WIND AND WIND WAVE CLIMATE FOR TURKISH COAST
AND
APPLICATION TO AEGEAN AND MEDITERRENEAN SEA

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
CIVIL ENGINEERING

JUNE 2008

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ABSTRACT

WIND AND WIND WAVE CLIMATE FOR TURKISH COAST AND APPLICATION TO AEGEAN AND THE MEDITERRANEAN SEA

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JUNE 2008, 53 pages

The wind waves have significant effects on small craft and fisheries. Therefore, wind wave climate has an important role in the design and operation of fishing harbors and harbors for small craft. The purpose of this study is to identify the wind wave climate along the eastern part of the Mediterranean Sea coastline of Türkiye. For this purpose, wind wave data for a certain period is obtained from ECMWF for the analysis. Moreover, the data will be analyzed for locations selected along the Turkish coast using a special software developed for this thesis study. For every location, the wind wave roses, significant wind wave height versus mean period of primary wind relations, extreme probability distribution, and log-linear cumulative probability distributions will be presented. By the help of software developed, it will be possible to analyse any coordinate using ECMWF data.

Keywords: Wind Climate, Aegean and Mediterranean Sea, Wind Propagation, Programming, Wind Wave, Wind Rose, Statistics of Wind Wave

ÖZ

TÜRKİYE KIYILARINDAKİ RÜZGAR VE RÜZGAR DALGA İKLİMİ VE
EGE VE AKDENİZ İÇİN UYGULAMASI

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Haziran 2008, 53 sayfa

Rüzgar kaynaklı dalgalar, balıkçı barınakları ve küçük deniz araçları üzerinde önemli etkilere sahiptir. Bu sebeple, rüzgar dalga iklimi balıkçı barınakları ve küçük limanların tasarımında önemli yere sahiptir. Bu çalışmanın amacı Türkiye'nin Akdeniz kıyılarındaki rüzgar dalga ikliminin açığa çıkarılmasıdır. Bu amaçla ECMWF (Avrupa Orta Vadeli Tahminler Merkezi) tarafından belli bir ay süreli data sağlanmıştır. Elde edilen datalar, bu tez çalışması için geliştirilmiş olan bir yazılım aracılığıyla Türkiye'nin Akdeniz kıyıları boyunca seçilen çeşitli bölgelerde incelenecektir. Her bölge için rüzgar ve rüzgar dalga gülleri, belirgin dalga yüksekliğine karşılık ortalama ana rüzgar dalgası periyodu ilişkisi, en yüksek değerler istatistiği analizi ve log-lineer toplam dağılımları sunulacaktır. Geliştirilen yazılım ile girilen koordinatların ECMWF dataları kullanılarak bütün detaylı analizleri yapılması mümkündür.

Anahtar Kelimeler: Rüzgar İklimi, Ege Denizi ve Akdeniz, Programcılık, Rüzgar Dalga İstatistiği

To My Parents

ACKNOWLEDGEMENTS

This study was suggested and has been completed under the supervision of Assoc. Prof. Dr. Ahmet Cevdet Yalçıner and Dr. Işıkhan Güler.

I would like to express my sincere thanks to my supervisor Assoc. Prof. Dr. Ahmet Cevdet Yalçıner for his invaluable guidance, patient, advice, and encouragements throughout this enjoyable study.

I would like to extend my thankful feelings to my co-supervisor Prof. Dr. Ayşen ERGİN for her encouragements and offering her all possibilities throughout the study.

I am indebted to my colleagues, YOLSU ENGINEERING, and Assistant Manager Metin MISIRDALI for their support and patience for my excuses.

The author acknowledges the ECMWF and Turkish State Meteorological Service for supplementing field data and Ersin Küçükkaraca.

I would like to thank Barış BARIŞERİ, Burak KUMRU, Cem KISIKLI and Gülsüm SAĞOL for their endless helps.

I would like to express my gratitude to my family and my friends for their generous attitude and support.

Finally to a very special thanks to 428423.

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ABBREVIATIONS AND ACRONYMS

WIND	10 meter wind speed (m/s)
MDPS	Mean direction of primary swell (degrees)
MDWW	Mean direction of wind wave (degrees)
MPPS	Mean period of primary swell (s)
MPWW	Mean period of wind wave (s)
SHPS	Significant height of primary swell (m)
T	Wave period (s)

CHAPTER 1

INTRODUCTION

1.1. PURPOSE AND SCOPE

The main purpose of this study is to investigate the wind and wind wave climate along the coastline of Aegean and Mediterranean Sea. Up to now, wind wave and swell wave climate are collectively studied. This study focuses on wind and wind wave climate, thus completing the previous work of Saygın Kemal DEREBAY, Wind and Swell Wave Climate for the Southern Part of Aegean and the Mediterranean Sea, 2007. Besides, by the help of the software developed for the thesis, for any coordinate, all parameters for swell and wind data can be easily extracted from ECMWF data. Moreover analyses for the extracted data can be easily done by this user friendly software.

The term wind wave refers to sea waves caused by winds over sea surface. Nevertheless, in this study the term “Wind Wave” is used for wind-generated waves, encountered in their generation zone. Wind waves are one of the main parameter in the design of coastal structures. All coastal structures are designed, or at least checked, against wind waves.

The scope of this study to investigate wind and wind wave climate mainly along Aegean and Mediterranean Sea coast of Turkey. Statistical analyses are carried out for chosen locations and results are presented by wind and wind wave roses, significant wave height versus mean period of wind wave relations, extreme probability distribution, and log-linear cumulative probability distribution. The results are provided separately for locations and entirely for the region in scope. Moreover, a user-friendly computer program is prepared for simulation, interpretation of the data and analyzing the information prepared by the program.

1.2. GEOGRAPHIC LOCATION

The region of study is Aegean and Mediterranean Sea shores of Türkiye. For the purpose of the study, data is obtained from ECMWF [ECMWF, 2006] for the whole Basin. Five locations are identified along the Aegean and Mediterranean Sea for the simulation of software developed for this thesis. The obtained data is analyzed in detail for the selected locations by the prepared software. These ten locations are identified as Anamur, Kaş, Datça, Kuşadası, and Edremit.

1.3. PREVIOUS STUDIES

Previous works on wave climate of Turkish Aegean and Mediterranean Sea shores is limited mainly because of limitations on obtaining data. The "Turkish Coast Wind and Deep Water Wave Atlas, 1999" (Özhan and Abdalla, [1999] and "15 Region Report, 1986" Ergin and Özhan [1985] are the two main works on wave climate research both of which include Aegean and Mediterranean Sea coastline of Türkiye.

In Turkish Coast Wind and Deep Water Wave Atlas, wind speeds and significant wave heights; yearly and seasonal wind and wave roses, monthly means and extreme values, extreme value statistics and also significant wave height vs. mean wave period relations in 30 km intervals for Black Sea, Aegean Sea and Mediterranean and 10 km intervals for Marmara Sea of Türkiye (Özhan and Abdalla, 1999) are considered. In “15 Region Report” wind rulers and synoptic pressure maps are considered for each location. However, neither of the studies mentioned in this section considered wind and swell waves separately.

1.4. METHOD OF STUDY

The method of this study is carried in the following steps; the data gathering, re-arrangement and refining of data, analysis of data in scope and presentation of findings. Data used in this study is obtained from the ECMWF Data Server. [ECMWF, 2006] The data is obtained for the whole Aegean and Mediterranean Sea basin. The data period is between 01.09.2000 to 10.12.2006. However, in the interpretation stage, it is found that data belonging to 2000 year is useless due to values like 100.00 m wave height. Because of this, data period between 01.01.2001 to 10.12.2006 totally 72 months in length is used. Data for the 5 locations are extracted from the whole data group and re-arranged for analysis. The 5 locations are analyzed separately and for every location, results are presented graphically. The wind and wind wave roses, significant wave height versus mean period of wind wave relations, extreme probability distribution, and log-linear cumulative probability distribution are provided for the locations.

The arrangement of the subsequent sections of this study is as follows. Chapter 2 presents a summary of theoretical considerations on wind waves and previous works related to this study. Detailed methodology of analysis and details on obtained data are presented in Chapter 3, followed by results of analysis for the 10 locations in Chapter 4. Summaries and how to use of the software are given in Chapter 5. Finally, conclusion of the study is given in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

In this chapter general information on wind wave characteristics and previous works on wind wave climate researches are given. In section 2.1. information about wind waves, their propagation and importance is given in general. In section 2.2 previous works on wind wave climate researches are given.

2.1. GENERAL INFORMATION ON WIND WAVES

The term wind wave is the general abbreviation to wind generated waves. In this study the wind wave term is used to emphasize the wind generated waves encountered in their generation zone. This definition is used to differentiate the wind waves from non-wind generated waves like tides, tsunamis, surges etc. and from other wind generated waves, mainly, from swells.

The most distinguishing property of wind waves is their irregularity. This irregularity brings forth a non-uniform sea surface, with interfered crest and troughs and short periods resulting in smaller steepness. As a result of this irregularity, some descriptive statistical methods for identification of wave characteristics are proposed. The concept of significant wind wave height is used to define the characteristics of wave trains, where the wave train means the group of waves that have the same wave period and direction.

The concept of significant wave height is first introduced by Sverdrup and Munk (1947). The definition of significant wave height is the mean height of the highest one third of all waves. Significant height is mainly denoted by H_s or $H_{1/3}$. Significant wave height has been found to be very similar to the estimated visual height by an experienced observer (Kinsman 1965).

The average of the chosen waves defines the significant wave height as

$$H_s = \frac{1}{\frac{N}{3}} \cdot \sum_{i=1}^{\frac{N}{3}} H_i \tag{2.1}$$

Where N is the number of individual wave heights H_i in a record ranked highest to lowest. Although the significant wave height concept seems to be a rather old fashioned method, it is a useful tool to reduce the complexity of a sea surface into one number. It should be kept in mind that, this is a statistical distribution given only for wave heights, and do not give us any clue about period and direction of the wave. [CEM, 2002]

A similar simplification with a different statistical approach is also proposed for wave periods and directions. For periods and directions mean wind wave period and mean wind wave direction concepts are introduced, where mean wind wave period is the arithmetic mean of all observed periods in a group of waves and mean wind wave direction is the arithmetic mean of directional counts in an observation.

The wind waves are the primary factor affecting the design and construction of coastal structures. All on-shore and off-shore coastal structures are designed, or at least checked, primarily against wind waves whatever purpose they have. The armor weight and thickness of rubble mound structures, the height and stability of wall type structures are all controlled by wind waves in general.

Wind have also important role in naval transportation. All freight and passenger ships around the world are designed against wind waves including offshore platforms.

2.2. LITERATURE SURVEY

In this section previous works related to wind and wave climate analysis is summarized. The current wind and wave information is very limited.

The study "Özhan, E. and Abdalla, S.: "Turkish Coast Wind and Deep Water Wave Atlas" 1999" is an atlas of Wind and wave climate prepared for Turkish coasts giving detailed information about wind and wave climate of seas surrounding Turkey. The atlas is directly related of NATOTU Waves project, which aimed to find out the wave climate of Turkish coast. The research is carried out from 1994-2000 by Prof. Dr. Erdal Özhan from Middle East Technical University. This study presents us the wind and wave climate given in 30 km intervals in Black Sea, Aegean Sea, and Mediterranean Sea and in 10 km intervals for Marmara Sea. For each location, surface wind speeds and observed wave heights are given both for annually and seasonally. In addition significant wave height vs. mean wave period relations, long-term extreme probability distributions of wind and waves and monthly largest wind and wave distributions are presented. For this work [Özhan, 1999], data are obtained from ECMWF Wind Fields, and Synoptic Maps obtained from General Directorate of Turkish State Meteorological Service. Since the reliable data from ECMWF is available for 8 years at that time and data resolution is inadequate, data from synoptic maps are processed via models to obtain data with longer duration [Özhan, Abdalla, 1999]. The detailed information about NATO-TU Waves project and some measured data can be accessed via http://www.mu.edu.tr/departments/muhendislik/tu-waves/introduction.htm web site.

" "Determining Wave and Design Wave Properties for 15 Sea Region" , by Ergin A., Özhan E." " study investigates 15 location along Turkish coast. 4 locations are in Mediterranean Sea, 4 locations are in Aegean Sea, 2 locations are in Marmara Sea and remaining 5 locations are in BlackSea. In the study, them main aim is to find out wave guess of 10 year return period and extreme wave height distribution in deep water for each of 15 regions.

Various numerical models are used to compute to define the non-linearity of waves, namely second order model of Ochi, Second order model of Al- Humoud, Tayfun and Askar and Model of Mori and Yasuda. Although this paper is not directly related to our study and analyses waves theoretically, it is considered beneficial for constructing models.

Tolman, Hendrick L. carried out studies of wind waves and wind wave modeling. "Treatment of unresolved islands and ice in wind wave models (2003)" study presents a method based on a technique used in the SWAN model to deal with such islands. The method is tested in the operational global WAVEWATCH III model of the National Centers for Environmental Prediction with a one-year hindcast, and the results show a local but dramatic impact on model errors. In "Numerical modeling of wind waves generated by tropical cyclones using moving grids (2004)" study, a new model option/version is intended for research into wind waves generated by tropical cyclones in deep water away from the coast. The main advantage of such an approach is that the cyclones can be modeled with spatial grids that cover much smaller areas than conventional fixed grids, making model runs with high spatial resolution more economically feasible. Besides, "Subgrid modeling of moveable-bed bottom friction in wind wave models" study offers a subgrid moveable-bed bottom friction model is developed for use in large-scale wind wave models.

Matthew Brownea, Bruno Castellea, Darrell Straussa, Rodger Tomlinsona, Michael Blumensteinb and Chris Lanec published "Near-shore swell estimation from a global wind-wave model: Spectral process, linear, and artificial neural network models" in 2006. A model is derived of the near-shore wave transformation from an offshore global swell model such as NOAA WaveWatch3 is an economical means to arrive at swell size estimates at particular locations of interest. Performance was assessed on data gathered from a total of 17 near-shore locations, with heterogeneous geography and bathymetry, around the continent of Australia over a 7 month period. It was found that the ANNs out-performed SWAN and the non-linear architecture consistently out-performed the linear method.

CHAPTER 3

DATA SOURCE AND ANALYSES OF DATA

In this chapter information about the data that is used in the analyses are given and analyses steps are explained. In section 3.1. the details of data source and download procedure are explained. In section 3.2. information on obtained data and the rearrangement of the data are discussed. Finally in section 3.3. the analysis procedures and presentation steps are given.

3.1. DATA SOURCE AND OBTAINING DATA

3.1.1 The Data Source

The data source for this study is the European Centre for Medium-Range Weather Forecasts (ECMWF in short). ECMWF, the Centre is an independent international organization established in 1975 and is currently supported by 28 States. [ECMWF, 2006] The organization has co-operation agreements with several other international organizations. Türkiye, being a member of this organization, does assist ECMWF and has access to ECMWF data by the Turkish State Meteorological Service. The ECMWF runs atmosphere global forecasts, ocean wave forecasts and seasonal forecast, stores the data obtained from observations, analyses, forecasts and research experiments, provides an ensemble prediction system and carries a range of research programs, which are available to its member states and co-operatives. The ECMWF Operational data, used in this study have been obtained from the ECMWF Data Server by special permission from General Directorate of Turkish State Meteorological Service and ECMWF.

The data archiving services of ECMWF is used to download the data. In the archive service, there are three sets of data available, which are Operational Archive, ERA-15 and ERA-40. ERA-15 and ERA-40 are archives of re-analysis of global and short range forecasts of relevant weather parameters for 15 and 40 years duration respectively. The operational archive of ECMWF is used in this study, which in turn is divided into six classes of data sets. The data sets; atmospheric and wave models are used to gather data. Atmospheric model is the richest data set from the space resolution and time duration point of view. The atmospheric model supports thirteen separate data sets. From these data sets, surface analysis data set is used and wind data are obtained from this set. In a similar manner, the wave model is divided into four data sets, namely sets of Global and Mediterranean wave analysis and forecasts. For the purpose of this study, the Mediterranean wave analysis set is selected. The parameters to be ordered are selected from parameter list of the data sets. Two parameters from surface analysis data set and four parameters from Mediterranean wave analysis data set are selected and these parameters are given as a list in Section 3.2.1.

3.1.2 Obtaining Data

In this section, obtaining data is explained in brief. Ordering of data from ECMWF can be made in different ways. Ordering data online is an easy way for selective parameters. Mainly Meteorological Archival and Retrieval System (MARS) is used for downloading bulk data with its own script language. However, for small amount of data, data can be ordered directly from data services. In this study, data is directly ordered from the Mediterranean Wave model of Operational archive. In this way, the interactive web environment directs user through the ordering process. After the selection of the data set, pages for selection of the data time range, available daily times, parameters and finally the area and grid spacing selection pages are opened. The request is evaluated and prepared by ECMWF for download. Afterwards the requested data is downloaded in GRIB file format. A single file for every month is downloaded for wind and wave data.

3.2. INFORMATION ON DATA AND DATA RE-ARRANGEMENT

3.2.1. Information on Obtained Data

The data to be used in the analysis are ordered from two data sets. Wind data are ordered from surface analysis data set and wave data are ordered from Mediterranean wave analysis data set. The parameters ordered form the wind data set of the atmospheric model is listed in the following;

- 10U - 10 meter U wind component (m/s)
- 10V - 10 meter V wind component (m/s)

The parameters ordered from the Mediterranean wave data set of Analysis wave model is listed in the following;

- TIME – Observation Time (Year, Month, Day, Hour)
- WIND - 10 meter wind speed (m/s)
- MDPS - Mean direction of primary swell (degrees)
- MDWW - Mean direction of wind wave (degrees)
- MPPS - Mean period of primary swell (s)
- MPWW - Mean period of wind wave (s)
- SHPS - Significant height of primary swell (m)
- SHWW - Significant height of wind wave (m)

These parameters can also be attained from the parameter catalogue of ECMWF. The 10-meter wind components, which are downloaded from wind data set, refer to wind speeds 10 meter above surface given in meters/seconds units. They are abbreviated as 10U and 10V. The abbreviation U specifies that the component is along the latitude and similarly V specifies that the component be along the longitude. The positive direction for the U component is towards east and for the V component, it is towards north. The resolution of the wind components are selected as 1.125°x1.125°.

In the wave data set, four parameters are ordered with a resolution of 1.125°x1.125°. The wind-abbreviated parameter gives only speed at 10 meters above water surface in meters/seconds units. Because this parameter does not contain direction of wind, this parameter is only used to crosscheck wind speeds obtained from wind data.

Parameters defined as MDPS, MPPS and SHPS are complementary parameters in defining swell waves. MDPS is an abbreviation for Mean Direction of Primary Swell, given in degrees measured clockwise starting from north. MDPS indicates the direction of incoming swells. MPPS is an abbreviation for Mean Period of Primary swell, given in seconds. Significant Height of Primary Swell is abbreviated as SHPS and is given in meters units. Other parameters defined as MDWW, MPWW and SHWW are complementary parameters in defining wind waves. MDWW is an abbreviation for Mean Direction of Wind Wave, given in degrees measured clockwise starting from north. MDWW indicates the direction of incoming waves. MPWW is an abbreviation for Mean Period of Wind Wave, given in seconds. Significant Height of Wind Wave is abbreviated as SHWW and is given in meters units. Due to recent changes in ECMWF data service, these parameters are being served as regard to total wind replacing primary wind applicable by November 2006.

For the purpose of this study, the study area covers whole Aegean and Mediterranean Sea region. The wind and wind wave data is used for a 72 months period starting from 01.01.2001 to 10.12.2006 with 12 hour data record interval covering whole Aegean and Mediterranean Sea basin. Totally, 4380 data records for every data location inside the matrix are acquired with every data record providing four data elements, which are the wind components 10 meter above sea level, the mean direction of wind wave, the mean period of wind wave and the significant height of wind wave. However, for some locations wave data is limited. Some locations are identified as “LAND” for some time of the record duration and for last two or one year are assumed as “SEA”. By the help of software developed for the thesis study, all necessary locations’ data can be easily extracted. By reading both wave and atmospheric model results, software can combine both model results for any location user needs in different ways.

Table 3.2.1.1: Index, name and coordinates of the 2 locations

Index	Location Name	E Coordinate (Degrees)	N Coordinate (Degrees)
3320	Edremit	26.00	39.50
3516	Kuşadası	27.00	37.50

2 locations along the Turkish coast are selected for analysis and given in Table 3.2.1.1. In this study the locations index, name and coordinates are used in conjunction. The locations on Aegean and Mediterranean Sea can be seen in Figure 3.2.1.1. In this figure locations investigated in Derebay, 2007 are shown.

Figure 3.2.1.1 The Layout of the 21 locations (Derebay, 2007)

3.2.2. The GRIB File Format

The source data are obtained in GRIB format as explained in Section 3.1.2. The GRIB is an abbreviation for “Gridded Binary”. The GRIB file format is a bit-oriented data exchange and storage format. In GRIB form, the data is efficiently packed and compacted and this way storage and transmission of data is made efficiently. However, GRIB files cannot be opened and/or viewed in conventional software before extraction. Special software is needed to unpack the GRIB files. Few programs exist for this purpose and unfortunately, it is hard to find satisfactory documentation for any of them. In this study, free software named WGRIB is used. In addition, the ECMWF serves another free software product, named GRIBEX for handling GRIB files, which is available for UNIX systems. [ECMWF, 2006] WGRIB runs in DOS environment and is well established and usage is quite simple and straightforward once commands are understood. The program is available from National Oceanic & Atmospheric Administration (NOAA) of U.S. Department of Commerce. [NOAA, 2006] The decoding process is carried out by using WGRIB program and the decoded GRIB files are saved as text files. Every GRIB file contained data for a month period, and so text files for every month was produced for wind and wave data totaling in 65 separate text files. The usage of WGRIB and links to detailed help files are given in the appendix. Although the extracted text files can be viewed in conventional software at this level, they are still not meaningful. The data in text files had to be re-arranged for processing the data as described in the following section.

3.2.3 Re-arrangement of Data

In this section, the re-arrangement of text files obtained from the decoding of GRIB files is described. The text files are composed of one column data and header information included in GRIB files does not exist. Inside the text files, in the first row total row and column counts are given for each day start, i.e. the matrix dimensions. In the following rows all data, covering whole region is listed, where the region is the total of locations. The data is listed starting from the upper right corner of the matrix and flowing in left-to-right and top-to-bottom order. For every location there is a data group listed. That is, for wind data the wind parameters 10U and 10V is listed in an alternating order. In addition, for wave data the parameters wind, MDWW, MPWW and SHWW are listed in an alternating order. In the file, the parameter group is given for a date and time value for all locations following the flow direction, and then the date and time value is incremented and the data flow continues in this way. The text files are re-arranged by a user-friendly software called as Wind and Wave Interpreter and Analyzer – Simulation 2 (WWIA-SIM2) written for especially re-arrangement of these files.

Briefly, WWIA-SIM2 takes the text files as input and extracts the parameters, and stores the monthly values of the parameter in a matrix form covering whole area. In addition, the programs are made to extract data for a single location in a tabular format as a data file (*.txt), indicating date and time of measurement and parameters in the following columns. This text file forming the base for all analysis can be viewed in a spreadsheet. These files are named as location-data type e.g. 33-17-Wave.txt or 34-19-Wind.txt. After extraction of data values from both model results, WWIA-SIM2 combines them hour by hour. If one of the model value is missing for that hour, software can either pass the hour or writes high values for the missing parts so that analyze routines simply denies such values. These combined files are later modified and necessary calculations made directly on them as needed.

3.3. DATA ANALYSIS AND PRESENTATION

In this section the analysis procedure and presentation steps are given. Before starting any analysis the data files that have been divided according to locations and obtained for every month of every year, are combined. Thus, one single data file for every location is produced. For each location one wave file and one wind file is prepared. For wind data, the wind vector that is given as U and V components are converted to polar coordinates. So wind speed and angle from North direction measured clockwise is computed along with the geographical bearing. Also for both wind and wave, data the year, month, day, and hour values of every measurement is extracted and placed on different columns merely for analysis purposes by the help of WWIA-SIM2.

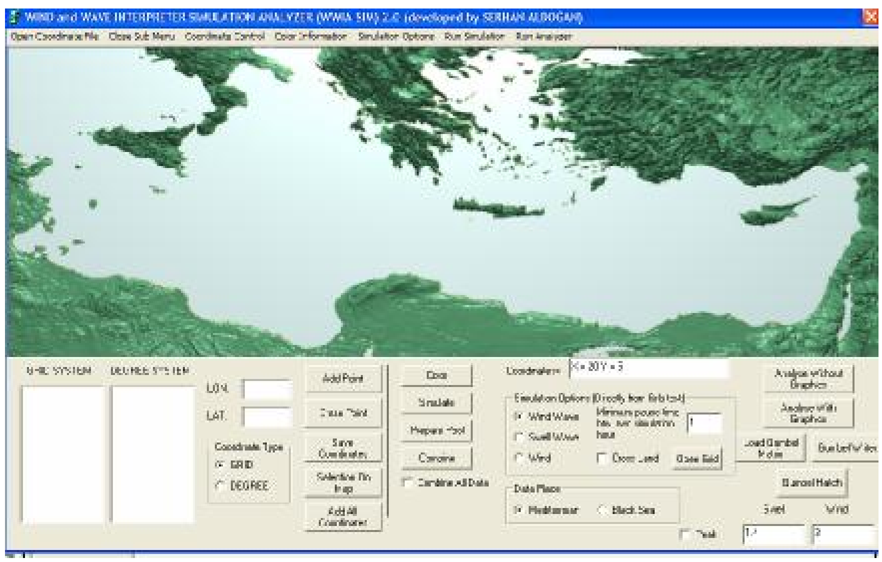

Figure 3.3.1 General View of the Software

3.3.1 Wind and Wave Roses

Roses are angular histograms plotted on polar coordinate system. Roses give the frequency distribution of geographical bearing of incoming winds and wind waves. To show the information about the distributions of wind speeds and wave heights, and the frequency of the varying directions, one may draw a so-called wind rose.

The frequency is given in percent of all directions plus the calm duration and the percent scale is given on the polar coordinate system. The roses at the same time have a magnitude scale and show the percentage of each magnitude interval. The magnitude intervals legend is given on a color scale. For every bearing, the percentages of magnitude intervals are added on former interval and thus the percent of any bearing is the total of percentages of each interval. Therefore, the calculation of percent of an interval e.g. 7.5 to 10 m/s for wind speed should be made for any direction by subtracting the percent reading of interval minimum from interval maximum.

Roses are plotted by using WWIA-SIM2. Software simply prepares all roses with a 5% incremental view by using the user interval and color information. In this study, the wind classes, that are the colored magnitude scale or intervals, are prepared as; 3-5, 5-7.5, 7.5-10, 10-12.5, 12.5-15, 15-17.5, 17.5-20.0, 20.0-22.5, and 22.5 higher in meters/second. This way, wind speed spectrum is divided into 10. The wind speeds lower than 3 m/s is treated as calm and the calm percentage is indicated at the lower right corner of the roses separately. If the calm duration or 0-3 m/s interval were to be indicated in the rose, the total of all petals would have made 100%. However, in the given roses the total percentage of all petals made up to 100% minus the percentage of calm duration or interval.

The wind wave roses are handled in a similar way to wind roses. The wave classes or intervals are selected as; 0.5-1, 0.5-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9 in meters. The wave spectrum is divided into 10 intervals. Wind wave heights lower than 0.5 meters is treated as calm and the calm percentage is indicated at the lower right corner of roses separately. The total percentage of petals of the rose makes 100% minus the calm percentage similar to the wind roses. If the user interval input cannot define the highest occurrence of the wave height, then the software automatically set the highest interval to that value.

The generation procedure for wind and wave roses is similar. The prepared data files are directly used as input to WWIA-SIM2 at this step. These files were divided according to location covering all data period. By pressing "Analyze With Graphics" button, software creates all the roses.

On the roses only the cardinal directions are given. The calm data frequency is indicated at the lower right corner of each rose as "calms" in percent. The corresponding season of the roses are indicated. The color scale and wind and wave classes are kept constant through all locations. For the sake of presentation, the seasonal and full year roses are assembled in a single page for every location as given in Chapter 4.

3.3.2 H_s vs. T_m Relation Graphs

The graphs of significant wind wave height versus mean period of wind waves, as will be shortly expressed as H_s vs. T_m relations thereafter, are the plot of every data point according to its significant height and mean period. The horizontal axis of the graph is significant wind wave height (H_s) in meters and the vertical axis is mean period of wind waves (T_m) in seconds. In the H_s vs. T_m relations, differently from the roses, all data points are plotted. These graphs effectively represent the relation between H_s vs. T_m and the maxima. The H_s vs. T_m relations are given for different bearings and one relation covering all directions.

The H_s vs. T_m relations are given in two pages and the directions are indicated above the graphs. As in the roses, all the graphs are prepared by the WWIA-SIM2.

3.3.3 Extreme Probability Distribution Graph

The Extreme Probability distribution is a tool for estimating probable wind wave heights for a given return period. In this section, the method that has been followed in this study for generation of extreme probability distribution graphs is explained.

The data that is used for generation of extreme probability distributions consist of the yearly maximums of wind wave heights. The yearly maximums of wind wave heights obtained from the data files for the locations are given in Table 3.3.3.1. WWIA-SIM2 simply gives all maxima values for each year in a text file prepared for each location folder called as “Sta.txt” and uses an insertion sort algorithm to put values in ascending order Afterwards, the extreme value probability distributions are plotted by using WWIA-SIM2, automatically.

The maximum values for axis are selected the same for every location. The vertical axis in the graphs represents the significant wind wave height in meters and the range is selected as 0 to 10. The below horizontal axis show the non-exceedance probability.

After the data points are set on the graph, WWIA-SIM2 uses its “REGRESS” algorithm based on the least squares method to find the best graphical solution line.

3.3.4 Log-Linear Cumulative Probability Distribution

The log-linear cumulative probability distribution gives a relation between the occurrence probability and a given significant wind wave height. The graph is generally used for estimating the duration of exceedance of a certain wind wave height. In this section, the method that has been followed in this study for generation of Log-Linear cumulative probability distributions is explained.

The frequency distribution of incoming wind waves is used as input for generation of log-linear cumulative probability distributions. The frequency distribution shows the counts of wind wave occurrences divided according to wind wave heights as used in wind wave roses and from each direction. These frequency distributions are obtained from WWIA-SIM2. WWIA-SIM2 uses its procedures and subroutines to analyze frequency distributions. Then frequency distributions are modified to obtain the cumulative frequency distributions. In the cumulative frequency distribution, every smaller wind wave height interval includes the occurrences observed at higher intervals. In this way, the smallest interval shows the total number of observations excluding calms. Afterwards the significant directions are extracted from the whole frequency distribution table. In addition, an “all directions” case is composed by adding counts for all directions. Then the all directions case and other significant directions are tabulated as cumulative frequency distribution table. Finally, the frequencies are converted to percentages by dividing table cells by total number of occurrences excluding calms. The final cumulative percent frequency distributions are plotted on a logarithmic-linear graph and a logarithmic trend is added to these data.

The horizontal axis in the graphs show probability and the maximum and minimum values are fixed to 1 and 0.0001 for every location. The vertical axis is the significant height of wind waves in meters. The range of vertical axis is arranged so that all locations can easily be compared.

Again, WWIA-SIM2 uses its subroutines to draw the plots. If any direction having points less than 3 to draw, then it is simply rejected. Afterwards, a regression line is drawn by WWIA-SIM2 using least squares method.

CHAPTER 4

GRAPHICAL RESULTS

In this chapter results of the analysis for two location are given. For each location firstly a brief description of location is given and following this description analysis graph results are provided.

The results of each location are given in a sub-chapter and follow an ascending order of location index. Geographical coordinates of the location is indicated. In addition, the location is approximately shown by a star on the Aegean and the Mediterranean Sea map given with the graphs. Inside the sub-chapters, the graphics provided from analysis results are given in the following order; Wind Roses, Wind Wave Roses, Significant Wind Wave Height (H_s) vs. Mean Wind Wave Period (T_m) Relations, Extreme value probability statistics, and Log-Linear cumulative probability distribution graph. Detailed descriptions of generation of these graphs are explained in section 3.3. Data Analysis and Presentation.

The wind and wind wave roses carry important information such as dominant directions, calm durations, and range of observed magnitudes with occurrence probability and seasonal changes of these parameters. The relations of significant height and mean period of wind waves show all available data for all considerable directions along with the maximum values. The distributions of extreme probability and log-linear cumulative probability are useful for analysis purposes.

The wind and wind wave roses plotted by SOFTWARE show the yearly and seasonal distribution of occurrence probability and magnitude of incoming winds or wind waves respectively. Roses are divided into 16 geographical directions. The directions are indicated on roses as N (North), NNW (North-Northwest), NW (North-West) etc. Every direction counts for a total of 22.5° (degrees) segment. The percentile distribution is scaled on the roses. The magnitude of the parameter can be seen from the color scale on the figure. The scale starts from a non-zero value. Magnitudes below that minimum value are regarded as "calm" values. The percentage of calm duration is indicated at right-bottom of each rose. The roses are given for full year and for all seasons separately.

Wind roses are related to wind speed, which is given as wind speed 10 meters above the sea, i.e. U10 in meters/second. For wind roses, magnitude scale is from 3 m/s to 25 m/s. Minimum wind speed is 3 m/s, below that level the wind state is regarded as calm. In the discussions of each results section comparisons with Özhan and Abdalla, 1999 are given. Since this study and the study Özhan and Abdalla, 1999 are based on different data sources the differences may be expected. In the case of using these results in any future engineering applications, the user must perform his/her own analysis procedure with the new available wind data and perform further comparisons between the results given in these studies and also his/her and other available result. Besides, the software prepared for this thesis study provides a very time saving tool. Any update in the database can simply be updated by just a few clicks.

Wind waves are related to significant height of wind wave in meters. For wind waves magnitude scale is from 0.5 m to 9 m. Minimum wind wave height is 0.5 m, below that level wind wave state is regarded as calm.

Roses are followed by Significant Wave Height (H_s) vs. Mean Wave Period (T_m) Relation Graphs. In this graph, the horizontal axis is significant height of wind waves (H_s) in meters and the vertical axis is mean period of wind waves (T_m) in seconds. Every graph is created by SOFTWARE. SOFTWARE defines the graphs upper and lower limits automatically. In these graphs, every dot relates to a wind wave data, plotted according to its H_s (m) and T_m (s) respective to wind wave-incoming direction. All directions are given for the detailed comparisons. These graphs can be used to relate wind wave height to wind wave period. In addition, these graphs show the general distribution of wind waves according to their directions.

Extreme value probability statistics for 10 different distribution graph plotted by SOFTWARE follows the H_s vs. T_m graph. Yearly maximum values for significant wave height of wind waves are plotted on extreme value graph, as the distribution of yearly maximums is assumed to be fitting distribution with the highest correlation (based on R value). Besides, user can choose "POT" method instead of yearly maximums. In this graph, below horizontal axis is percent non-exceedance probability, and vertical axis is significant wind wave height in meters. Best line is fit to these data values and the best line is elongated. Using this graph expected significant wave height can be obtained for reasonable return periods.

Log-linear cumulative probability distribution follows the extreme value probability graph. SOFTWARE draws all directions' points, if the direction has at least three (3) points to be analyzed. In this graph, horizontal axis is occurrence probability and the vertical axis is significant wind wave height in meters. As the name of the graph implies the horizontal axis is in logarithmic scale. The log-linear cumulative distribution graph is useful for estimating the duration of exceedance of a certain wind wave height. The orientation of the data points in the graph should be close to a line ideally. However, because of limited data the exact linear distribution cannot be observed.

Results relate to data covering all year of analysis duration, i.e. 72 months, as described in the 3rd Chapter. However, some locations have less data. Also extreme value probability graph is not given for these locations because of lack of data. Details on extreme value probability graphs are also given in the 3rd Chapter.

4.1. LOCATION 3320 - EDREMİT

The 3320 abbreviated point is located approximately 5 km West of Baba Burnu (80 km West of Edremit), 20 km North of Midilli Island and 30 km South of Bozcaada. In this context Edremit (3320) is the most northward point among all data points. The coordinates of point 3320 is; 39.50˚ N, 26.00˚ E.

The Wind Roses, Wind Wave Roses, Significant Wave Height (Hs) vs. Mean Wave Period (Tm) Relations, Extreme value probability statistics and Log-linear cumulative probability distribution are given in this section for this location.

Wind roses are given in Figure 4.1.1 and show that location 3320 is subject to mainly SW and WSW winds. Strong winds are effective in SW and WSW directions in all seasons.

Wind Roses are compared with the wind roses at the nearest location (39.50 N˚, 25.90˚ E) in Ozhan and Abdalla, (1999) where the dominant wind is from N to NNE direction for this location. The yearly wind roses are not in correlation with both studies.

Wind wave roses are given in Figure 4.1.2. Nearly 26.5% of the time wind waves are coming from NNE and NE directions totally in a full year. NNE and NE wind waves' percentile increases in winter up to 32.0%. The maximum wind wave height is between 4.5 and 5.0 meters.

The relations between Significant Wave Height (Hs) vs. Mean Wave Period (Tm) are given in Figure 4.1.3. In this graph, NNE and NE wind wave domination can be seen. In addition, S and SSW wind waves are observed commonly. Several data points, exceeding 8-second periods and few data points exceeding 4 m of wind wave heights are observed for northern direction with a maximum wave height of 4.76 m.

The graph of extreme value probability statistics is given in Figure 4.1.4. Data values show high correlation.

Log-linear cumulative probability distribution is given in Figure 4.1.5. Nine of the directions are plotted along with all directions. It is seen from this graph that significant height of wind waves exceeds 4.0 meters in about 10 hours duration every year.

ANALYSIS TYPE (Y = AX+B)	R	A	B
(OLD GUMBLE (M N+1))	0.942	0.519	3.571
(FT I - GODA)	0.957	0.421	3.595
(FT II - k=2.5)	0.991	0.233	3.533
(FT II - k=3.33)	0.991	0.218	3.533
(FT II - k=5.0)	0.981	0.338	3.550
(FT II - k=10.0)	0.971	0.383	3.570
(Weibull - k=0.75)	0.983	0.385	3.364
(Weibull - k=1.0)	0.977	0.571	3.246
(Weibull - k=1.4)	0.961	0.817	3.070
(Weibull - k=2.0)	0.941	1.120	2.821

TABLE 4.1.1

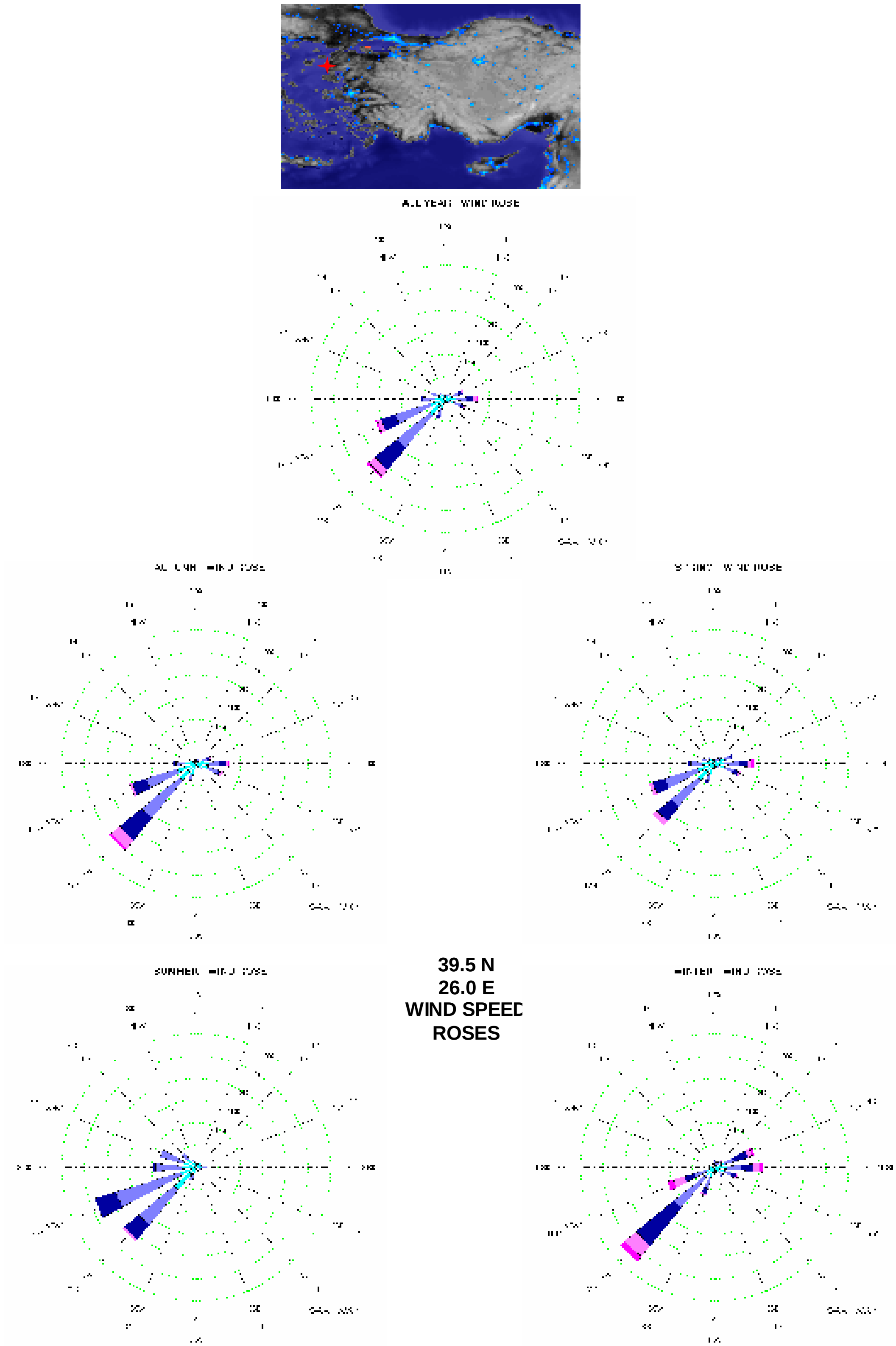

Figure 4.1.1 Wind climate at 39.5 N, 26.0 E

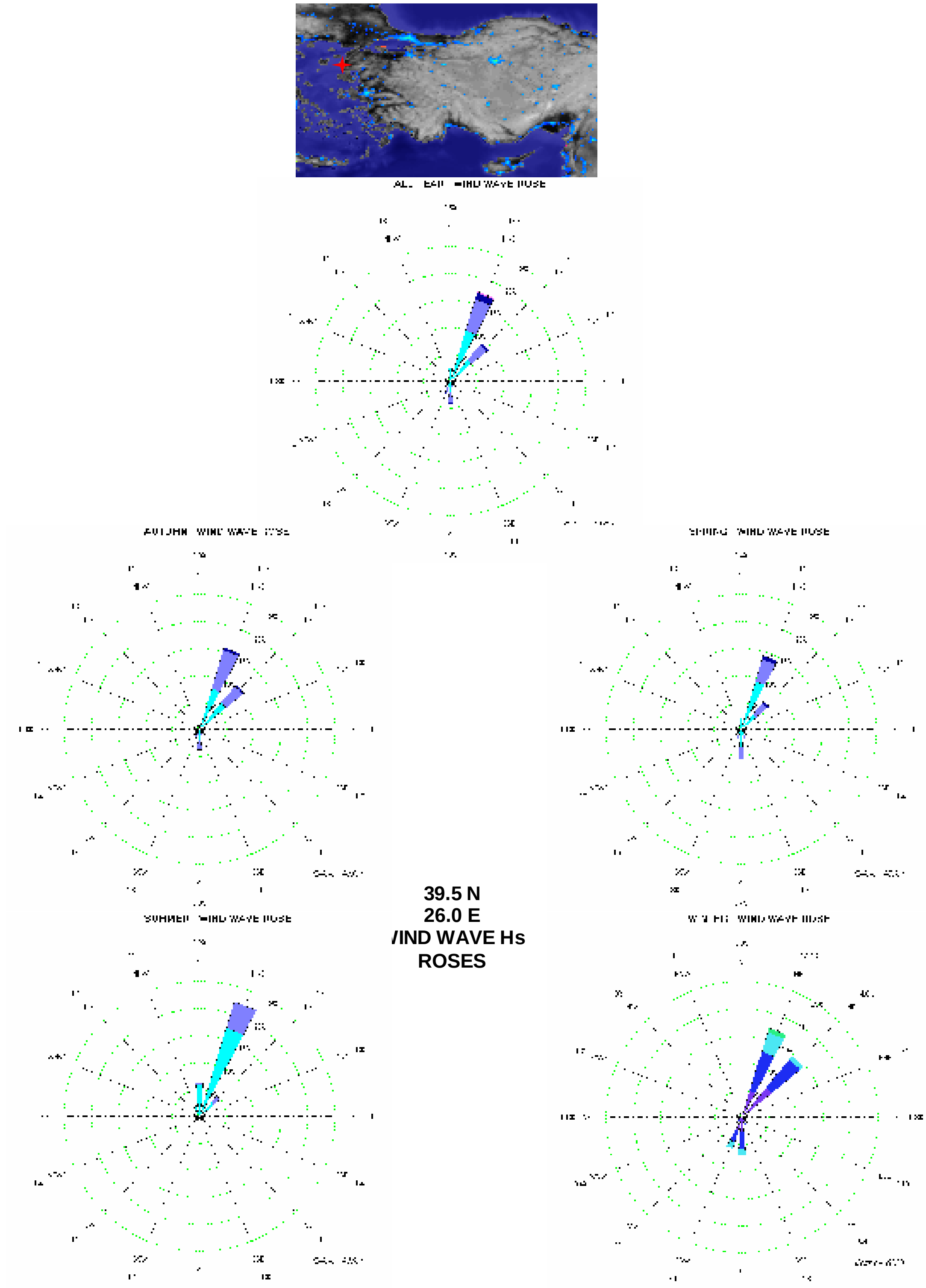

Figure 4.1.2 SHWW climate at 39.5 N, 26.0 E

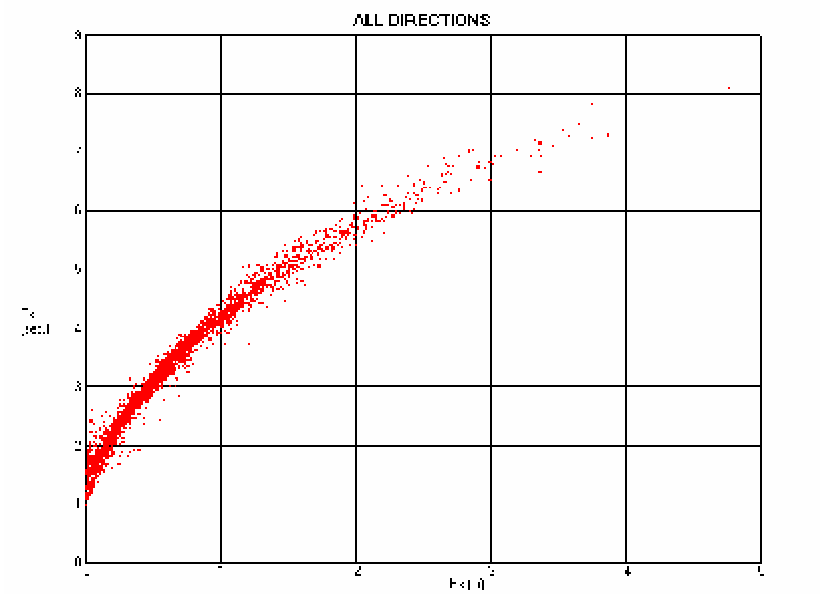

Figure 4.1.3 Relationship between MPWW & SHWW at Edremit

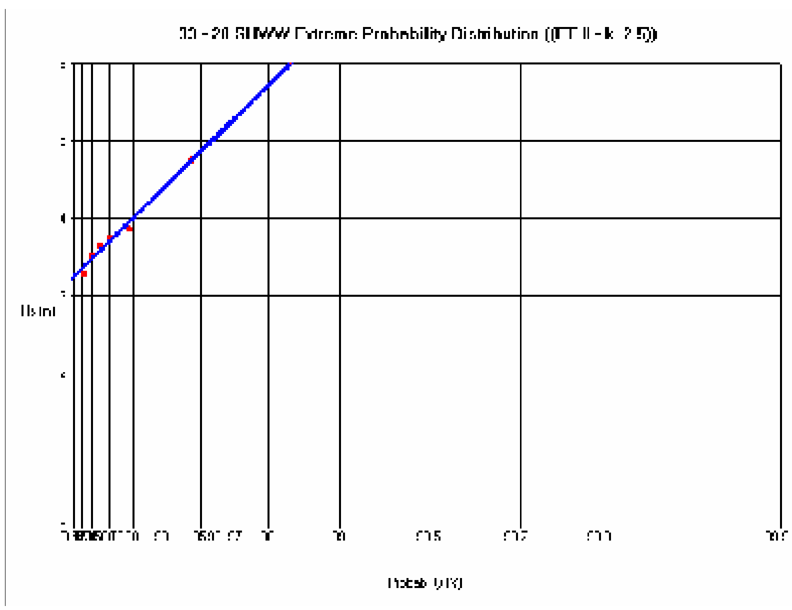

Figure 4.1.4 Extreme probability distribution at Edremit

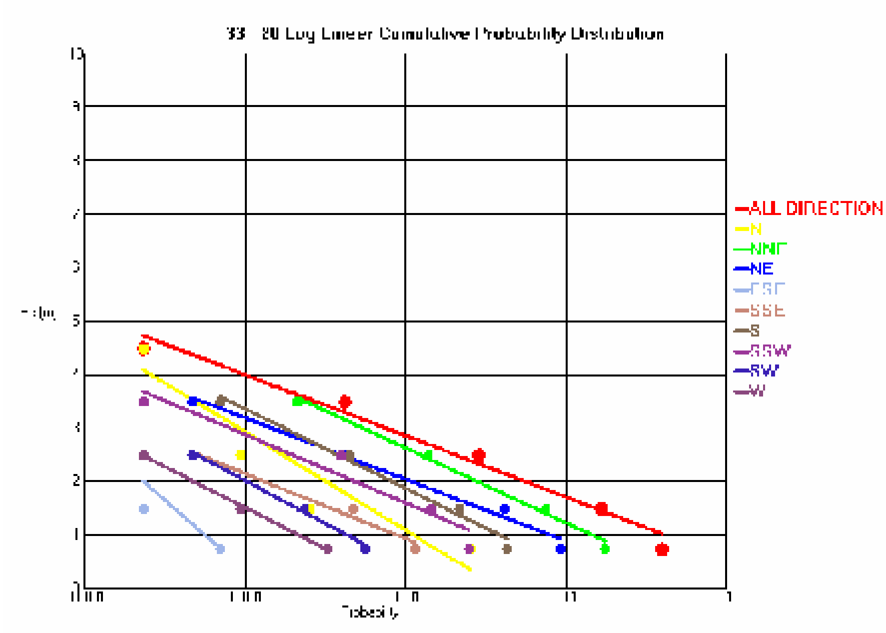

Figure 4.1.5 Log-Linear cumulative probability distribution at Edremit

4.2. LOCATION 3516 - KUŞADASI

The 3516 abbreviated point is located approximately 15 km West of Akköy and 20 km North West of Didim. The coordinates of point 3516 is; 37.50˚ N, 27.00˚ E.

The Wind Roses, Wind Wave Roses, Significant Wave Height (Hs) vs. Mean Wave Period (Tm) Relations, Extreme value probability statistics and Log-linear cumulative probability distribution are given in this section for this location.

Wind roses are given in Figure 4.2.1 and show that location 3516 is subject to mainly WNW to WSW winds. Strong winds are effective in W direction in all seasons and slides to WNW in summer. Also relatively strong winds are seen from reverse direction, namely ENE to ESE in winter.

Wind Roses are compared with the wind roses at the nearest location (37.75 N˚, 27.10˚ E) in Ozhan and Abdalla, (1999) where the dominant wind is from N to NNW direction for this location.

Wind wave roses are given in Figure 4.2.2. This location is has a calm percentage of 70.9% in a full year. Nearly 10% of the time wind waves are coming from N and 5.9% of the time coming from NNW. In summer dominant wave direction is NNW. SSE wind waves' percentile increases in winter. The maximum wind wave height is between 3.50 and 4.00 meters.

The relations between Significant Wave Height (Hs) vs. Mean Wave Period (Tm) are given in Figure 4.2.3. In this graph N and NNW wind wave domination can be seen via Figure 4.2.2. Several data points, reaching to 8 second periods in SW direction and few data points exceeding 3.0 m of wind wave heights are observed for SSE direction with a maximum wave height of 3.71 m.

The graph of extreme value probability statistics is given in Figure 4.2.4. Data values show high correlation.

Log-linear cumulative probability distribution is given in Figure 4.2.5. Three dominating directions; namely WSW, SW and NW are plotted along with all directions. It is seen from this graph that significant height of wind waves exceeds 3.2 meters in about 10 hours duration every year.

ANALYSIS TYPE (Y = AX+B)	R	A	B
(OLD GUMBLE (M N+1))	0.938	0.593	2.528
(FT I - GODA)	0.945	0.477	2.556
(FT II - k=2.5)	0.904	0.244	2.511
(FT II - k=3.33)	0.899	0.227	2.512
(FT II - k=5.0)	0.930	0.367	2.518
(FT II - k=10.0)	0.939	0.425	2.534
(Weibull - k=0.75)	0.892	0.401	2.336
(Weibull - k=1.0)	0.914	0.614	2.196
(Weibull - k=1.4)	0.931	0.908	1.978
(Weibull - k=2.0)	0.940	1.284	1.666

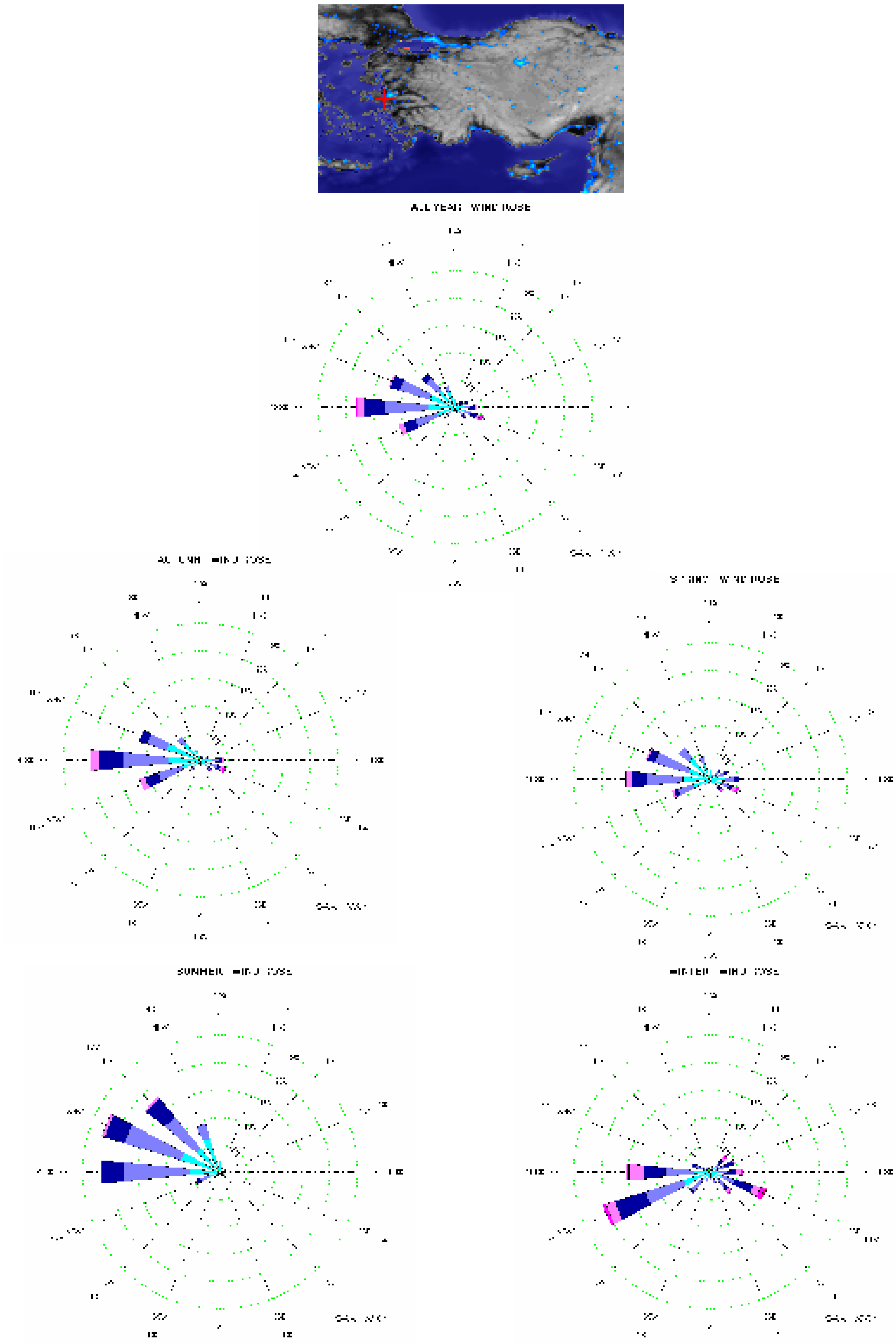

Figure 4.2.1 Wind climate at 37.5 N, 27.0 E

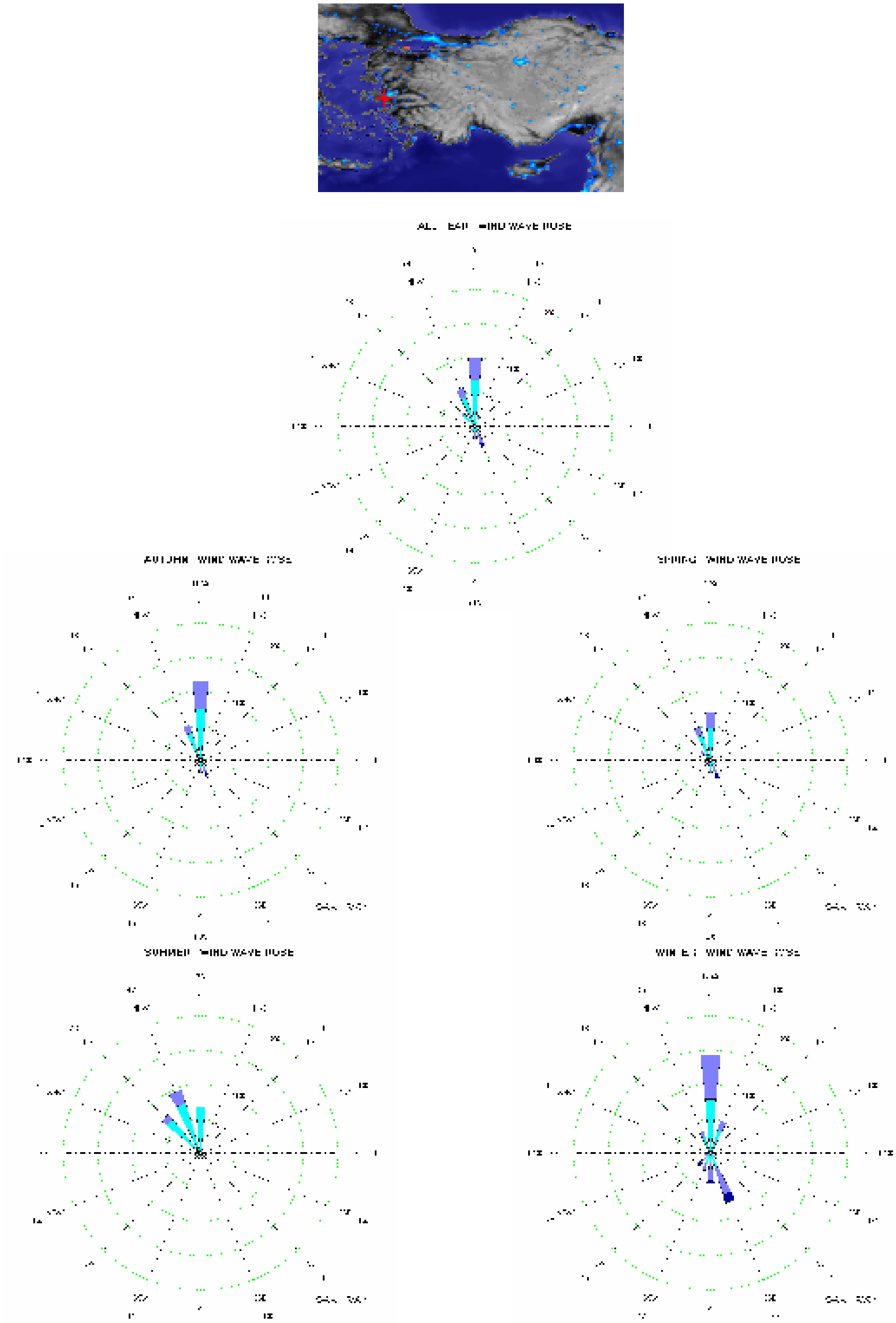

Figure 4.2.2 SHWW climate at 37.5 N, 27.0 E

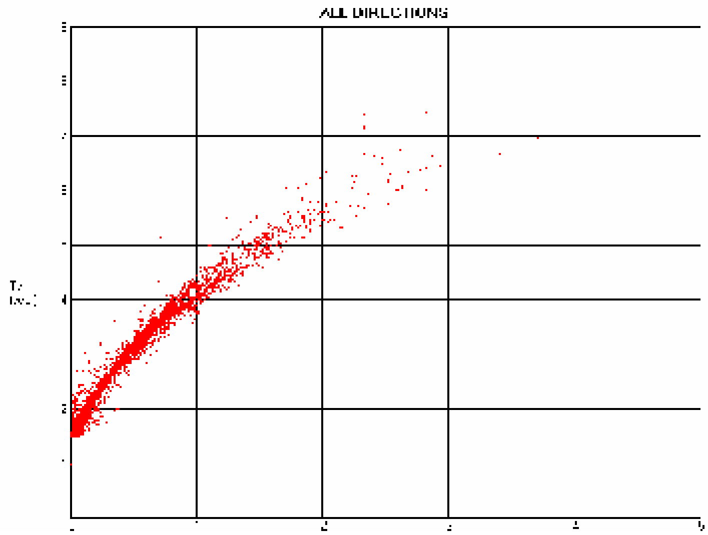

Figure 4.2.3 Relationship between MPWW & SHWW at Kuşadası

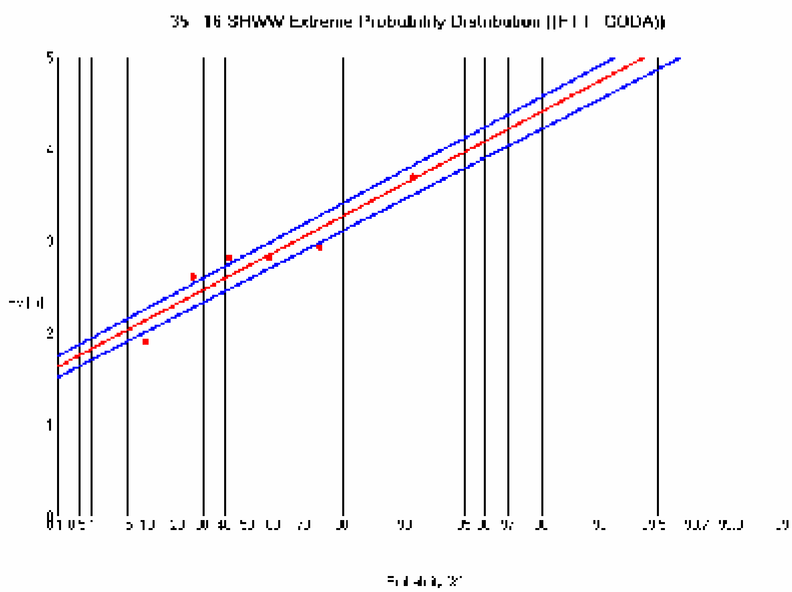

Figure 4.2.4 Extreme probability distribution at Kuşadası

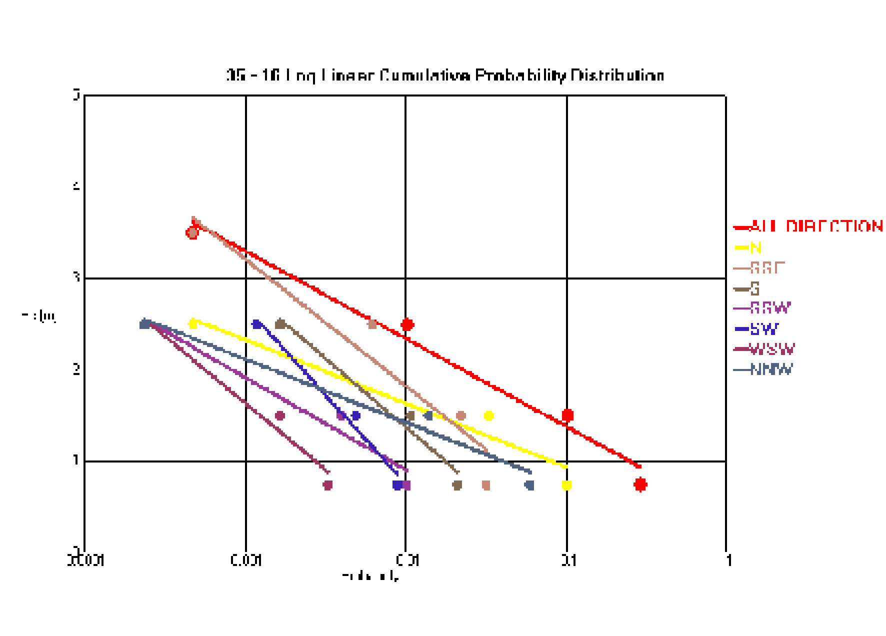

Figure 4.2.5 Log-Linear cumulative probability distribution at Kuşadası

CHAPTER 5

DISCUSSION OF RESULTS

AND

USAGE OF SOFTWARE

The results of analysis were given in Chapter 4 for every location. In Chapter 4, some of the results, which can be obtained very easily, prepared by WWIA-SIM2, are given. In this chapter a general discussion of the results and the usage of the software will be given.

In Chapter 4, sample analyses were made for the two locations. The details of locations were given in Chapter 3. Although in Derebay 2007, 21 locations are investigated. In this thesis, two locations are investigated to show the presentation of the software developed and for two of them analyses graph are presented.

Discussions on the results are given in the following section. General notes are stated here before the discussion. The data are obtained for 72 months duration in 12-hour intervals and the results are based on only this duration of data. As stated in Derebay 2007, 12-hour interval is rough for wind wave observations in Aegean and Mediterranean Sea. Thus, the actual maximums may be larger than the maximum values given in this study. However, wind and wave climate would be affected very slightly with the large data record intervals.

5.1. GENERAL DISCUSSION OF RESULTS

In this thesis new software is developed to extract data from ECMWF, combine wave and atmosphere model data, analyze data and using the analyzed data prepare the graphics. Therefore, all the stages are simply based on the data taken from the ECMWF. Any missing value or unmatched wave and wind model combination leads the software in wrong direction and thus lots of useless results.

Software is powered to enhance the unexpected situations. One of these is unmatched time durations of the wave and atmosphere model results. In combination command, all the data values are matched such that wind and wave model values for the same time duration is combined together. If one of the model type result is missing somehow, the software is simply uses the user response at the beginning. If the user has chosen to combine all data, then WWIA-SIM 2 just uses “1000” instead of missing values. Otherwise, the software passes this time duration and looks for the next duration.

Another unexpected situation is location land or sea condition change. Some of the locations' in both Black-Sea and Mediterranean Database, condition may change month to month. This may cause the software to gain very few data for that location and leads to result in useless values especially in statistical analyses. In order to solve this situation if less than 3 years data exist, then software does not apply extreme probability analyses.

Moreover there are some unexpected data values in the databases such as wind speeds over than 200 m/s. these values over 30 m/s, 30 m, 30 s are neglected by the software to keep the results in the order of magnitude. Besides, wind speed values in the wave model may not match the corresponding wind speed values. For few locations, there is some difference in the order of magnitude for with speed values.

5.1.1 COMPARISIONS OF THE LOCATIONS

5.1.1.1 Edremit

For Edremit detailed analyses are carried out. Wind Roses, Wind Wave Roses, Swell Wave Roses, Extreme Probabiliy Analyses are prepared by the software.

WSW and SW are the dominant wind directions. Besides, E direction is the third dominant direction. In total 39.30% of the wind is blowing form WSW and SW direction. 20.4% of the wind data is calm.

NNE direction is the dominant wind wave direction with a percentage of 17.3% of the years. Second dominant direction is NE with 9.2%. Wave steepness is found to be 0.0374. Extreme Probability statics is done and the resultant is

Tablo 5.1

Return Period (yr)	Wave Height(m)	95 % Confidence Interval + " / " - (m)
1.0	3.219	0.009
1.0	3.249	0.009
1.0	3.266	0.009
1.1	3.326	0.008
1.1	3.367	0.008
1.3	3.432	0.007
1.4	3.491	0.007
1.7	3.554	0.006
2.0	3.625	0.006
2.5	3.712	0.006
3.3	3.830	0.006
5.0	4.012	0.006
10.0	4.384	0.009
20.0	4.862	0.014

5.1.1.2 Kuşadası

For Kuşadası detailed analyses are carried out. Wind Roses, Wind Wave Roses, Swell Wave Roses, Extreme Probabiliy Analyses are prepared by the software.

W is the dominant wind direction with a percentage of 18.3%. However WNW and WSW have a total of 23.6% of the wind blowing of all year.

N direction is the dominant wind wave direction with a percentage of 10.0% of the years. Second dominant direction is NNW with 5.9%. Besides, highest waves are also coming from SSE direction. Wave steepness is found to be 0.0370. Extreme Probability statics is done and the resultant is

Tablo 5.2

Return Period (yr)	Wave Height(m)	95% Confidence Interval + " / " - (m)
1.0	1.635	0.109
1.0	1.761	0.099
1.0	1.828	0.094
1.1	2.033	0.079
1.1	2.159	0.070
1.3	2.329	0.059
1.4	2.468	0.052
1.7	2.598	0.046
2.0	2.731	0.043
2.5	2.877	0.043
3.3	3.048	0.048
5.0	3.272	0.058
10.0	3.630	0.082
20.0	3.973	0.109

5.2. USAGE OF SOFTWARE (WWIA-SIM 2.0)

5.2.1 DATABASE ENTRY

First, the user must use the correct database. If the user will work on Black-Sea, then in the "ATMOSPHERE" folder, there must be atmosphere model results for the Black-Sea and in the "WAVE" folder there must be atmosphere model results for the Black-Sea. These folders must be in the same directory with the software.

After WWIA-SIM 2 is executed, user must choose which location will be studied from the GUI (Graphical User Interface).

5.2.2 LOCATION ENTRY

User may enter the location information in different ways. First one is using the textboxes. User simply writes locations' longitude and latitude values with choosing "DEGREE" from the "COORDINATE TYPE" frame.

Second way is the writing grid numbers, which is one of the constraints in database. In Black Sea 16x9 matrix exist, whereas in Mediterranean 54x23 matrix exist. As same before, user may simply writes grid numbers in textboxes with choosing "GRID" from the "COORDINATE TYPE".

Third way is picking points from the map. After activating "SELECTION ON MAP", user may left-click on the map for the necessary location. As the user left-clicks, software puts a circle on the location. When the user right-clicks, software cancels selection on map mode.

If all the locations in the database wanted to be added, then user just clicks "ADD ALL COORDINATES" button. Last method is the opening a coordinate file, saved before. However, if a coordinate file is loaded then all previous location information will be lost.

All the coordinates added will be shown in the list boxes in the lower left of the GUI.

5.2.3 SAVING COORDINATES

After all the necessary location information is given, user must save the coordinates. In order to save locations, “SAVE COORDINATES” button must be clicked. If already a coordinate file is activated, then the software asks whether to overwrite the document of save as different document. Otherwise, directly save-as procedure is activated.

5.2.4 DATA GATHERING and COMBINING

After databases are put in directories, data places (Mediterranean or Black Sea) is chosen and location information are entered user may press “PREPARE POOL” button to create a file named “POOL” in the same directory. In this directory, all location values will be stores. If one of the locations is 1-1 (GRID Method), then “1-1-Wave.txt” and “1-1-Wind.txt” files will be created. Wave model results will be written in wave text and atmosphere model results will be written in wind text. This will be repeated for every location. While data gathering procedure is active, software also stores the maxima values for wind speed, wave heights, and periods.

After data gathering, user must click “COMBINE” to combine two model results together. However, user must pay attention that, database time durations may vary. If the user wants to use all the data at the hand, then “COMBINE ALL DATA” must be activated. Otherwise only the time durations both of the model have will be combined. Combined data will be stored in “CPOOL” folder.

5.2.5 ANALYZE

Software can easily analyze extracted data. If the user wants a complete analyze, then “ANALYSE WITH GRAPHICS” must be pressed. “ANALYSE WITHOUT GRAPHICS” is useful if the user has chosen a very large amount of locations and just wants extreme value results. If latter one is activated, then software handles all data and only prepare a file named “GUMBLESTA.sta” in the “RESULT” file where all the analyze results will be stored in the folder for each of the locations.

CHAPTER 6

CONCLUSIONS AND SUGGESTIONS

In this study wind and wind wave climate along the Aegean and the Mediterranean Sea coast of Türkiye is attempted to be enlightened by analysis of certain wind and wave data. The data used in this study is obtained from the ECMWF Data Server. [ECMWF, 2006] The data is obtained for the whole Aegean and Mediterranean Sea basin. The data period is between 01.01.2001 to 11.12.2006, totally 72 months in length. Analyses were made for 10 locations along the Aegean and Mediterranean Sea coastline of Türkiye.

In this study the two locations are analyzed separately and for every location results are presented graphically via a software developed for this thesis study called WWIA-SIM2. The wind and wind wave roses, significant wave height versus Mean period of primary wind relations, extreme probability distribution and log-linear cumulative probability distributions are provided for the locations and are presented in the 4th chapter. The 4th chapter thus presents the wind wave climate for the south coast of Aegean and Mediterranean Sea. In the 5th chapter, more detailed information about the software is given.

The results of wind wave climatology analyses expose the directions and magnitudes of wind waves that the selected locations are subject to. The results are provided in seasonal basis for comparison of seasonal differences. The calm durations, which indicate very limited wind or wind activity, are also given for the locations. Roses prepared by the software, show that there are some points where atmosphere and wave model data are not compatible with each other. This situation may be studied by running newly developed softwares which will be based on the mathematical models, in the light of this study.

In this study a sound and straightforward method for inspection of wind and wave climate is introduced and the method is used to discover wind and wind wave climate along the Aegean and Mediterranean Sea. Moreover WWIA-SIM2 is also capable of Black-Sea database. Thus a complete analyzes for the Turkey coasts is very easy. Besides, by using all coordinates all of the Black Sea, Marmara, Aegean and Mediterrean Sea can be analyzed in couple of days without any man power loss.

As mentioned before detailed analyses of the locations shows that wind roses and wind wave roses are not coherent to each other. This means that there are differences between wave model data and the atmosphere model data. Besides in this thesis, only 12 hour interval data is used of 4-D analysis of ECMWF. Therefore the reliability of the results are not good. However by the help of the software developed, it will be very easy to analyses any data taken from ECMWF. Even for different locations with some modifications software is ready to analyse 6 hours interval data for any grid.

This study has been performed as a basic research on ECMWF data based on 12 hours interval database of wind and wave for a short duration (6 years). Because of the limited duration of wave data long term estimations given in this study are subject to discussions. It is hoped that this study would be a starting point for further similar studies considering shorter interval (i.e. 6 hours).

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APPENDIX A

USAGE OF WGRIB

The steps followed for handling for *.grib files by WGRIB program is given in the following. Further help on WGRIB can be found at;

http://dss.ucar.edu/datasets/common/ecmwf/ERA40/software/wgribexamples.html

http://tmap.pmel.noaa.gov/~tmap/ecmwf/wgrib.html

WGRIB is a tool for handling *.grib files and works in DOS environment. In Microsoft Windows hit win+R and type "cmd" to open command prompt. Using DOS commands locate the directory of WGRIB executable. The following commands are given assuming that the input file, "wgrib.exe" and "cygwin1.dll" are in the same directory. (The wgrib program is standalone and can be carried and run in any directory, in the following commands wgrib is located in c:/wgrib/ and the input file name is 2001_06.grib)

c:/wgrib>wgrib

Starts wgrib and/or shows the help screen

C:/wgrib>wgrib 2001_06.grib -s

Displays short inventory of the input file (replace -s with -v for verbose)

C:/wgrib>wgrib 2001_06.grib -V -d N

Displays the details of a single (N'th) data record (if –d is not stated all data records are displayed in this way)

C:/wgrib>wgrib 2001_06.grib -d N –text

The N'th data record is extracted to a "dump" file in ascii format.

C:/wgrib>wgrib 2001_06.grib -d all -text -o -2001_06.txt

The input file is transformed into 2001_06.txt file in ascii format. This command is sufficient for generally all cases. A single data record can be opened by replacing "all" with data record number "N".

APPENDIX B

PROGRAM SNAPSHOTS

Figure B.1

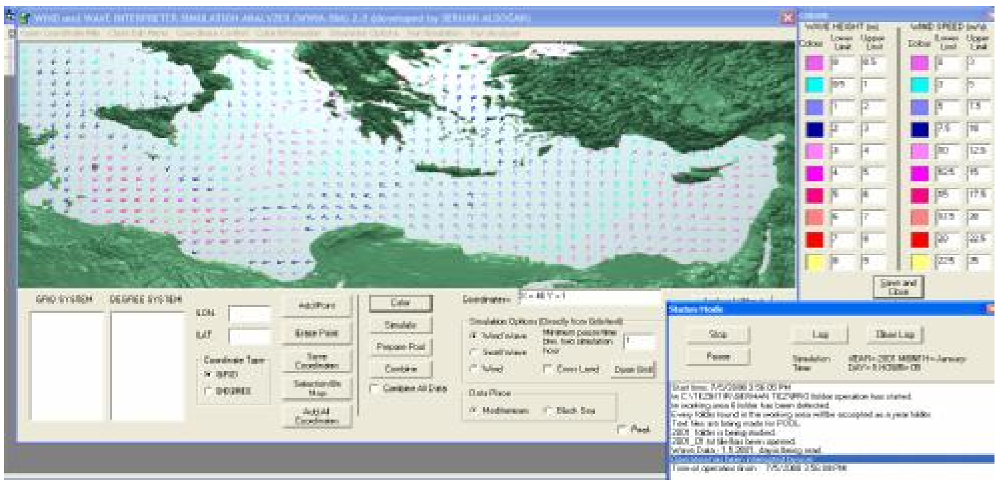

Figure B.2