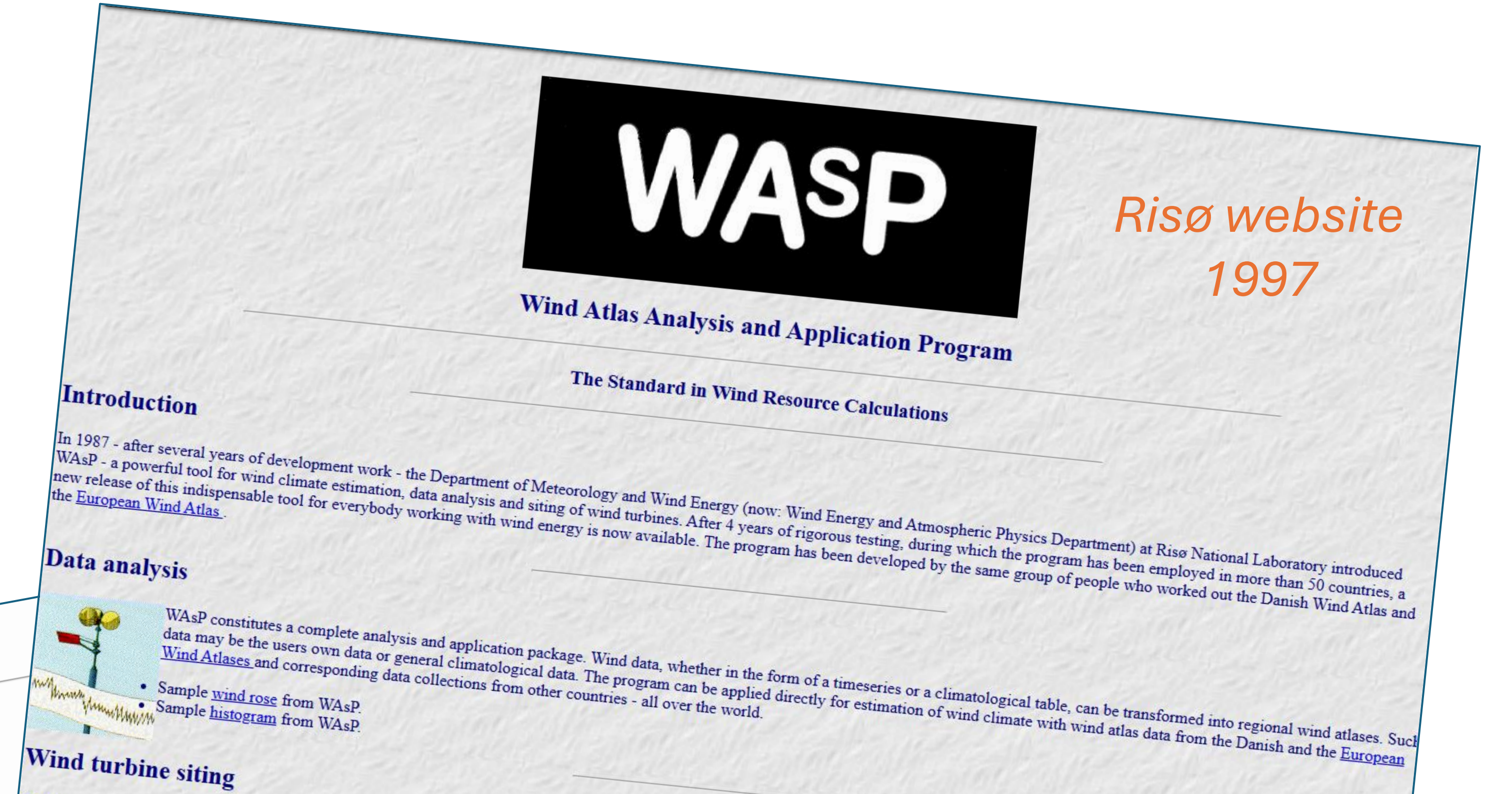
WAsP was released (commercially?) in 1987

Who were the first users?

How did it look like?



WAsP

Wind Atlas Analysis and Application Program

The Standard in Wind Resource Calculations

Introduction

In 1987 - after several years of development work - the Department of Meteorology and Wind Energy (now: Wind Energy and Atmospheric Physics Department) at Risø National Laboratory introduced WAsP - a powerful tool for wind climate estimation, data analysis and siting of wind turbines. After 4 years of rigorous testing, during which the program has been employed in more than 50 countries, a new release of this indispensable tool for everybody working with wind energy is now available. The program has been developed by the same group of people who worked out the Danish Wind Atlas and the European Wind Atlas .

Data analysis

WAsP constitutes a complete analysis and application package. Wind data, whether in the form of a timeseries or a climatological table, can be transformed into regional wind atlases. Such data may be the users own data or general climatological data. The program can be applied directly for estimation of wind climate with wind atlas data from the Danish and the European Wind Atlases and corresponding data collections from other countries - all over the world.

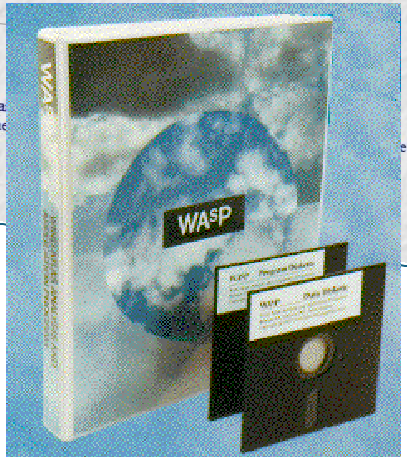
- Sample wind rose from WAsP.
- Sample histogram from WAsP.

Wind turbine siting

For detailed siting, WAsP allows the user to specify any number of complications in the form of terrain inhomogeneities, sheltering obstacles a[...] calculations supply information on the mean wind speed, the expected mean power production and on the so-called Weibull distribution. Furthe[...] information is given:

- Frequency
- Wind decrease due to shelter
- The influence of the terrain features

Risø website 1997



Hardware requirements

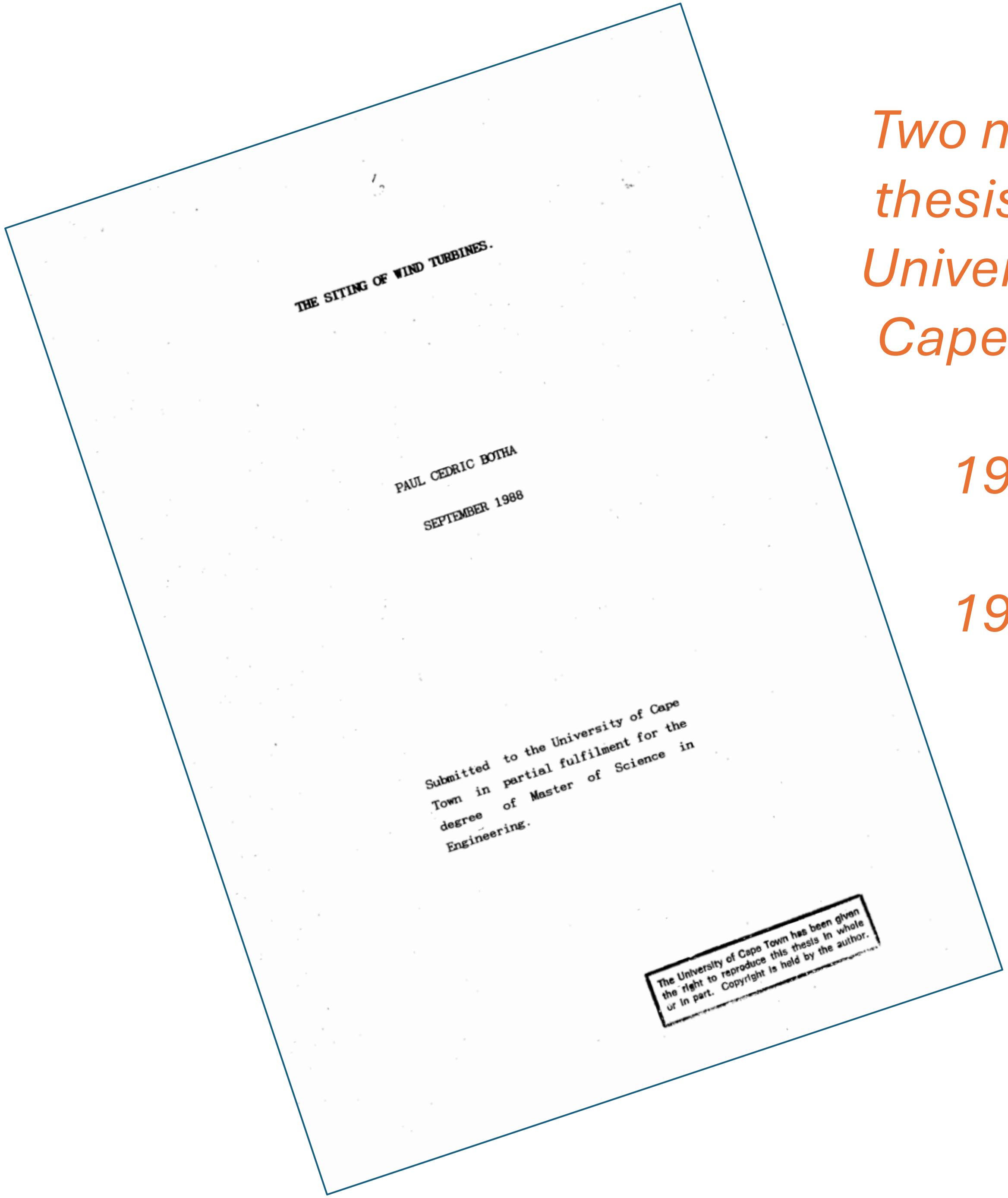
WAsP will run on IBM Personal Computers (PC, XT or AT), IBM Personal System/2 and true compatibles with:

- PC-DOS or MS-DOS operating system, version 2.0 or higher.
- one floppy disk drive, 5.25" or 3.5" .
- one hard disk drive.
- at least 512 kbytes memory (RAM). However, a full 640 kbytes memory is strongly recommended.
- an 8087 or 80X87 mathematical coprocessor.
- Most common graphics adapters are supported by WAsP:
  - IBM CGA
  - EGA
  - VGA
  - Hercules Graphics Card
  - Wyse WY-700
  - AT&T; PC6300

The following optional hardware is strongly recommended:

- Printer
- Digitizing tablet.

WAsP Back to WAsP page.



THE SITING OF WIND TURBINES.

PAUL CEDRIC BOTHA

SEPTEMBER 1988

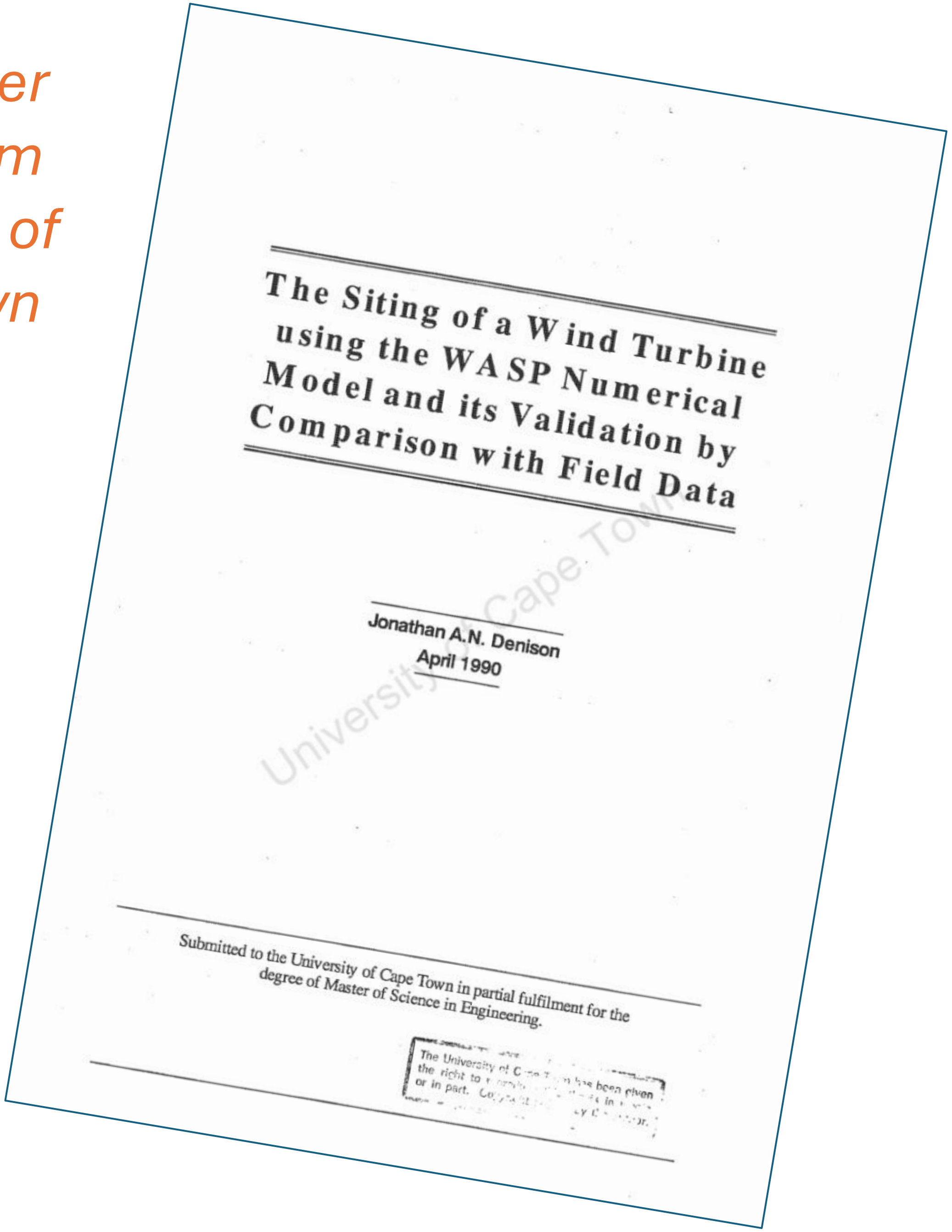
Submitted to the University of Cape Town in partial fulfilment for the degree of Master of Science in Engineering.

The University of Cape Town has been given the right to reproduce this thesis in whole or in part. Copyright is held by the author.

Two master thesis from University of Cape Town

1988

1990



The Siting of a Wind Turbine using the WASP Numerical Model and its Validation by Comparison with Field Data

Jonathan A.N. Denison

April 1990

University of Cape Town

Submitted to the University of Cape Town in partial fulfilment for the degree of Master of Science in Engineering.

APPENDIX 5.4. (b)

SUMMARY OF HISTORICAL WIND DATA: (b) Wind data for 1982 and 1983

Summary of data in file : C:\WASP\1982WIND.PRN [per mille]
Number of observations : 1096 Observations skipped: 0
Number of reading errors: 76 Wind speed bin width: 1.0 m/s

Sect	Freq	<1	2	3	4	5	6	7	8	9	11	13	15	17	>17	A	k
0:	2.1	241	0	379	0	190	47	47	95	0	0	0	0	0	0	3.3	1.37
30:	0.5	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	10.34
60:	18.7	27	16	99	0	52	126	110	183	99	209	37	0	42	0	8.5	2.73
90:	10.2	49	0	96	0	48	86	183	259	96	106	58	10	10	0	8.1	3.27
120:	12.6	47	0	141	8	125	219	195	172	62	31	0	0	0	0	6.4	3.75
150:	0.5	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	10.34
180:	5.5	91	0	196	0	196	178	143	107	36	36	0	0	18	0	6.0	2.28
210:	0.7	718	0	0	0	0	141	0	0	0	0	0	0	0	141	2.6	0.67
240:	27.9	18	7	113	11	106	116	81	232	134	127	39	11	7	0	8.0	3.47
270:	14.3	35	14	55	14	68	157	130	185	137	151	21	7	27	0	8.1	2.99
300:	6.6	76	0	119	0	194	209	134	89	75	89	15	0	0	0	6.4	2.43
330:	0.5	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	10.34
Total		61	7	112	6	97	140	123	187	100	119	27	5	16	1	7.6	2.69

Number of calms (included): 61 Mean wind speed: 6.0 m/s

DUMP DOS RETURN
RAWDATA>

Summary of data in file : C:\WASP\1983WIND.PRN [per mille]
Number of observations : 1096 Observations skipped: 0
Number of reading errors: 42 Wind speed bin width: 1.0 m/s

Sect	Freq	<1	2	3	4	5	6	7	8	9	11	13	15	17	>17	A	k
0:	1.8	516	0	108	161	108	54	0	54	0	0	0	0	0	0	2.7	1.35
30:	1.6	578	60	121	60	0	181	0	0	0	0	0	0	0	0	1.9	1.04
60:	14.2	64	0	167	60	47	114	100	247	0	147	53	0	0	0	7.3	2.73
90:	13.1	69	0	115	72	87	180	130	231	14	94	7	0	0	0	6.7	2.95
120:	11.1	82	0	146	154	103	274	94	120	0	26	0	0	0	0	5.5	3.15
150:	3.1	294	0	153	123	246	92	31	61	0	0	0	0	0	0	4.0	2.10
180:	5.7	158	0	264	132	99	83	66	116	0	66	17	0	0	0	4.7	1.49
210:	1.6	578	0	181	181	0	0	0	0	0	60	0	0	0	0	2.3	0.98
240:	22.5	40	4	135	88	59	143	118	135	17	164	55	0	42	0	7.5	1.97
270:	16.5	55	0	104	52	40	115	98	219	12	213	69	0	23	0	8.3	2.76
300:	7.6	120	0	239	63	38	113	113	63	0	176	50	0	25	0	6.6	1.73
330:	1.3	706	74	74	74	74	0	0	0	0	0	0	0	0	0	0.9	0.81
Total		109	3	148	87	68	141	98	159	8	126	37	0	15	0	6.7	2.04

Number of calms (included): 115 Mean wind speed: 5.4 m/s

DUMP DOS RETURN
RAWDATA>

APPENDIX 6.2.

TYPICAL DISPLAY OF INPUT DATA FROM THE NUMERICAL MODEL

```
ATLAS
                                   :CAPE AGULHUS WIND DATA '80-85
                                   :

OROGRAPHY
C:\WASP\AGLMAP.MAP                 :+AGULHUS , CARTESIAN CO-ORDINATES
(1950,550)                         :19 m a.s.l. · , φ : 2.8, 1.58E+04 m
ROUGHNESS
C:\WASP\COORDS\LIGHTHOU.RDS        :LIGHTHOUSE
C:\WASP\COORDS\LIGHTHOUSE.RDS      :LIGHTHOUSE
OBSTACLE
                                   :LIGHTHOUSE
                                   :

RAWDATA-(2 m a.g.l.)               WECS
C:\WASP\1985WIND.PRN

C:\WASP\AGLWIND.TAB
AGULHUS WIND DATA '80-85           ≡ C:\WASP\COORDS

  HEIGHT DATA OBSTACLE ROUGHNESS OROGRAPHY ATLAS
  WECS FREQUENCY TEXT DISPLAY RETURN DOS HELP STOP
WAsP>
```

```
ATLAS
                                   :CAPE AGULHUS WIND DATA '80-85
                                   :

OROGRAPHY
C:\WASP\AGLMAP.MAP                 :+AGULHUS , CARTESIAN CO-ORDINATES
(0,3000)                           :59.8 m a.s.l. · , φ : 2.1, 1.16E+04 m
ROUGHNESS
C:\WASP\COORDS\POINTI10.RDS        :POINT J10
                                   :
OBSTACLE
                                   :POINT J10
                                   :

RAWDATA-(2 m a.g.l.)               WECS
C:\WASP\1985WIND.PRN

C:\WASP\AGLWIND.TAB
AGULHUS WIND DATA '80-85           ≡ C:\WASP\COORDS

  HEIGHT DATA OBSTACLE ROUGHNESS OROGRAPHY ATLAS
  WECS FREQUENCY TEXT DISPLAY RETURN DOS HELP STOP
WAsP>
```

Botha 88

APPENDIX 6.3. (a)

TYPICAL DISPLAY OF RESULTS FROM THE NUMERICAL MODEL

(a) Results for the lighthouse at 2m and 10m a.g.l.

CAPE AGULHUS WIND DATA '80-85 — 29/ 5/88 12:12

LIGHTHOUSE — Height: 2.0 m a.g.l.

Sect	Rch	Input		Obstacle	Orography			A	k	%	E%
0:	0	0.0%	0°	0.0%	-3.5%	10°	:	3.2	1.15	2.0	0.8
30:	1	0.0%	0°	0.0%	16.8%	12°	:	5.3	1.62	3.6	2.9
60:	2	0.0%	0°	0.0%	21.8%	3°	:	6.9	2.20	11.6	14.5
90:	0	0.0%	0°	0.0%	18.1%	-5°	:	6.7	2.39	13.8	14.5
120:	0	0.0%	0°	0.0%	5.1%	-10°	:	5.9	2.21	9.9	7.7
150:	0	0.0%	0°	0.0%	-8.3%	-4°	:	4.8	1.86	3.6	1.8
180:	0	0.0%	0°	0.0%	-6.1%	7°	:	4.8	1.83	3.9	2.1
210:	0	0.0%	0°	0.0%	8.6%	9°	:	5.9	1.85	5.5	5.1
240:	0	0.0%	0°	0.0%	19.5%	3°	:	7.0	2.12	16.7	22.4
270:	1	0.0%	0°	0.0%	26.4%	-7°	:	6.5	2.20	16.2	17.2
300:	0	0.0%	0°	0.0%	10.2%	-13°	:	5.9	1.84	9.5	9.0
330:	0	0.0%	0°	0.0%	-7.5%	-5°	:	4.4	1.56	3.7	1.9
M= 5.5 m/s		E= 194. W/m²						6.2	1.99		

HEIGHT DATA OBSTACLE ROUGHNESS OROGRAPHY ATLAS
WECS FREQUENCY TEXT DISPLAY RETURN DOS HELP STOP
WAsP>

CAPE AGULHUS WIND DATA '80-85 — 29/ 5/88 12:14

LIGHTHOUSE — Height: 10.0 m a.g.l.

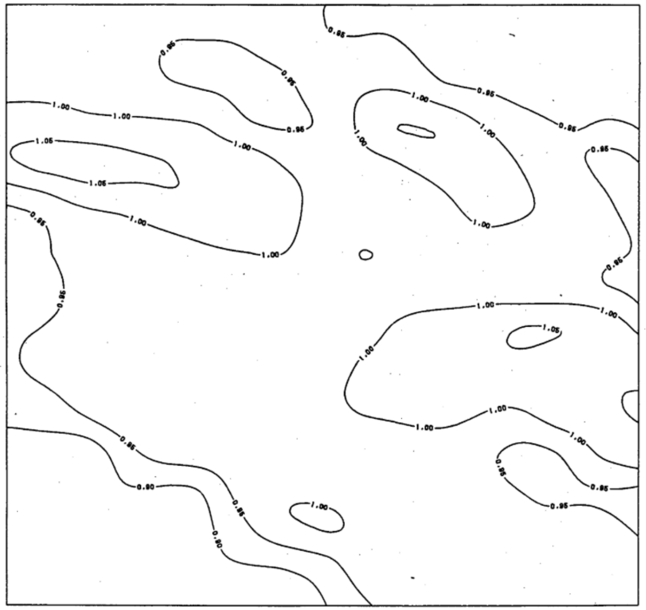
Sect	Rch	Input		Obstacle	Orography			A	k	%	E%
0:	0	0.0%	0°	0.0%	-5.0%	8°	:	5.4	1.30	2.1	1.3
30:	1	0.0%	0°	0.0%	10.5%	9°	:	8.4	1.85	3.8	4.8
60:	2	0.0%	0°	0.0%	15.9%	2°	:	9.0	2.42	11.1	12.9
90:	0	0.0%	0°	0.0%	12.7%	-4°	:	8.3	2.65	12.9	11.3
120:	0	0.0%	0°	0.0%	3.0%	-6°	:	7.5	2.45	10.7	7.3
150:	0	0.0%	0°	0.0%	-5.1%	-2°	:	6.4	2.04	4.0	2.0
180:	0	0.0%	0°	0.0%	-2.5%	4°	:	6.5	2.01	4.3	2.2
210:	0	0.0%	0°	0.0%	7.8%	6°	:	7.7	2.05	5.7	4.9
240:	0	0.0%	0°	0.0%	14.9%	2°	:	8.7	2.33	15.9	17.6
270:	1	0.0%	0°	0.0%	14.9%	-5°	:	9.3	2.46	15.4	20.1
300:	0	0.0%	0°	0.0%	2.6%	-10°	:	8.8	2.10	10.2	12.5
330:	0	0.0%	0°	0.0%	-10.0%	-3°	:	7.1	1.76	3.9	3.2
M= 7.4 m/s		E= 427. W/m²						8.3	2.19		

HEIGHT DATA OBSTACLE ROUGHNESS OROGRAPHY ATLAS
WECS FREQUENCY TEXT DISPLAY RETURN DOS HELP STOP
WAsP>

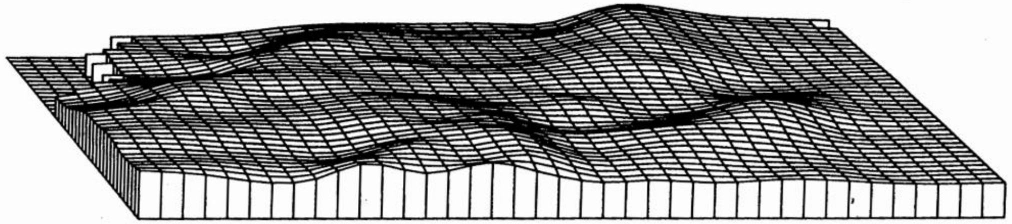
APPENDIX 6.5. (c)

RESULTS FROM THE NUMERICAL MODEL: FOR AN ENE WIND DIRECTION

(c) Relative velocities at 100m a.g.l.



VELOCITY. H=100M A.G.L



VELOCITY. H=100M A.G.L.

RESULTS FROM THE NUMERICAL MODEL: FOR AN ENE WIND D

(c) Relative velocities at 100m a.g.l.

Denison 90

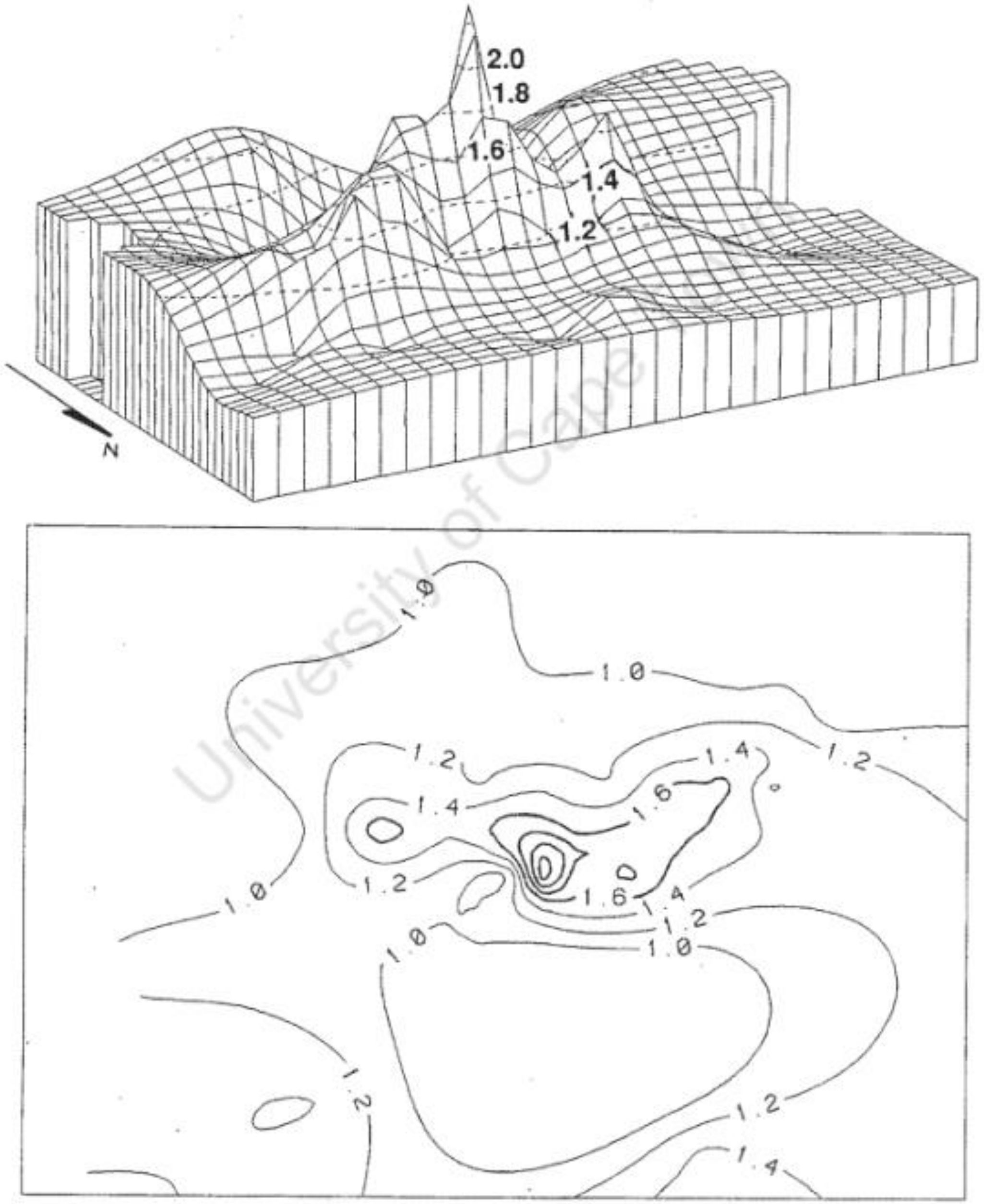


Figure 6.5: *Typical contour plot and 3D projection (of relative power at H = 50 metres above ground level).* <u>*Note that a non - standard North orientation is used.*</u>

Appendix II

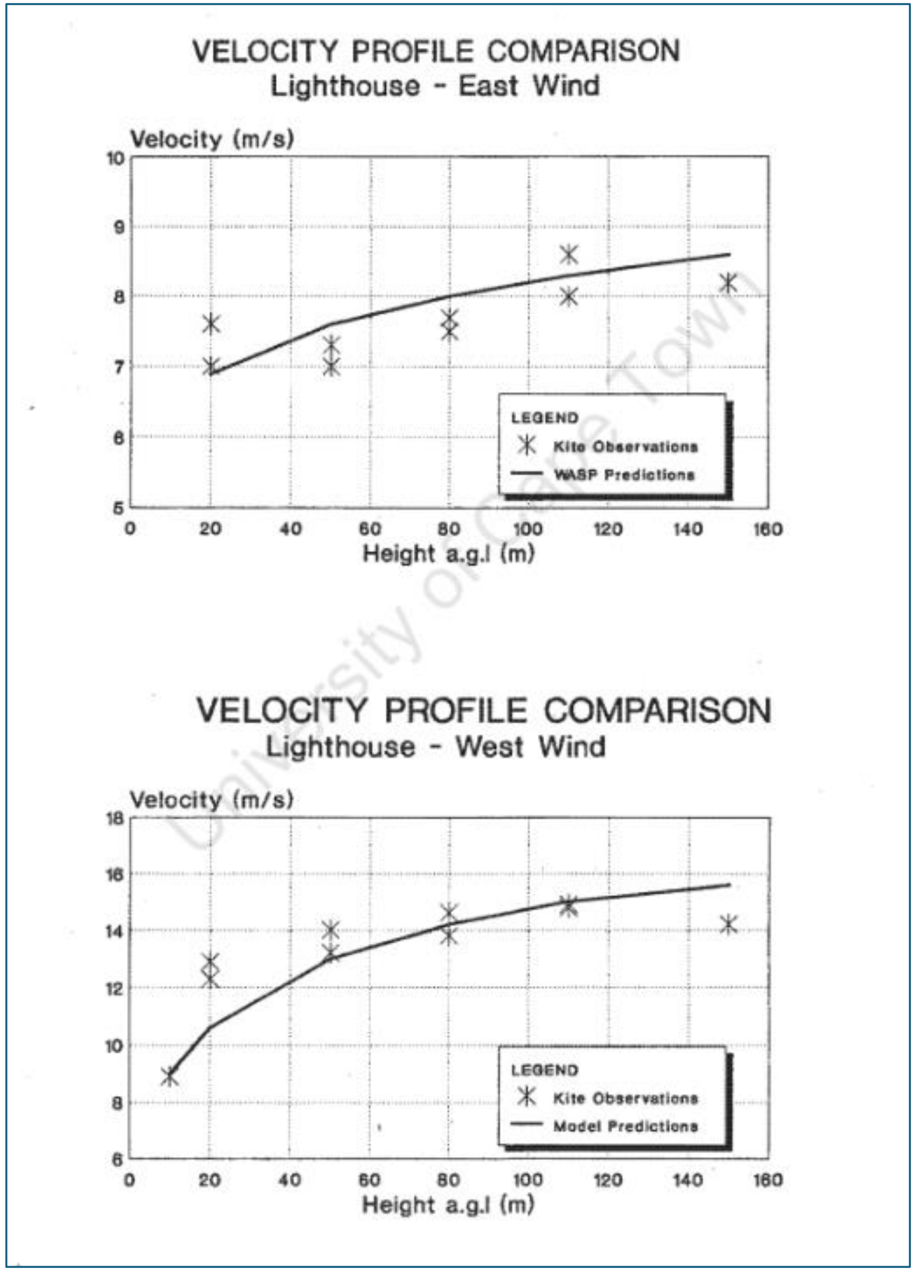
Listing of Programme used to Digitise Topographic Map

```
10    !THIS PROGRAM WILL HOPEFULLY COLLECT XY DATA OFF THE DIGITSER
20    !AND STORE IT ON A FILE"
30    OPTION BASE 1
40    PRINTER IS 1
60    PRINT "ENTER THE ORIGIN FROM DIGITSER"
70    BEEP
80    BEEP
90    BEEP
100   PRINT "SET THE BUTTON TO POINT MODE"
110   PRINT "------------------------------"
120   ENTER 702 USING "3(1D.D,X),#";A,R,V
130   PRINT R,V
140   BEEP
150   PRINT "SET THE BUTTON TO STREAM MODE"
160   PRINT "---------------------------------"
170   INPUT "ENTER THE CONTOUR VALUE FOR THIS FILE",H
180   PRINT "READY TO GO ............START DIGITISING"
181   BEEP
182   BEEP
183   ALLOCATE X1(700),Y1(700)
190   PRINT "N    X    Y   Z"
200   FOR I=1 TO 700
210   N=I
220   ENTER 702 USING "1D,X,2(4D.1D,X),1D,X,#";A,X1(I),Y1(I),D
230   PRINT I,X1(I),Y1(I),H
240   IF D<>8 THEN GOTO 270
250   IF D>2 THEN GOTO 290
260   BEEP
270   NEXT I
280   !*** OUTPUT TO DISC****
290   INPUT "WHAT IS THE FILE NAME FOR DATA STORAGE",File_b$
291   BEEP
292   BEEP
293   BEEP
294   BEEP
300   Len=(I*20*3/256)+2
310   CREATE ASCII File_b$,Len
320   ASSIGN @Disc TO File_b$
330   FOR I=1 TO N
340   IMAGE 6D.1D,6D.1D,6D.1D
350   X1(I)=X1(I)-R
360   Y1(I)=Y1(I)-V
370   OUTPUT @Disc;X1(I),Y1(I),H
380   NEXT I
390   INPUT "DO YOU WANT TO CONTINUE ?,(Y/N)",An$
400   IF An$="Y" THEN 405
405   DEALLOCATE X1(*),Y1(*)
406   GOTO 150
410   IF An$="N" THEN 420
415   DEALLOCATE X1(*),Y1(*)
420   END
```

University of Cape Town

Digitizing maps omg poor souls

Denison 90



5.1 Experimental Method

Predictions from the numerical model (WASP) were compared with actual measurements from the field to obtain an indication of how accurately the model simulates reality.

The procedure that was initially adopted is listed below:

- The wind was to be measured at five points on and around the Soetanysberg.
- Hourly velocity readings were to be obtained from the Cape Agulhas lighthouse anemometer over the time period that the TALA kite was flown on the Soetanysberg.
- The lighthouse anemometer readings were to be used as input to the numerical model and the predicted values compared with those measured on site.

On arriving at the lighthouse it was found that the rotating cup anemometer on a 5m mast was not working. The lighthouse-keeper, who was in charge of the digital equipment, had no need to repair it. He was certain that the Beaufort Scale which he had been using for the past 35 years was as good as the anemometer which, in his opinion, was badly placed with regard to the lighthouse buildings.

Due to the necessity of obtaining accurate data, a TALA kite was used at a position on the coastline due south of the lighthouse to obtain the hourly data to be used as input for WASP. This reference kite was flown at 10m above ground level.

A preliminary analysis of the wind flow over the Soetanysberg was performed using WASP. This yielded certain regions of relatively high wind speed. Four points were chosen in these regions as sites for the field tests (Sites A,B,C and D). One other point (Site E) on the coastline towards the western end of the Soetanysberg was also chosen as a site. This allowed for a comparison to be made of a site that was not affected by orographic forcing. The locations of the field-test sites are shown in Figure 5.1.

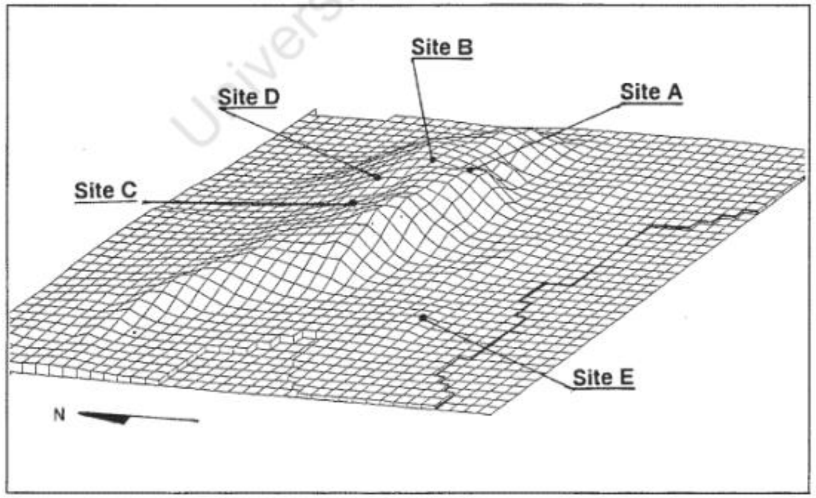


Figure 5.1: *Map of the Soetanysberg with the sites where the TALA Kite was flown*

University of Cape Town

TALA kites. Example below from Ron Nierenberg (around 1980)