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LOCAL WINDS RELATED TO SYNOPTIC SCALE GEOSTROPHIC WINDS IN THE LOWER NERVION VALLEY AREA

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SUMMARY AND CONCLUSIONS

An analysis of the synoptic scale geostrophic winds compared to the local winds in the lower Nervion Valley area was performed by NILU in collaboration with Labein.

The analysis was based upon one year of data taken from 00 GMT and 12 GMT weather maps from 1 March 1986 to 1 February 1987.

The following conclusions have been drawn:

- The most frequent geostrophic wind directions were from around west in all seasons except the summer, which was dominated by weaker north-easterly winds.
- For westerly geostrophic winds the local winds in the area were related to the synoptic scale wind and turned 0 to 45 degrees to the left.
- For easterly geostrophic winds there was no clear relationship to the local wind patterns.
- The mesoscale and local wind system of the area most often over-ruled the external synoptic scale geostrophic wind patterns.

Examples are given of typical situations of very strong geostrophic winds which might influence the local wind pattern in the area. A typical summer situation is described where a local low pressure area builds up over the Iberian peninsula, creating easterly geostrophic winds and up-valley sea breeze in the surface layer.

CONTENTS

LOCAL WINDS RELATED TO SYNOPTIC SCALE GEOSTROPHIC WINDS IN THE LOWER NERVION VALLEY AREA

1 INTRODUCTION

The Norwegian Institute for Air Research (NILU) is in collaboration with Laboratorios de Ensayos e Investigaciones Industriales (LABEIN) performing an air quality study in the lower Nervion area. The study is being carried out for the Basque Government.

This report is part of the evaluation of meteorological conditions of the area and presents the relationship between local winds and synoptic scale geostrophic winds.

The analysis is based upon one year of data; from 1 March 1986 to 1 February 1987. The evaluation of geostrophic wind based upon pressure isobars taken from surface weather maps, was carried out by LABEIN. The statistical evaluation and discussions were performed by NILU.

2 GEOSTROPHIC WIND

The geostrophic wind is a hypothetial wind velocity for which the coriolis force exactly balances the horizontal pressure force. The geostrophic wind is directed along the contour lines on a constant pressure surface. On a weather map this will be along the isobars with low pressure to the left in the Northern Hemisphere.

A graphical device can be developed for determination of the speed of the geostrophic wind, from the isobar or the contour line spacing on a synoptic weather chart. This is based upon the solution of the geostrophic wind equation:

$$V_g = (\partial P/\partial n)/\varrho \cdot f$$

where

f = the coriolis parameter = $2\ \Omega \sin \Theta$

P = the pressure at a fixed height (sea surface)

n = horizontal distance measured normal to the flow (m)

ϱ = the density of air ($1.29\ kg\ m^{-2}$)

The n-axis is directed to the right of the flow (in the Northern Hemisphere).

In the analysis for the lower Nervion Valley area, weathermaps from the Deutsche Wetterbericht at 1200 GMT and 00 GMT was used. The distance, Δn between each 5 mb was read and the speed of the geostrophic wind was estimated from

$$V_g\ (m/s) = (\varrho \cdot 2\ \Omega \cdot \sin \Theta)^{-1}\ (\Delta p/(M \cdot \Delta n))$$

where

Ω = earth angular velocity ($0.7292\ 56 \cdot 10^{-4} s^{-1}$)

Θ = degree latitude (45^0)

and M is the map scale. This was $1{:}30 \cdot 10^6$ for the 1200 GMT maps, $1{:}60 \cdot 10^6$ for the 00 GMT maps. The geostrophic wind direction was taken directly along the isobars with lower pressure to the left.

3 DATA AVAILABILITY

Surface weather maps were available for all days during the period March 1986 to Februar 1987. During the winter season the isobaric spacing was usually well defined and it was possible to read a geostrophic wind speed. Only two observations were thus missing during this season.

In the summer season, however, a high pressure area often covered the Bisquay area. No pressure gradients could be found close to the area and it was thus impossible to evaluate a geostrophic wind speed at all.

For the whole year of 730 observations, the data availability was about 93%.

4 GEOSTROPHIC WIND DIRECTIONS

The frequency of geostrophic wind directions are presented in Figure 1 for each season.

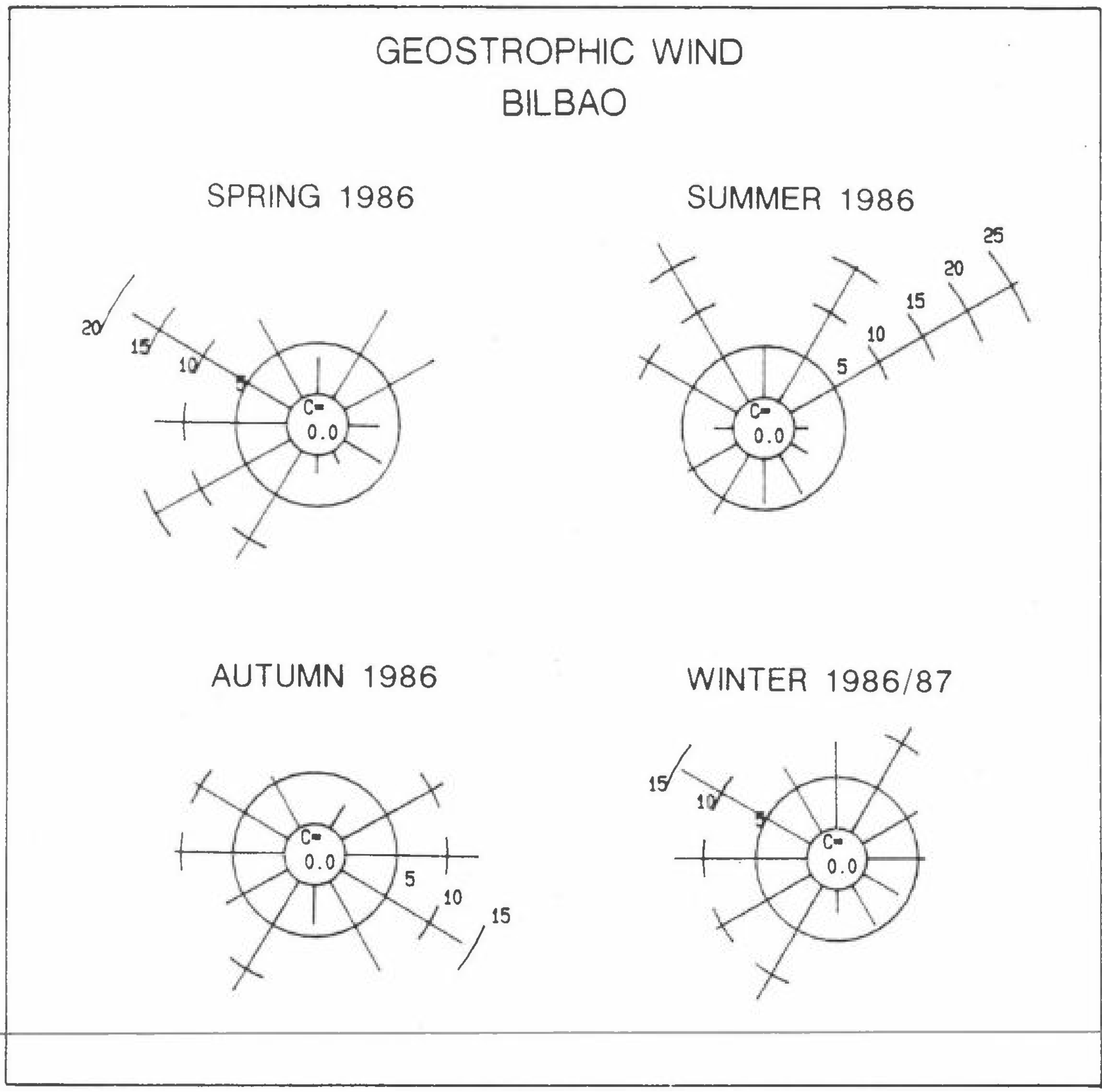

Figure 1: Seasonal frequency distributions of geostrophic wind directions over the Lower Nervion Valley area.

During the spring 1986 the dominating geostrophic wind direction was from the sector west-southwest (210^0-300^0). Wind from this sector occurred in 67% of the time. Winds from around northeast (30^0-60^0) occurred in 19% of the time in this season.

The summer season was dominated by northeasterly winds ($45^0 \pm 30^0$). These wind directions occurred more than 40% of the time, indicating that higher pressure was located north of the Iberian peninsula. Another important geostrophic wind direction, which occurred 29% of the time in the summer, was from around northwest.

Both easterly and westerly winds occurred during the autumn. These winds along the coastline appeared much more frequently than winds from northerly and southerly directions.

During the winter season, the area of northern Spain frequently experienced the large scale westerlies with high pressure to the south. The most pronounced wind directions were from around west-southwest ($255^0 \pm 45^0$).

5 GEOSTROPHIC WIND SPEEDS

The frequency distributions of geostrophic wind speed is presented in Figure 2.

The highest wind speeds occurred during the winter season. The maximum geostrophic wind speed was observed to 35 m/s. The median value in this season was around 7 m/s.

The wind speeds during the summer season were lower than during the other seasons with a median value of about 5 m/s and no wind speed higher than 18 m/s. The arithmetic average, median, 95% and maximum wind speeds for each season are given in Table 1.

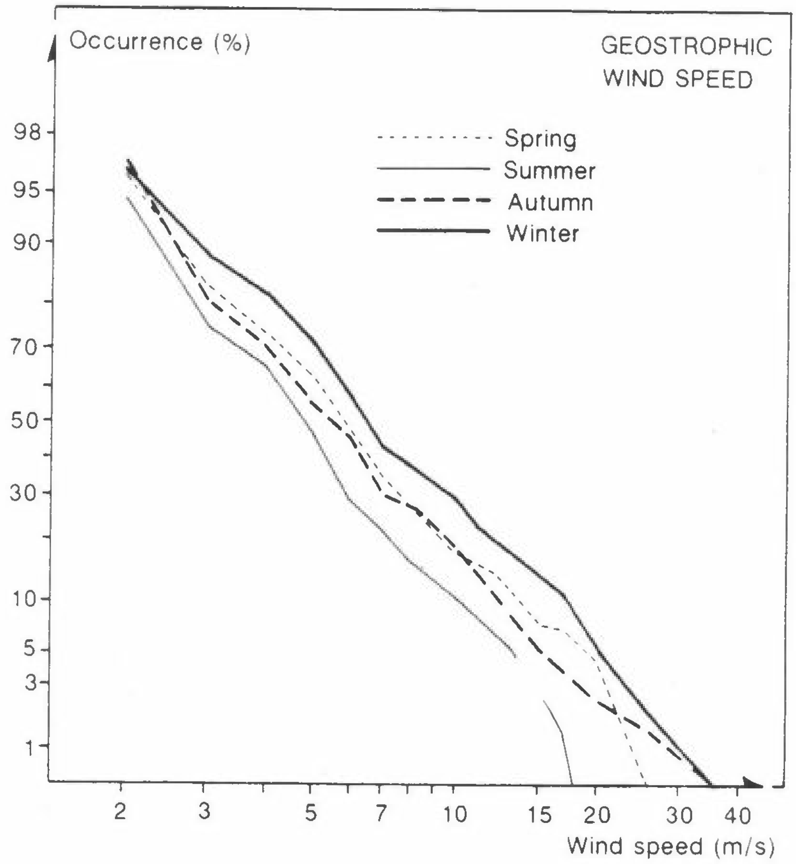

Figure 2: Cumulative frequency distribution of geostrophic wind speeds for each season.

Table 1: Geostrophic wind speed statistics given by median, average, 95-percentile and maximum values for each season.

	Geostrophic wind speed (m/s)			
SEASON	Medium	Average	95%	Max.
Spring	5.9	7.2	18.0	26.0
Summer	4.9	5.5	14.5	17.5
Autumn	5.7	6.7	16.5	35.0
Winter	6.8	8.4	21.0	35.0

In figure 3 the seasonal average wind speeds are given as a function of the wind directions. The highest wind speeds occurred during winds from around west-southwest for all seasons, except for the summer season.

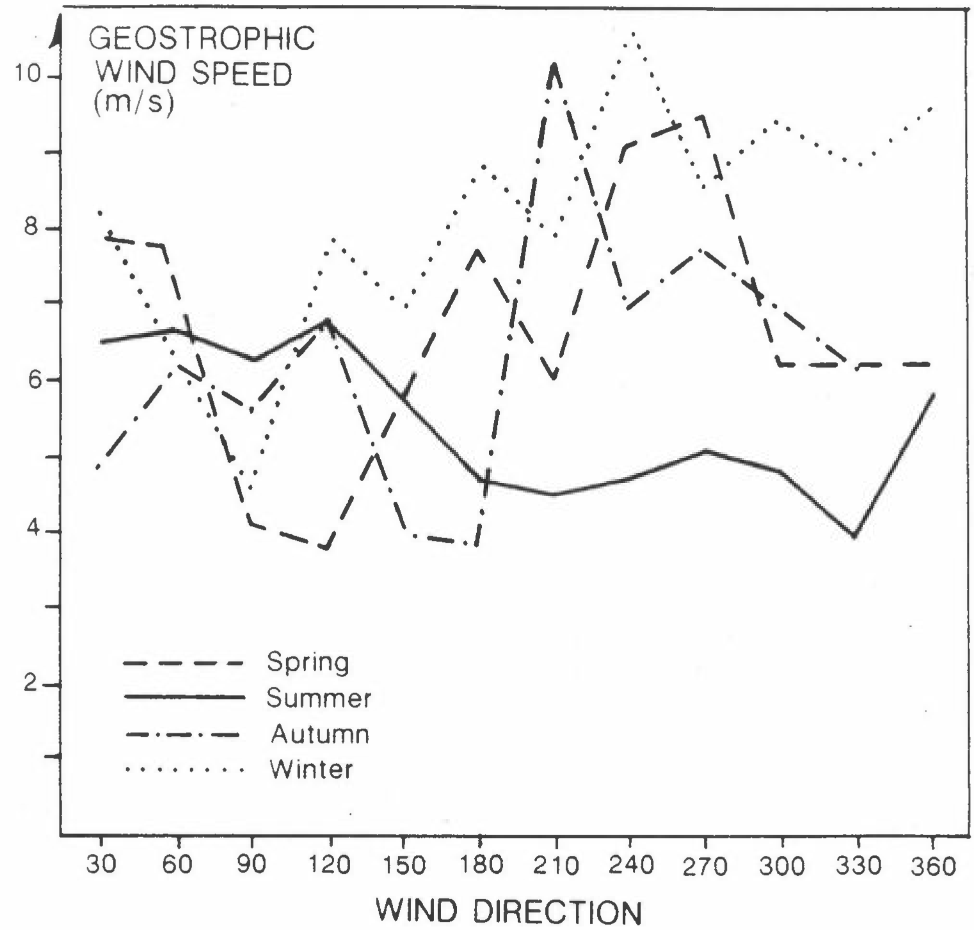

Figure 3: Average geostrophic wind speeds as a function of the wind direction given for each season.

Figure 3 shows that the summer season geostrophic winds clearly deviate from the other seasons. It is expected in the further evaluations that local and mesoscale influences on the local wind patterns are stronger in the summer, and that correlations to large scale weather patterns are more difficult to identify.

6 LOCAL WINDS VERSUS GEOSTROPHIC WINDS

Statistical evaluations of the local wind patterns in the Lower Nervion Valley area are presented in 4 quarterly reports (Bøhler et al., 1987-88). A summary of station location and wind roses is presented in Appendix A. Wind frequency distributions for the geostrophic winds are given in previous chapter. These distributions of local winds and large scale winds can be compared directly.

In this chapter we will only discuss simultaneous observations of local winds and geostrophic wind to investigate whether a mathematical relationship can be established.

Figure 4 shows the number of simultaneous observations of geostrophic wind directions and wind directions measured at Banderas.

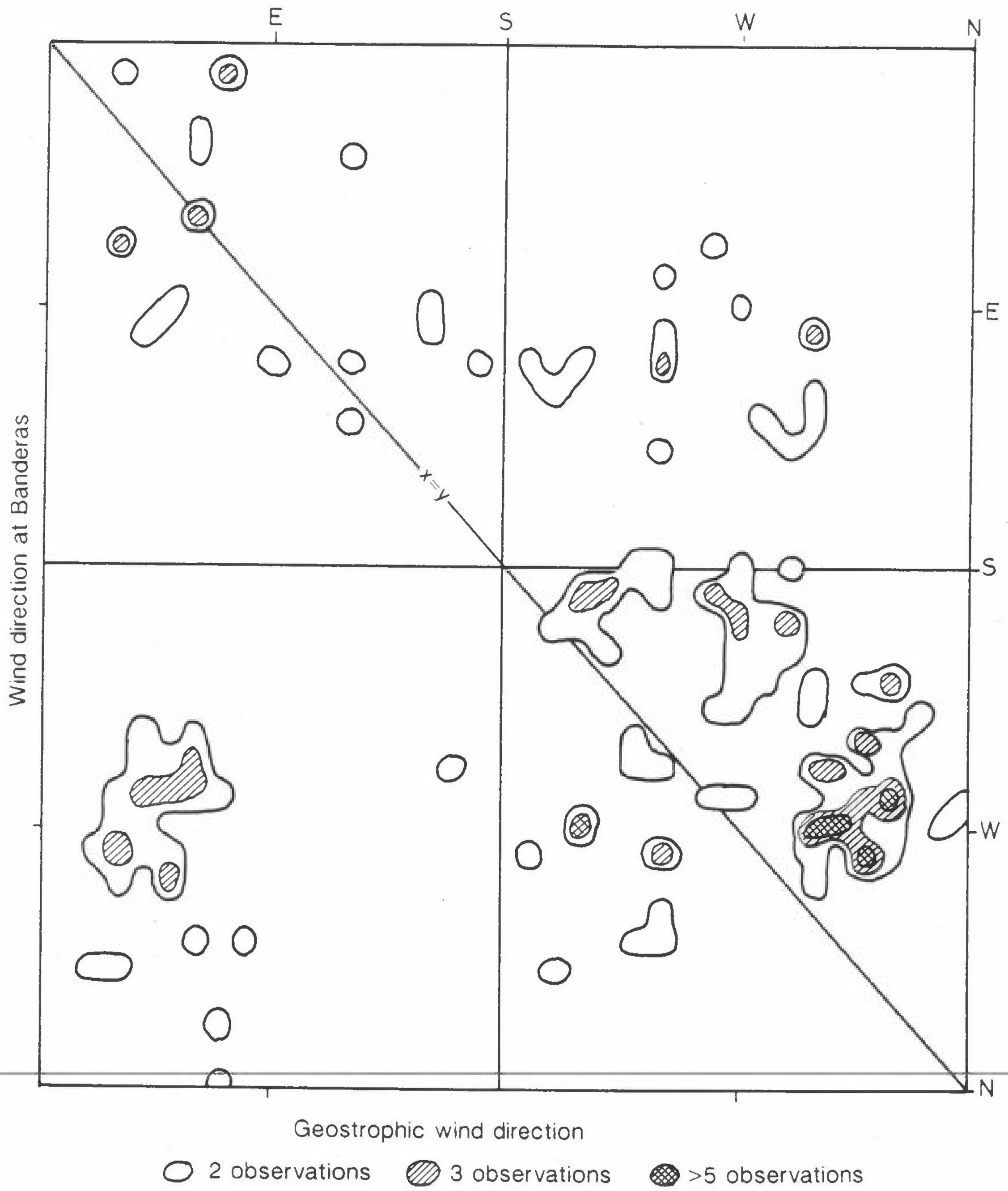

Figure 4: Geostrophic wind versus wind at Banderas. Number of observations of simultaneous wind directions devided into 10 deg. sectors. Observations along the diagonal are identical wind directions.

A close connection between geostrophic wind directions and wind at Banderas cannot be seen. The winds at Banderas seemed to be channelled from around west for all directions of the geostrophic winds. However, for geostrophic winds from around westerly directions the local Banderas winds also tended to be from around west.

To further investigate the local wind dependency upon geostrophic wind, the two predominant geostrophic wind directions have been selected for additional analysis in Figures 5 and 6.

When the geostrophic wind was blowing from west-northwest ($300^0 \pm 15^0$), the most frequent local wind directions at Banderas were from around west. At Sondica the local winds were blowing from around west, south and south-easterly directions. The stronger geostrophic winds from west-northwest showed more or less the same pattern. At Banderas the winds were more often nicely turned to the let compared to the geostrophic wind, according to theoretical expected dependency.

When the geostrophic wind was blowing from around north-east (50 ± 15^0), very weak dependency to the local winds at Banderas was found. In fact, for easterly geostrophic winds the local wind at Banderas was most often blowing from the opposite direction; around west.

At Sondica the stronger (> 5 m/s) north-easterly geostrophic winds normally gave rise to down-valley flows. A turning of the local wind to the right compared to the geostrophic wind is caused by local channelling along the Sondica valley.

No consistant conclusions about the local wind pattern relative to geostrophic winds can be drawn based upon this analysis.

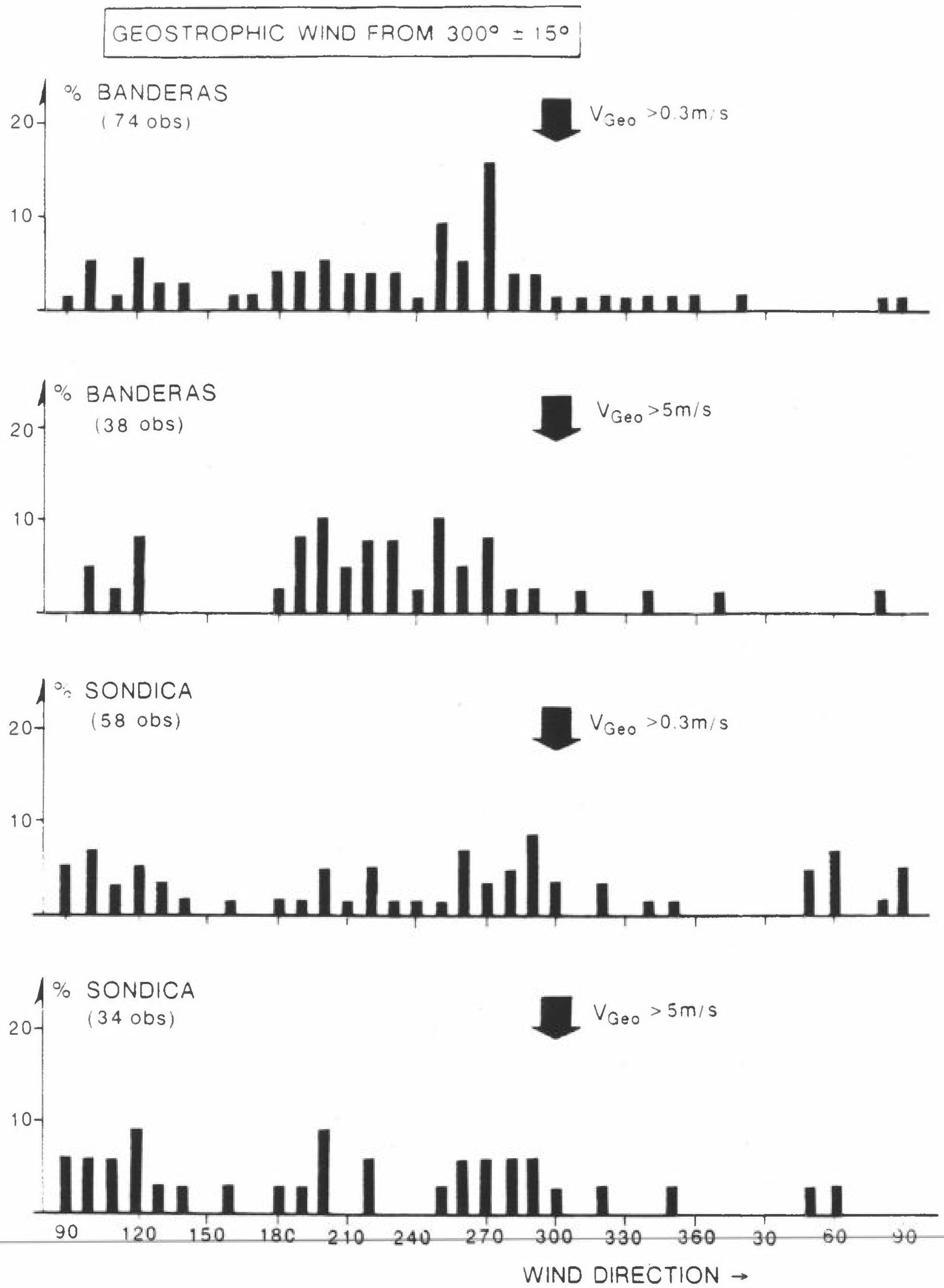

Figure 5: Wind direction frequency distribution at Banderas and Sondica for cases when the geostrophic wind is blowing from west-northwest ($300^0 \pm 15^0$).

a) for all geostrophic windspeeds (> 0.3 m/s)

b) for geostrophic windspeeds in excess of 5 m/s.

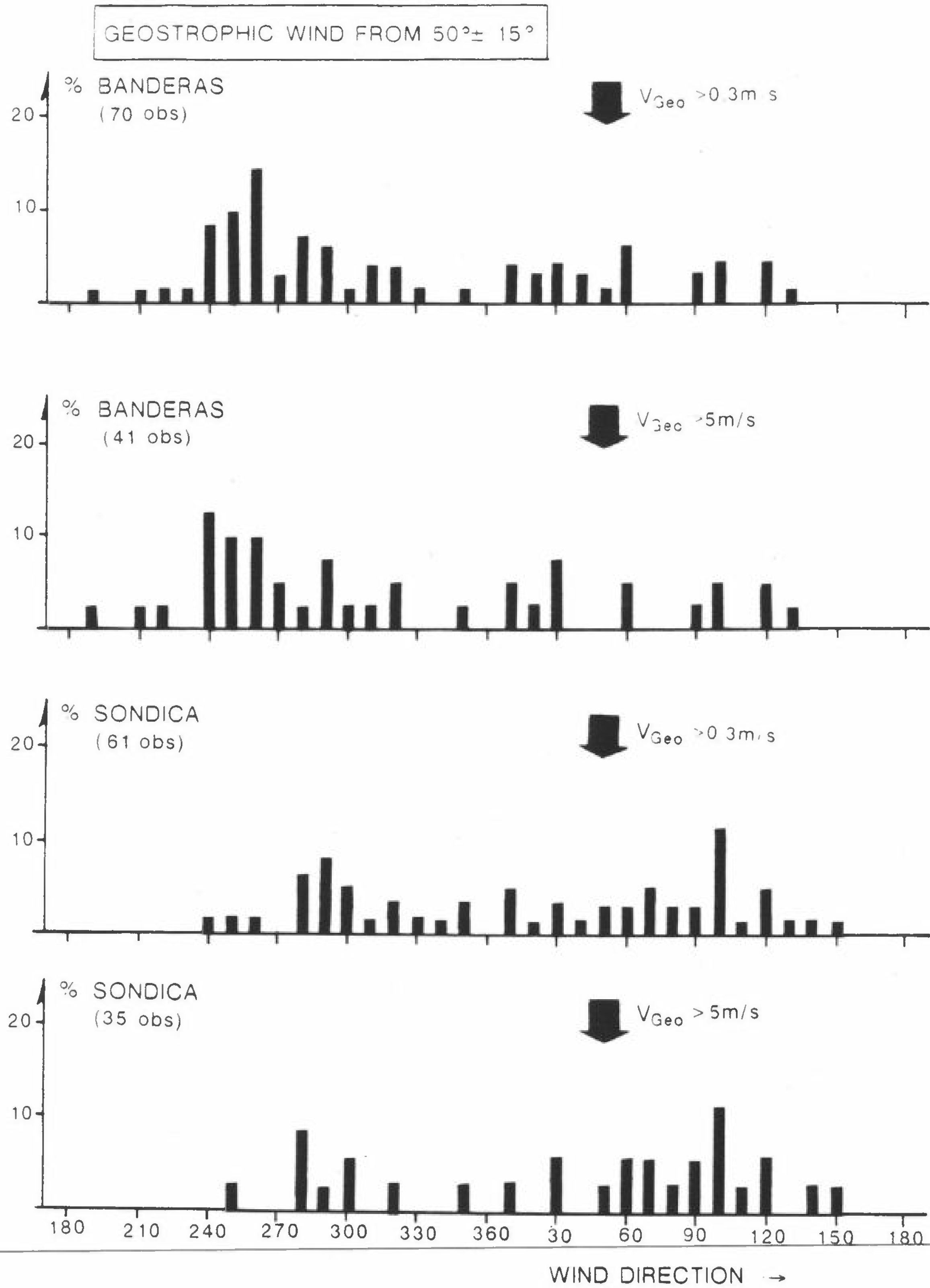

Figure 6: Wind direction frequency distribution at Banderas and Sondica for cases when the geostrophic wind wass blowing from northeast ($50^0 \pm 15^0$).
a) for all geostrophic windspeeds (> 0.3 m/s)
b) for geostrophic windspeeds in excess of 5 m/s.

7 LOCAL WIND PATTERNS ON SELECTED DAYS

To illustrate the influence of synoptic scale geostrophic winds on the local and mesoscale wind flow pattern in the lower Nervion valley area, we have analyzed the winds for selected days.

7.1 WINTER CONDITIONS, STRONG GEOSTROPHIC WINDS

Figure 7 presents the wind conditions on 26 December 1986, when the geostrophic wind at 00 GMT was observed at 34 m/s from west-northwest.

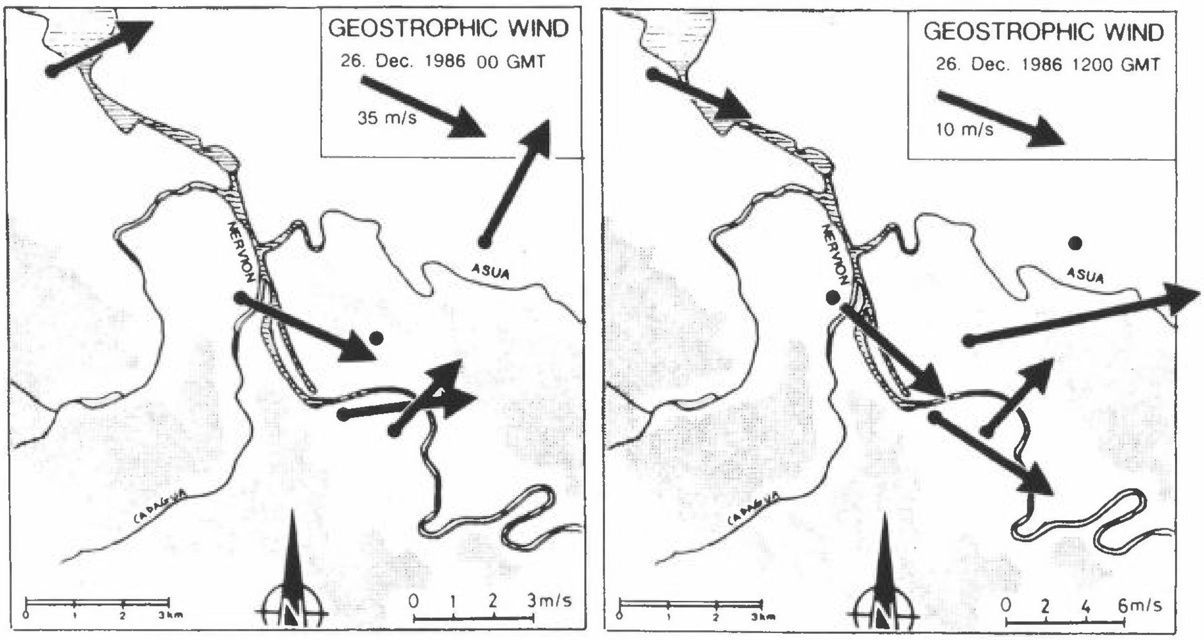

Figure 7: Local winds for a case with strong westerly geostrophic winds. 26 December 1986 at 00 GMT and 12 GMT.

Normally the night time winter wind conditions are represented by a stable cold air drainage down the valleys and towards the coast. The local winds are usually from south and south-east.

At midnight on 26 December 1986, however, the geostrophic wind speed of 34 m/s from west-northwest was sufficient to produce a local north-westerly flow (up-valley) in the whole area.

At noon the geostrophic wind was still from west-northwest but weakened to about 10 m/s. At this time of the day the local winds are usually up-valley from the north and northwest. The wind speeds on 26 December were strengthened by a favourable geostropic wind, and the local flow was stronger than normal; at 6 to 10 m/s.

7.2 SUMMER CONDITIONS

The geostrophic wind speeds during the summer season were normally much weaker than in the other seasons. Figure 8 presents a typical situation during westerly geostrophic wind conditions.

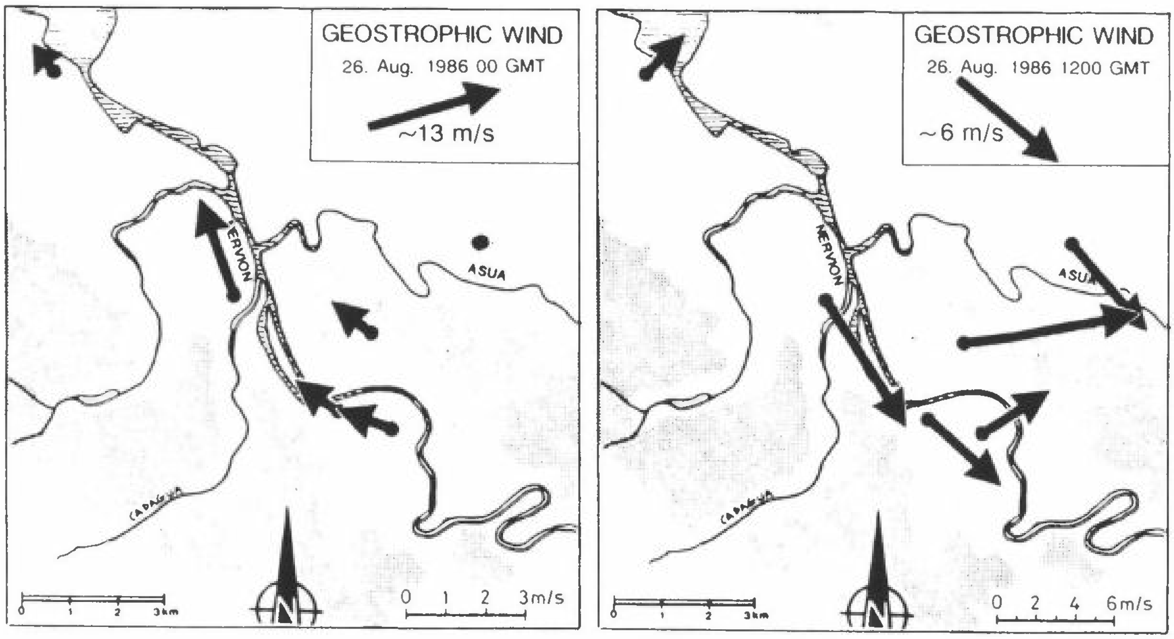

Figure 8: Local wind flows during westerly geostrophic winds in the summer season. 26 August 1986 at 00 GMT and 1200 GMT.

The typical summer season local and mesoscale flow pattern with weak down-valley drainage winds at night time and stronger up-valley sea breezes during day time hours also appeared on 26 August 1986. The westerly geostrophic winds of 7 to 13 m/s did not manage to break through and change the local flow pattern significantly. However, it can be seen that the up-valley flow started earlier due to the external pushing of the westerly geostrophic wind, than in cases when there was little or no geostrophic wind. This difference is illustrated in Figure 9.

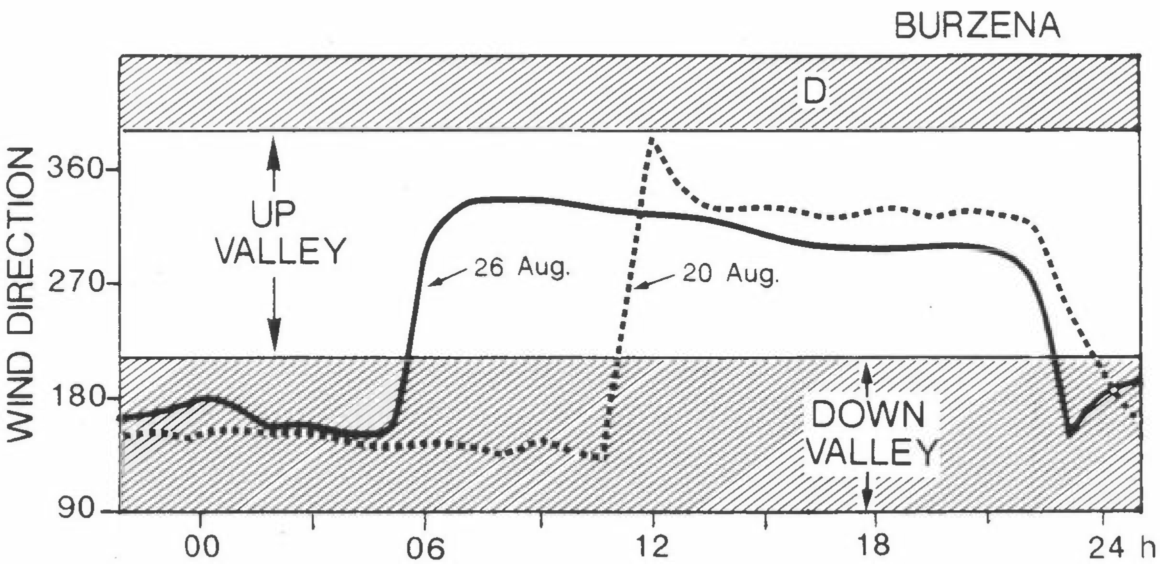

Figure 9: Local wind directions measured at Burzena as a function of time of day. On 26 August with a well defined westerly geostrophic wind and on 20 August with very weak geostrophic winds.

With very weak synoptic scale geostrophic wind the up-valley sea breeze started at Burzena around 1100 GMT. When the stronger westerly synoptic scale wind was added to the thermally driven local winds, the onset of the sea breeze was already at 0600 GMT.

7.3 MESOSCALE CIRCULATIONS

The strong mesoscale and local thermally driven wind systems very often seemed to over-rule the external synoptic scale pressure driven geostrophic winds in the lower Nervion valley area. The combination of a mountain/valley wind and land/see-breeze wind system usually dominates the winds observed in the surface boundary layer of the atmosphere.

These observations are illustrated in Figure 10, which shows two situations when the local flow was opposite to the relatively strong geostrophic winds.

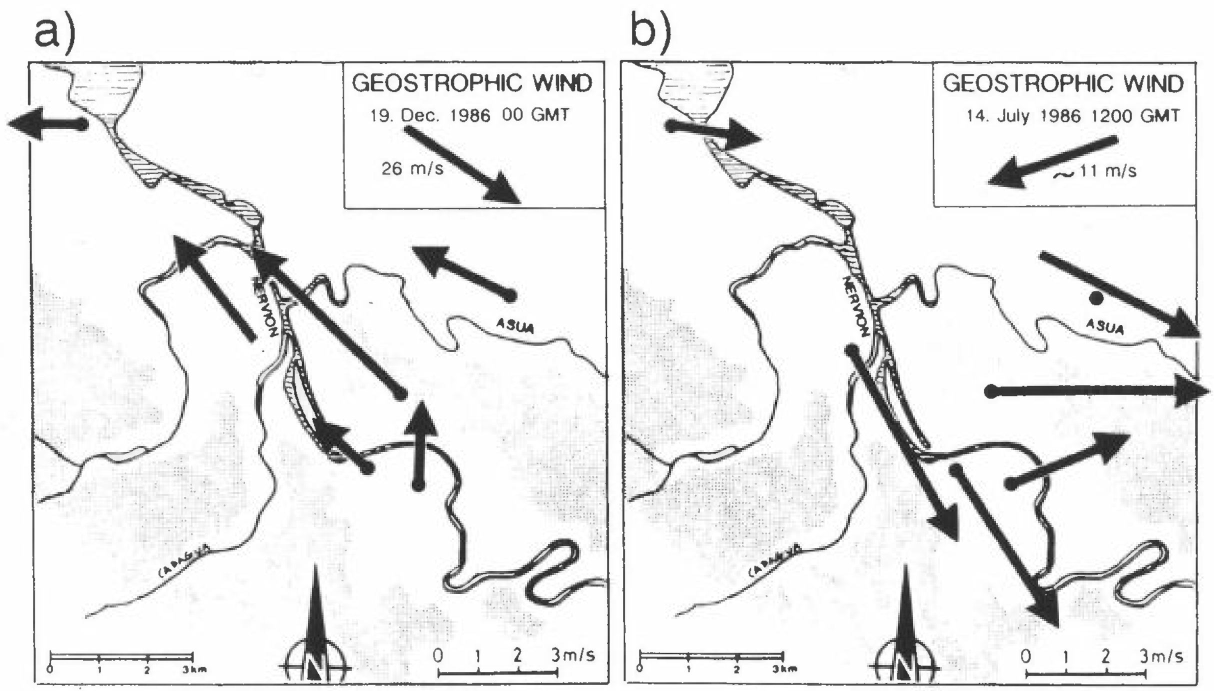

Figure 10: Local winds observed in the surface boundary layer during opposite geostrophic wind directions.
a) night time winter, down-valley drainage winds
b) day time summer, up-valley sea breeze.

During winter nigths the stable cold air drainage down the valleys towards the coast are more or less decoupled from the large scale weather systems. Even at a geostrophic wind speed of 26 m/s, the local surface layer winds are not influenced by the external geostrophic winds aloft.

Similarly in the summer season at day time hours, the heating of the land compared to the colder ocean creates a local low pressure onland, which again sets up a mesoscale sea breeze circulation. Even with a 10 m/s geostrophic wind from east-northeast the local sea breeze is blowing from west and northwest. This would also represent a typical explainable relationship between the synoptic scale pressure system with a local low on the Iberian peninsula, creating an easterly geostrophic wind over northern Spain, again leading to a northerly mesoscale sea breeze over the northern coasted regions. These wind patterns represent a typical summer situation for the area.

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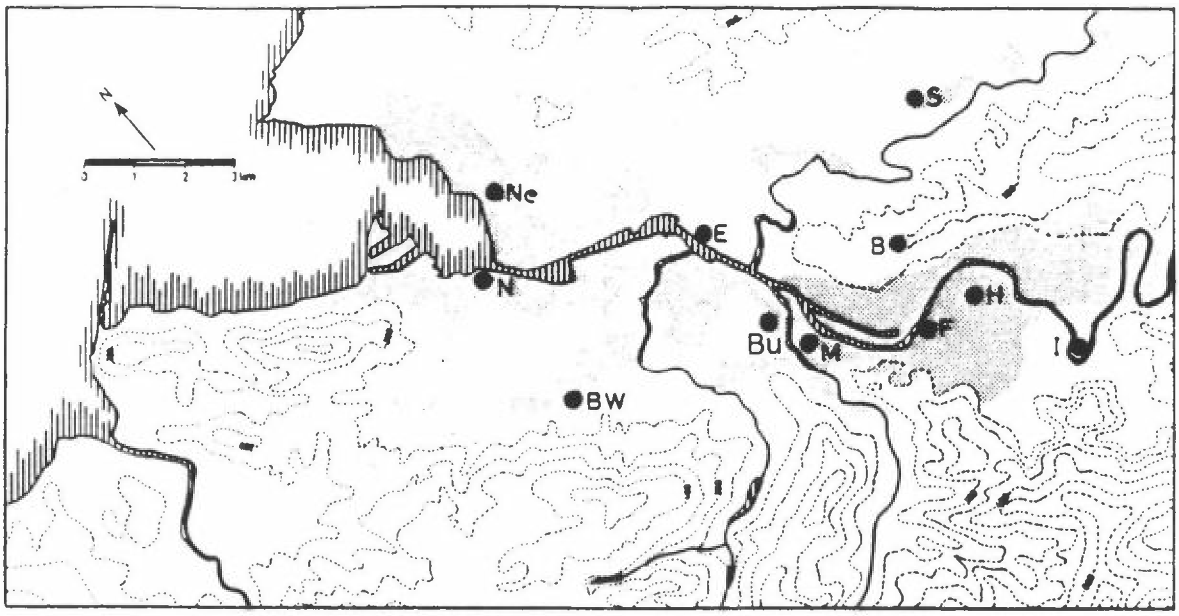
APPENDIX A

Observations of local winds in the lower Nervion valley area



	Station	Parameters
N =	Nautica	FF, DD, T, SO_2
BW =	BAWI	T, SO_2
M =	Matadero	SO_2
F =	Feria	FF, DD, T, SO_2
I =	Isla	SO_2
E =	Erandio	SO_2
Ne =	Neguri	SO_2
S =	Sondica	FF, DD, T, SO_2
B =	Banderas	FF, DD, T
H =	Hacienda	FF, DD, T

Figure A1: The study area and the location of the monitoring stations for meteorology and sulphur dioxide (SO_2).
FF = windspeed, DD = wind direction, T = temperature.

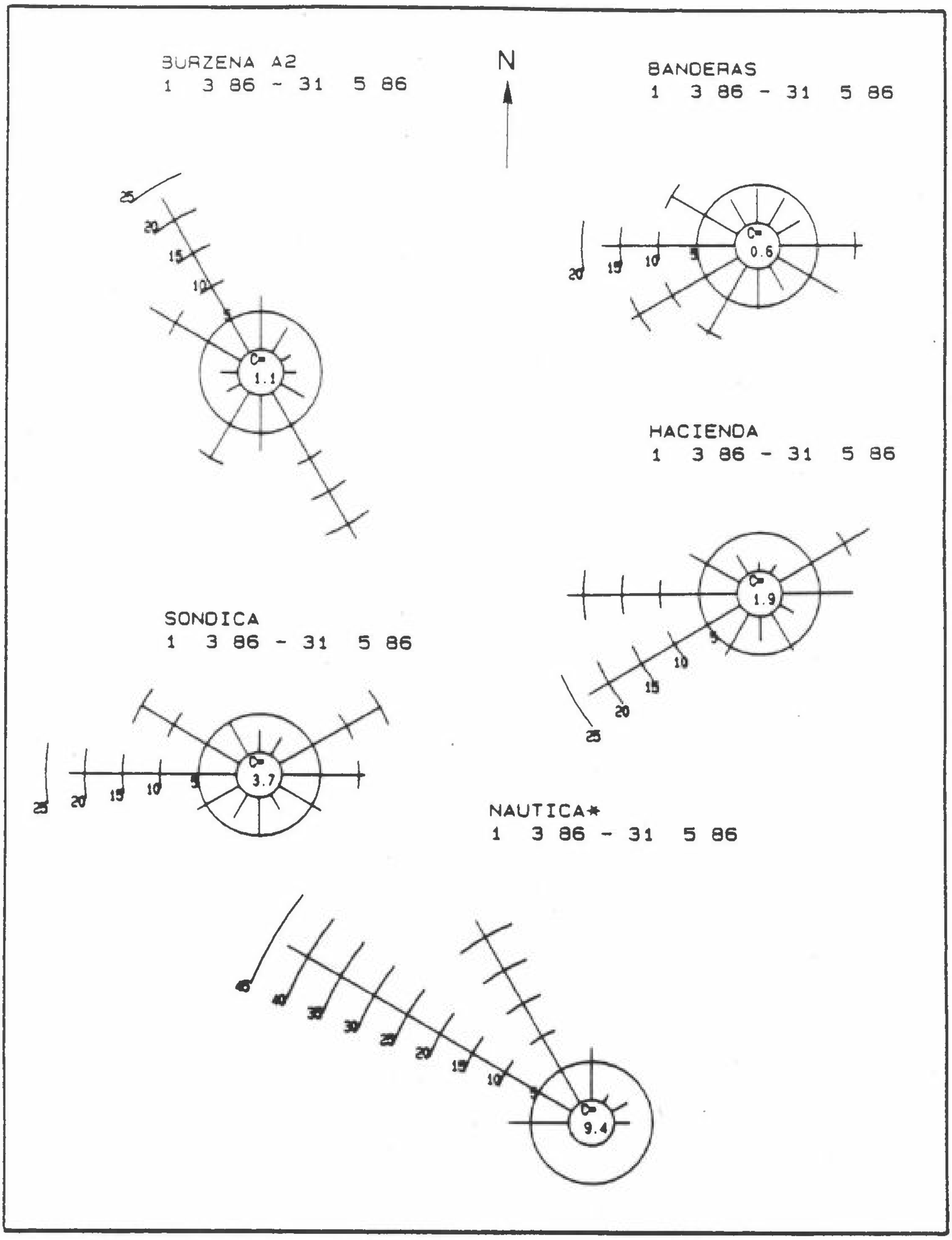


Figure A2: Wind direction frequency distributions (wind roses) for 5 stations in the lower Nervion area during the spring 1986 (March, April, May). The bars indicate the frequency of wind in percent from each 30^0-sector, C = calm.

* Low data availability, see Table 1.

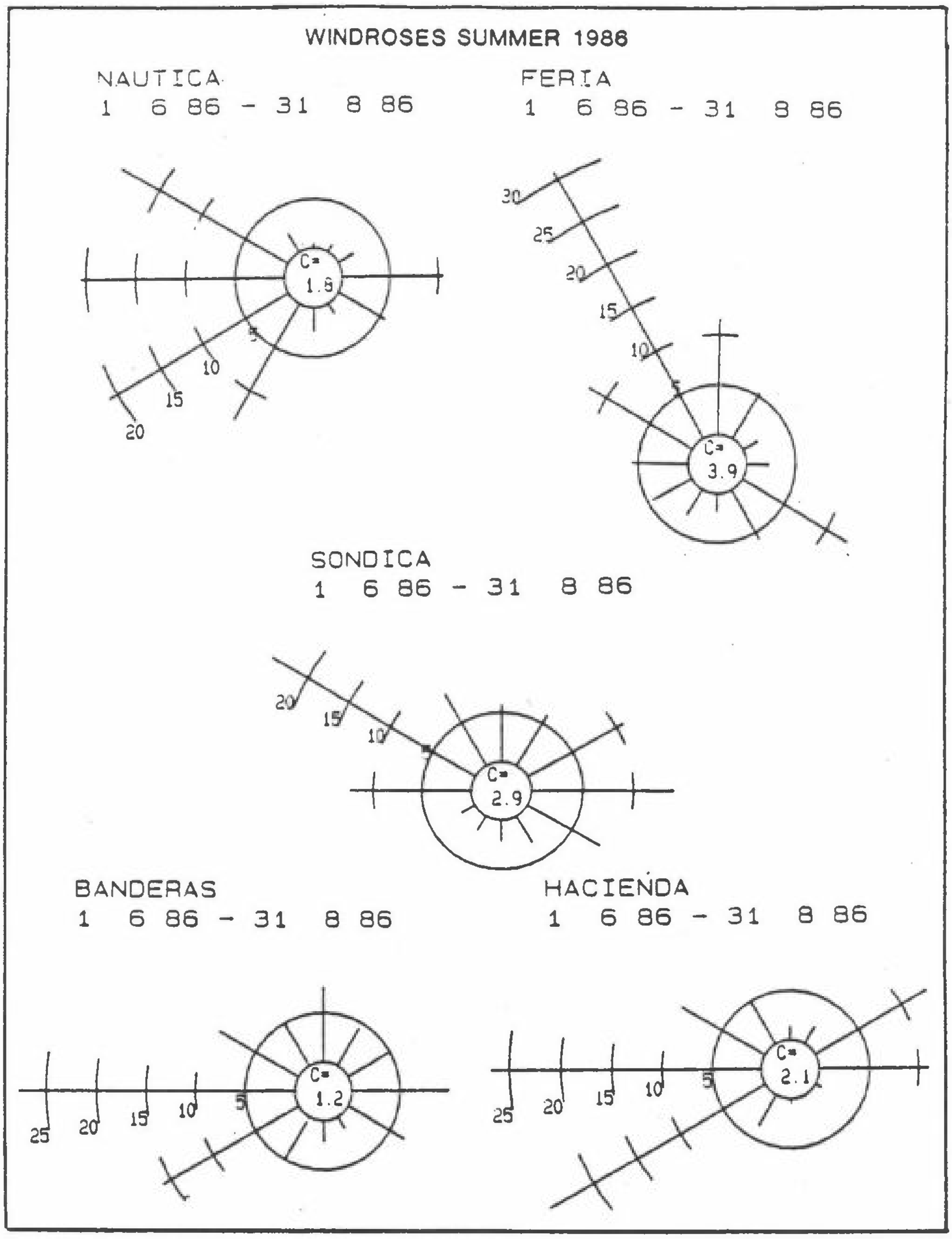


Figure A3: Wind direction frequency distributions (wind roses) for 5 stations in the lower Nervion area during the summer 1986 (June-July-August). The bars indicate the frequency of wind in percent from each 30^0-sector, C = calm.

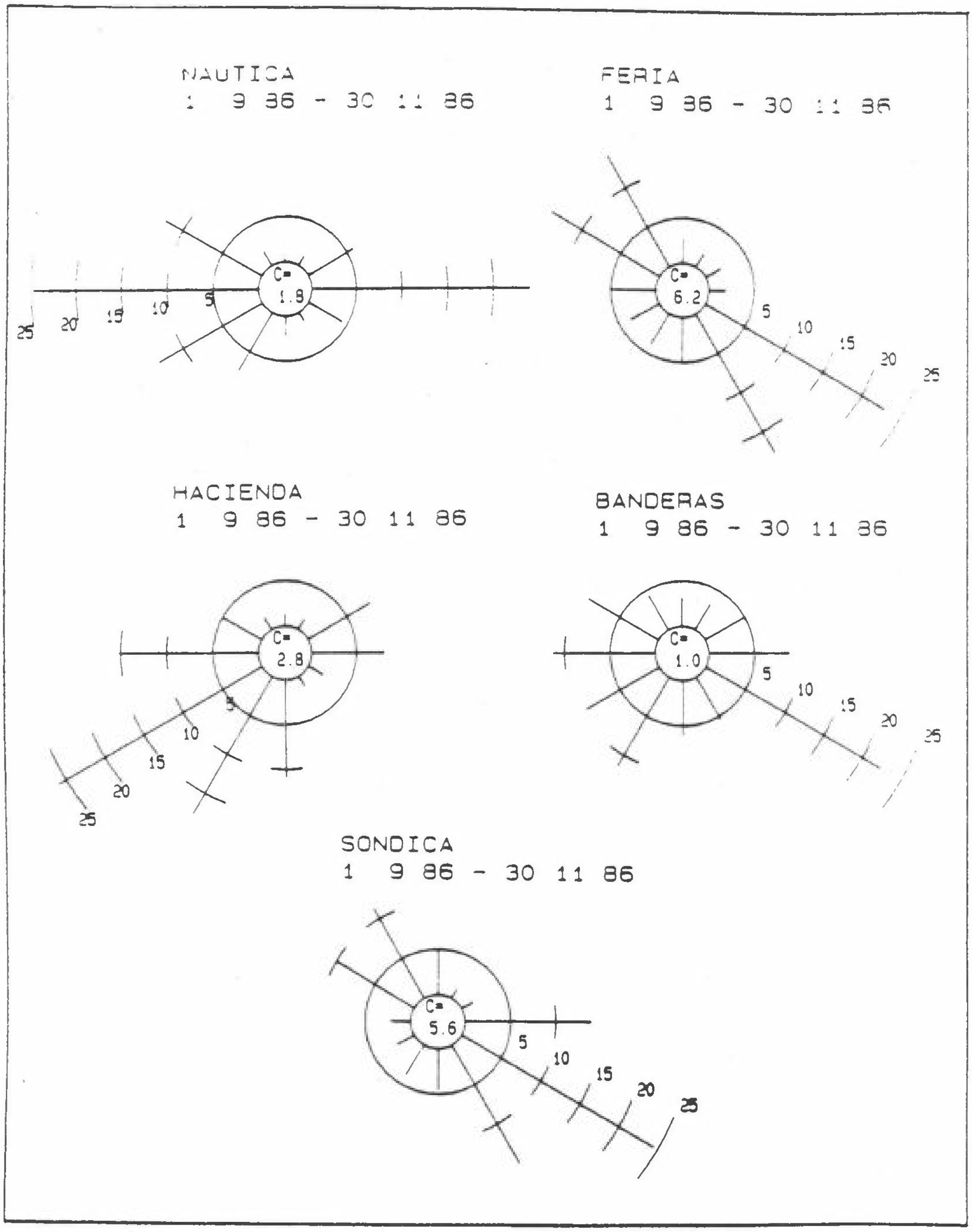


Figure A4: Wind direction frequency distributions (wind roses) for 5 stations in the lower Nervion area during the autumn 1986. The bars indicate the frequency of wind in percent from each 30^0-sector, C = calm.

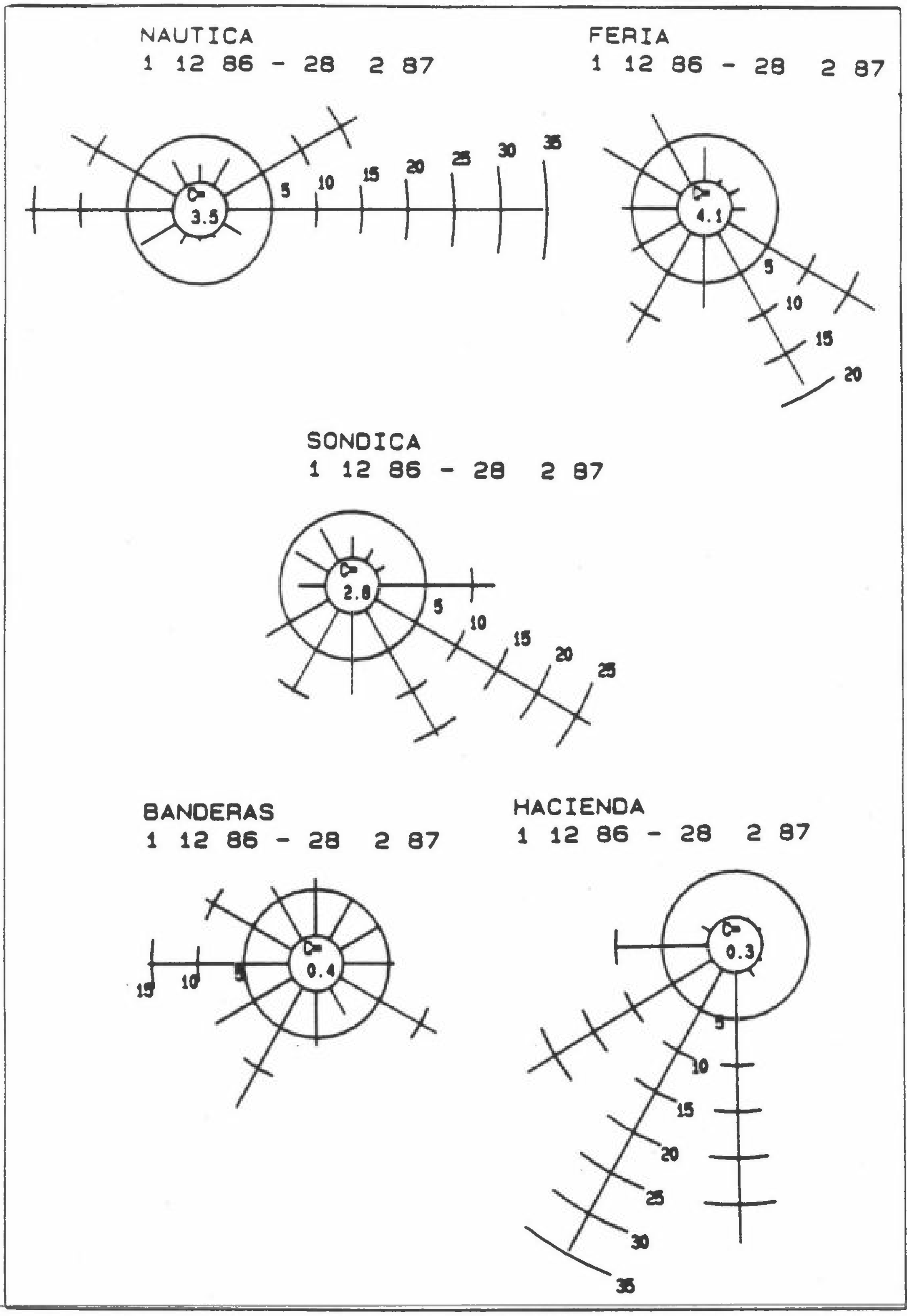


Figure A5: Wind direction frequency distributions (wind roses) for 5 stations in the lower Nervion area during the winter 1986. The bars indicate the frequency of wind in percent from each 30^0-sector, C = calm.

APPENDIX B

Frequency distributions of geostrophic wind directions
and wind speeds

Station : GEOSTROF BILBAO
Periode : 01.03.86 - 31.05.86

DIURNAL VARIATION OF WIND DIRECTIONS (%)

*) Wind-direction	Hours 12	Hours 24	Wind-rose
30	8.1	12.0	10.1
60	10.5	8.4	9.5
90	4.7	1.2	3.0
120	3.5	4.8	4.1
150	1.2	.0	.6
180	1.2	2.4	1.8
210	11.6	13.3	12.4
240	12.8	16.9	14.8
270	11.6	14.5	13.0
300	19.8	16.9	18.3
330	12.8	4.8	8.9
360	2.3	4.8	3.6
Calm	.0	.0	.0
Nobs	(86)	(83)	(169)
Average wind m/s	5.2	9.3	7.2

DISTRIBUTION OF WINDSPEED WITH WIND DIRECTIONS (%)

Class I: Windspeed .3 - 2.0 m/s
Class II: Windspeed 2.1 - 4.0 m/s
Class III: Windspeed 4.1 - 6.0 m/s
Class IV: Windspeed > 6.0 m/s

*) Wind-direction	Classes I	II	III	IV	Total	Nobs	Average wind m/s
30	.0	.6	2.4	7.1	10.1	(17)	7.9
60	.0	.6	3.6	5.3	9.5	(16)	7.7
90	.0	1.8	.6	.6	3.0	(5)	4.1
120	1.2	1.8	.6	.6	4.1	(7)	3.8
150	.0	.6	.0	.0	.6	(1)	2.3
180	.0	.6	.0	1.2	1.8	(3)	7.7
210	.0	3.0	3.6	5.9	12.4	(21)	6.0
240	.0	2.4	4.7	7.7	14.8	(25)	9.3
270	.0	3.0	1.8	8.3	13.0	(22)	9.5
300	1.8	5.3	4.7	6.5	18.3	(31)	6.2
330	.6	1.8	1.8	4.7	8.9	(15)	6.2
360	.0	1.2	1.2	1.2	3.6	(6)	6.2
Calm					.0	(0)	
Total	3.6	22.5	24.9	49.1	100.0	(169)	
Average wind m/s	1.6	3.0	5.0	10.7			7.2

*) This number indicates central direction of sector

Station : GEOSTROF BILBAO
Periode : 01.06.86 - 31.08.86

DIURNAL VARIATION OF WIND DIRECTIONS (%)

*) Wind-direction	Hours 12	24	Wind-rose
30	15.9	15.2	15.5
60	30.5	20.3	25.5
90	1.2	1.3	1.2
120	1.2	2.5	1.9
150	2.4	6.3	4.3
180	3.7	5.1	4.3
210	6.1	7.6	6.8
240	6.1	5.1	5.6
270	.0	2.5	1.2
300	8.5	13.9	11.2
330	18.3	16.5	17.4
360	6.1	3.8	5.0
Calm	.0	.0	.0
Nobs	(82)	(79)	(161)
Average wind m/s	4.1	6.9	5.5

DISTRIBUTION OF WINDSPEED WITH WIND DIRECTIONS (%)

Class I: Windspeed .3 - 2.0 m/s
Class II: Windspeed 2.1 - 4.0 m/s
Class III: Windspeed 4.1 - 6.0 m/s
Class IV: Windspeed > 6.0 m/s

*) Wind-direction	Classes I	II	III	IV	Total	Nobs	Average wind m/s
30	.0	3.7	5.0	6.8	15.5	(25)	6.5
60	1.2	3.7	10.6	9.9	25.5	(41)	6.6
90	.0	.0	.6	.6	1.2	(2)	6.3
120	.0	.0	.6	1.2	1.9	(3)	6.8
150	.0	1.2	1.2	1.9	4.3	(7)	5.8
180	.0	1.2	2.5	.6	4.3	(7)	4.7
210	.0	3.1	2.5	1.2	6.8	(11)	4.5
240	.0	3.1	1.9	.6	5.6	(9)	4.7
270	.0	.6	.0	.6	1.2	(2)	5.7
300	.0	3.7	6.2	1.2	11.2	(18)	4.8
330	4.3	5.6	5.0	2.5	17.4	(28)	3.9
360	.0	1.9	1.2	1.9	5.0	(8)	5.8
Calm					.0	(0)	
Total	5.6	28.0	37.3	29.2	100.0	(161)	
Average wind m/s	1.6	2.9	5.0	9.3			5.5

*) This number indicates central direction of sector

Station : GEOSTROF BILBAO
Periode : 01.09.86 - 30.11.86

DIURNAL VARIATION OF WIND DIRECTIONS (%)

*) Wind-direction	Hours 12	Hours 24	Wind-rose
30	3.6	1.3	2.5
60	13.3	8.0	10.8
90	13.3	13.3	13.3
120	10.8	16.0	13.3
150	8.4	12.0	10.1
180	3.6	4.0	3.8
210	12.0	13.3	12.7
240	7.2	6.7	7.0
270	10.8	9.3	10.1
300	8.4	13.3	10.8
330	8.4	2.7	5.7
360	.0	.0	.0
Calm	.0	.0	.0
Nobs	(83)	(75)	(158)
Average wind m/s	4.4	9.2	6.7

DISTRIBUTION OF WINDSPEED WITH WIND DIRECTIONS (%)

Class I: Windspeed .3 - 2.0 m/s
Class II: Windspeed 2.1 - 4.0 m/s
Class III: Windspeed 4.1 - 6.0 m/s
Class IV: Windspeed > 6.0 m/s

*) Wind-direction	Classes I	II	III	IV	Total	Nobs	Average wind m/s
30	.0	1.3	.0	1.3	2.5	(4)	4.9
60	.0	2.5	3.8	4.4	10.8	(17)	6.2
90	.0	2.5	6.3	4.4	13.3	(21)	5.6
120	.6	3.8	2.5	6.3	13.3	(21)	6.8
150	.6	3.8	3.8	1.9	10.1	(16)	4.0
180	.6	1.9	.6	.6	3.8	(6)	3.9
210	.0	1.9	3.2	7.6	12.7	(20)	10.3
240	.6	1.3	1.9	3.2	7.0	(11)	7.0
270	.6	1.3	1.3	7.0	10.1	(16)	8.0
300	.0	3.2	1.9	5.7	10.8	(17)	6.9
330	.0	2.5	.0	3.2	5.7	(9)	6.2
360	.0	.0	.0	.0	.0	(0)	.0
Calm					.0	(0)	
Total	3.2	25.9	25.3	45.6	100.0	(158)	
Average wind m/s	1.8	2.9	4.8	10.2			6.7

*) This number indicates central direction of sector

Station : GEOSTROF BILBAO
Periode : 01.12.86 - 28.02.87

DIURNAL VARIATION OF WIND DIRECTIONS (%)

*) Wind-direction	Hours 12	24	Wind-rose
30	11.1	12.6	11.9
60	8.9	3.4	6.2
90	4.4	6.9	5.6
120	3.3	4.6	4.0
150	4.4	4.6	4.5
180	2.2	2.3	2.3
210	12.2	11.5	11.9
240	10.0	11.5	10.7
270	14.4	10.3	12.4
300	14.4	14.9	14.7
330	7.8	6.9	7.3
360	6.7	10.3	8.5
Calm	.0	.0	.0
Nobs	(90)	(87)	(177)
Average wind m/s	5.5	11.4	8.4

DISTRIBUTION OF WINDSPEED WITH WIND DIRECTIONS (%)

Class I: Windspeed .3 - 2.0 m/s
Class II: Windspeed 2.1 - 4.0 m/s
Class III: Windspeed 4.1 - 6.0 m/s
Class IV: Windspeed > 6.0 m/s

*) Wind-direction	Classes I	II	III	IV	Total	Nobs	Average wind m/s
30	.0	2.8	1.7	7.3	11.9	(21)	8.2
60	.0	1.1	2.3	2.8	6.2	(11)	6.2
90	1.1	.6	2.8	1.1	5.6	(10)	4.6
120	.0	.0	1.1	2.8	4.0	(7)	7.9
150	.0	.6	2.3	1.7	4.5	(8)	6.9
180	.0	.6	.6	1.1	2.3	(4)	8.9
210	.0	2.8	2.3	6.8	11.9	(21)	8.1
240	.0	.6	1.7	8.5	10.7	(19)	10.7
270	.6	3.4	1.1	7.3	12.4	(22)	8.2
300	1.1	1.7	4.0	7.9	14.7	(26)	9.4
330	.0	.6	1.1	5.6	7.3	(13)	8.8
360	.6	.0	2.3	5.6	8.5	(15)	9.6
Calm					.0	(0)	
Total	3.4	14.7	23.2	58.8	100.0	(177)	
Average wind m/s	1.5	3.0	5.0	11.5			8.4

*) This number indicates central direction of sector

NORSK INSTITUTT FOR LUFTFORSKNING (NILU)
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RAPPORTTYPE OPPDRAGSRAPPORT	RAPPORTNR. OR 25/88	ISBN-82-7247-918-4	
DATO MARCH 1988	ANSV. SIGN. J. Schjoldager	ANT. SIDER 29	PRIS Kr 45,-
TITTEL Local winds related to synoptic scale geostrophic winds in the lower Nervion valley area.		PROSJEKTLEDER	
		NILU PROSJEKT NR. O-8556	
FORFATTER(E) T. Bøhler B. Sivertsen		TILGJENGELIGHET A	
		OPPDRAGSGIVERS REF.	
OPPDRAGSGIVER (NAVN OG ADRESSE) Labein Avda Montevideo S/n Olabeaga Bilbao 13, Spain			
3 STIKKORD (à maks. 20 anslag)			
REFERAT (maks. 300 anslag, 7 linjer) Denne rapporten inneholder bearbeidelse av geostrofisk vind sammenholdt med lokale vindforhold i Nervion-området, Bilbao. Geostrofvind forekom oftest fra rundt vest i alle årstider unntatt om sommeren, som var dominert av svakere vinder fra nordøst. For geostrofvind fra vest var lokalvinden dreiet 0 til 45 grader mot venstre, mens geostrofvind fra nordøst ikke viste noen sammenheng med lokalvind. Oftest dominerte de lokale vindsystemer som land/sjøbris over geostrofvind.			

TITLE
ABSTRACT (max. 300 characters, 7 lines) This report contains an analysis of geostrophic winds compared to local winds in the lower Nervion area. The most frequent geostrophic wind directions were from around west in all seasons, except the summer, which was dominated by weaker north-easterly winds. For westerly winds the local winds were related to the geostrophic wind, for north-easterly geostrophic winds there was no clear relationship to the local wind patterns. The mesoscale and local wind system of the area most often overruled the external geostrophic winds.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C