carrier anchorage; maximum winds occur in the afternoon and minimum winds are reached shortly after midnight. For example, wind speeds of 30-35 kt during the afternoon decrease to 20-25 kt at night.

With northwesterly winds in both the Gulf of Lion and the anchorage, westerly swell from the Gulf of Lion is experienced at the anchorage. Given a period of northwesterly winds at the anchorage of 25-35 kt, for example, a westerly swell of 4-5 ft and wind wave of 4-5 ft can occur. When the wind direction becomes more northerly in the Gulf of Lion, the swell diminishes. However, northwest winds of 35 kt gusting to 45-50 kt at the anchorage can produce wind waves of 6-8 ft even though the fetch to the northwest of the anchorage is only 3 n mi.