Philippine Wind Information for Engineering, Research, and Mitigation

A report prepared by
Ronwaldo Emmanuel R. Aquino
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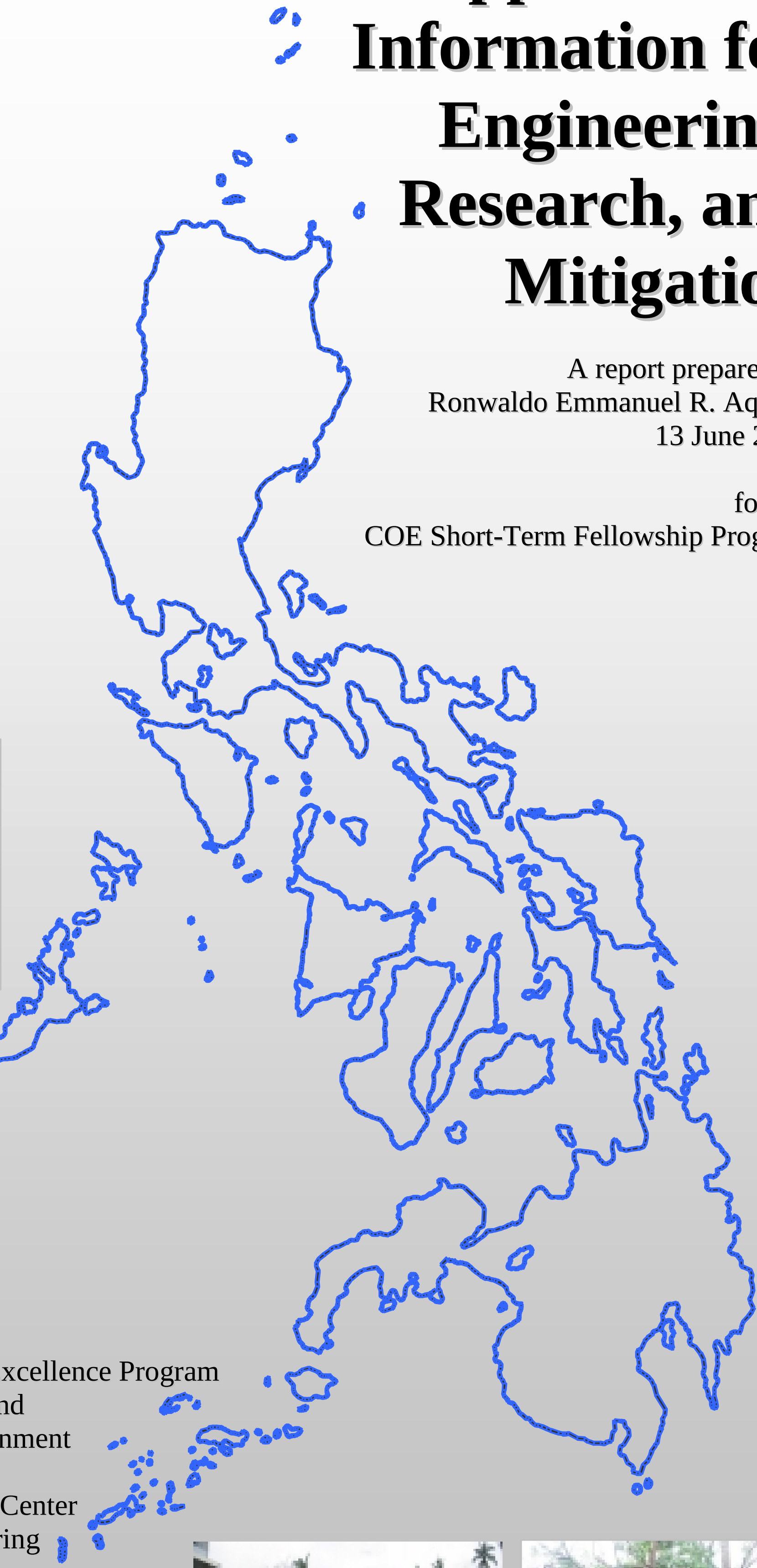

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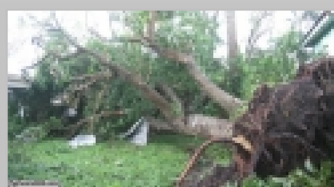

Philippine Wind Information for Engineering, Research, and Mitigation

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ABSTRACT: The Philippines is considered to be the most disaster-prone country in the 20th century, and wind storms rank 1st as worst natural disaster, with an annual average of 20 tropical cyclones passing the Philippine Area of Responsibility (PAR), 9 of which are landfalling. While there is much attention to the effect of devastating earthquakes, which ranks as 2nd worst natural disaster in the Philippines, there are numerous sources of available wind information for engineering, research, and mitigation. These information such as available wind speed data, and wind-induced damage information are presented and discussed in this report, including how these may be used for engineering and mitigation, and for future research studies on wind engineering in the Philippines.

KEYWORDS: PAR, NSCP, PAGASA, NDRB, OCD-NDCC, PICE-DMAPS & DQRP

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The title page photos were taken by Mr. Michael Padua after Typhoon 'Unding' (Muifa).

About the Author

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Content Outline

1 INTRODUCTION

The Philippines is an archipelago country in Southeast Asia (Figure 1), that is located within the "Typhoon Alley of the Pacific." [Rellin, et al, ~2002] A short summary information about the Philippines is presented in Table 1. This report aims to present sources of wind speed data and wind damage information from the Philippines that could be used by engineers, architects, planners, and hazard/disaster mitigation experts for wind hazard mitigation, wind engineering and research, and disaster management.

The PAGASA 2004 Annual Report states that tropical cyclones and particularly typhoons have a significant influence on the climate and weather in the Philippines. They generally originate from the region of the Marianas and Caroline Islands of the Pacific Ocean, which are on the same latitude as the southernmost big island of Mindanao, and follow a northwesterly direction. (See Chapter 3 for information about PAGASA.)

1.1 *The Philippines and Wind Disasters*

A database of natural and technological disasters worldwide compiled by the Center for Research on the Epidemiology of Disasters (CRED) shows that the Philippines suffered the worst combination of disasters among all countries for the 20th century (i.e. from 1901 to 2000) as cited by Pacheco [2004]. (Data source: EM-DAT: The OFDA/CRED International Disaster Database – www.em-dat.net – Universite Catholique de Louvain – Brussels – Belgium) The database however includes only disasters that meet certain criteria.

The Asian Disaster Reduction Center (ADRC) based in Japan, analyzed trends from the same database from EM-DAT, such as presented in the report, "ADRC 20th Century Asian Natural Disasters Data Book" at http://www.adrc.or.jp/publications/databook/databook_20th/top_e.htm. The trends show that wind storms rank as worst natural disaster, followed second by earthquakes and floods, and third by volcanic eruptions. [Pacheco, 2004] "Wind storm" disasters include tropical cyclones, as well as those disasters listed in Table 2, as in the EM-DAT database. Table 3 shows totals per disaster type of number of disasters recorded, number of killed, injured, homeless, affected, and total affected persons, and total sum of damage cost according to the ADRC report.

Pacheco [2004] however noted that the impact is more intense than would be suggested by average annual numbers, because these disasters would hit in relatively short durations, and that the numbers from the first half of the century are almost surely understated because relatively few major disasters had been recorded prior to 1975.

1.2 *Frequency of Tropical Cyclones*

An average of about 20 tropical cyclones pass through the Philippine Area of Responsibility or PAR (see Table 1 & Figure 2) each year mostly coming from the Pacific on the east side, and about 9 of these directly pass through land. Figures 3a & 3b show the trend in number of tropical cyclones affecting PAR from 1948 to 2004. In 2004, there were 25 tropical cyclones that entered the PAR. There were two years (in the early 90's and in the 60's) were there were more than 30 cyclones. 1998 was considered to be relatively "quiet" as there were only just over 10 cyclones, although strong cyclones during that year also caused considerable damage. From October to April winds generally prevail in the southwest direction, and in the northeast direction the rest of the year. ([Rosaria & Pacheco, 1999] after [PAGASA, ____])

In this report, some government and non-government organizations and individuals that deal with wind disasters shall be cited, including their activities related to wind disaster mitigation. However, given the frequency of tropical cyclones affecting the Philippines each year and the total number of damage by all these tropical cyclones combined greater than those by all other disasters combined, and possibly because the worst earthquake has caused more damage than the worst wind storm (Table 4), there still seems to be quite a range of possibilities for research on wind engineering and wind hazard mitigation.

Figure 1. The Philippines and neighbor countries
(from the CIA World Factbook 2005 http://www.cia.gov/cia/publications/factbook/index.html)

Table 1. Short Summary Information About the Philippines

Official Name (Long Form)*	Republic of the Philippines
Official Name (Short Form)*	Philippines
Land Area*	298,170 km^2
Total Area*	300,000 km^2
Number of Islands	7,107
Coast Line*	36,289 km
Population*	~87.9 million (estimate for JUL-2005)
Surrounding Bodies of Water	Bounded by: South China Sea on the west, Luzon Strait on the north, Sulu Sea on the southwest, Celebes Sea on the south, and Philippine Sea on the east (towards the Pacific Ocean)
Nearest States/Countries/Islands	Hong Kong (North West), Taiwan (North), Ryukyu Islands (Japan, North East), Vietnam (West), Brunei, Malaysia, Indonesia (South), Federal States of Micronesia (East), Papua New Guinea (South East) (See Figure 1a.)
Philippine Area of Responsibility**	Defined by imaginary lines that make equal oblique angles with all meridians joining the following points: 25°N 120°E, 5°N 135°E, 5°N 115°E, 15°N 115°E, and 21°N 120°E (See Figure 1b.)

* According to Association for Human Rights Defense International – Factbook – Philippines. http://www.4humanrights.org/world/geos/rp.html or from the Central Intelligence Agency – World 2005 Factbook - http://www.cia.gov/cia/publications/factbook/index.html
** From http://www.typhoon2000.ph/tcterm.htm#P after Pardo, R.R. (1990). “A Primer on Terms Used By PAGASA,” Philippine Almanac: Book of Facts 1990, Aurora Publications, pp. 968-969.

Table 2. Types of Natural Disasters Categorized under Wind Storms*

Storm
Tornado
Tropical Storm
Typhoon
Winter

* As categorized by EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium

Table 3. Total Damages by Recorded Top Natural Disasters* in the Philippines within the Period 1901-2000

Natural Disaster	Disaster Count	Thousand People Killed	Thousand People Injured	Million People Affected	Thousand People Homeless	Million Total People Affected	Million US$ in Damage
Wind Storms	**214**	**32**	**28**	**76**	**8,000**	**84**	**7,000**
Earthquakes	21	10	11	2	135	2	517
Floods	54	3	< 1	12	500	13	506
Volcanic Eruptions	19	6	1	> 1	77	> 1	227

Data source: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium
* Top natural disasters in the Philippines in the 20th century according to Asian Disaster Reduction Center, as cited by Pacheco [2004]. Numbers are rounded off and approximate.

Figure 2. Philippine Area of Responsibility
(from de Leon, C.A.G., "Cyclones: Philippine Experience" at http://www.proventionconsortium.org/files/adpc_workshop/day1C/PhilippinesCyclones.pdf)

Table 4a. Top 10 Natural Disasters in the Philippines by Number of People Killed

Disaster	Date	Killed
Earthquake	**1976 AUG 16**	**6,000**
Wind Storm	1991 NOV 05	5,956*
Earthquake	**1990 JUL 16**	**2,412**
Wind Storm	**2004 NOV 29**	**1,619**
Wind Storm	1970 OCT 13	1,551
Wind Storm	**1984** SEP 01	1,399
Volcano	1911 JAN 31	1,335
Wind Storm	**1984** NOV 03	1,079
Wind Storm	1949 OCT 31	1,000
Wind Storm	1952 OCT 16	995

As of April 22, 2005
Source: "EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net – Université Catholique de Louvain – Brussels – Belgium"
* Some sources state that this number could be actually around 8,000.

Table 4b. Top 10 Natural Disasters in the Philippines by Number of People Affected

Disaster	Date	Affected
Wind Storm	**1991 NOV 10**	**6.5 M**
Wind Storm	**1990 NOV 06**	**6.2 M**
Wind Storm	1973 NOV 20	3.4 M
Flood	**1972 JUL** __	2.8 M
Wind Storm	1976 MAY 17	2.7 M
Drought	1998 ___ __	2.6 M
Wind Storm	1984 NOV 03	2.3 M
Flood	1999 AUG __	2.1 M
Wind Storm	1998 OCT 21	2.1 M
Wind Storm	1994 DEC 23	2.0 M

As of April 22, 2005
Source: "EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net – Université Catholique de Louvain – Brussels – Belgium"

Table 4c. Total Damages by Recorded Worst Top Natural Disasters* in the Philippines within the Period 1901-2000

Natural Disaster	Thousand People Killed	Thousand People Injured	Million People Affected	Thousand People Homeless	Million Total People Affected	Million US$ in Damage
Worst Wind Storms	**6**	3	**6**	**1,171**	**7**	709
Worst Earthquakes	**6**	**7**	2	135	2	**920**
Worst Floods	1	0	3	371	3	220
Worst Volcanic Eruptions	2	1	1	57	1	211

Data source: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium
* Top natural disasters in the Philippines in the 20th century according to Asian Disaster Reduction Center, as cited by Pacheco [2004]. Numbers are rounded off and approximate. Note that the wind storm that caused the most number of people injured may not be the same wind storm that caused the most number of people killed.

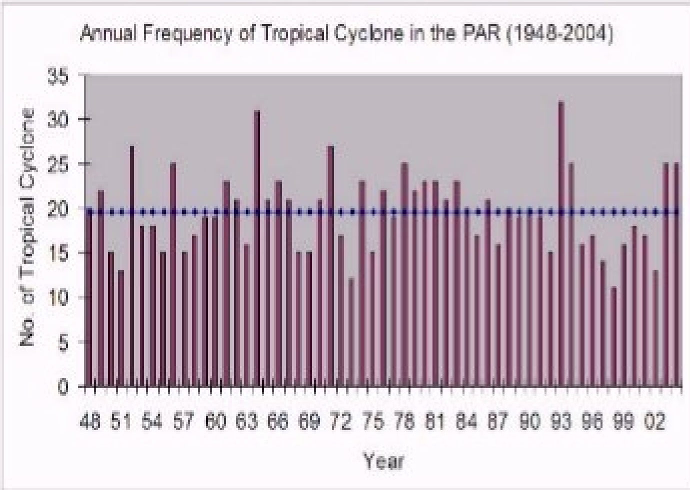


Figure 3a. Annual Frequency of Tropical Cyclone in the PAR (1948-2004)
(from PAGASA: http://www.pagasa.dost.gov.ph/cab/statfram.htm)

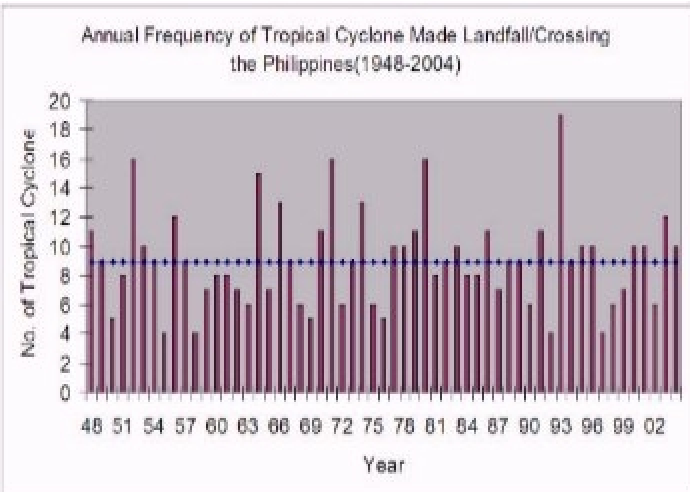


Figure 3b. Annual Frequency of Tropical Cyclone Landfalling in the Philippines (1948-2004)
(from PAGASA: http://www.pagasa.dost.gov.ph/cab/statfram.htm)

2 THE NSCP AND WIND SPEED MAPS FOR WIND RESISTANT STRUCTURAL DESIGN

The National Structural Code of the Philippines or NSCP is probably the most important document for wind hazard mitigation in the Philippines. It presents minimum design requirements for wind loading on various structures. We will talk about Volume 1 of NSCP only which is for buildings, towers, and other vertical structures. Volume 2 deals with structural design for bridges and other similar structures.

The current (5^{th}) edition of NSCP (2001) uses a wind zone map that is based on around 35 years of wind data (1961-1995), and adapts the 1995 version of the American Society of Civil Engineers' Standard 7 (ASCE 7-95) to suit local conditions. The NSCP has been historically adopting US practice, although the NSCP does not include the Commentary that comes with the ASCE Standard. The previous (4^{th}) edition (NSCP 1992) was based on the 1988 Uniform Building Code, which in turn was based on the American National Standards Institute (ANSI) Standard A58.1-1982. [Tanzo & Pacheco, 2004] Tanzo & Pacheco [2004] have cited that there have been major code revisions in NSCP 2001 from the previous (4^{th}) edition (NSCP 1992), more so with the wind load code provisions such as: 3-second gust speed in place of fastest kilometer wind speed, accounting of topographic effects, and accounting for torsional effect in buildings above 18 meters.

In the Philippines, while the NSCP could be considered an "equivalent" of the ASCE Standard 7 in the USA and the Architectural Institute of Japan (AIJ) Recommendations for Loads on Buildings (AIJ-RLB) in Japan, being a "recommendation" by a group of professionals in the field, i.e. by the Association of Structural Engineers of the Philippines or ASEP as to the ASCE or the AIJ, it becomes parallel to the Building Standard Law of Japan when it is approved and endorsed by the Professional Regulation Commission as a referral code of the National Building Code of the Philippines.

The wind zone maps of NSCP 2001 as well as from other sources are discussed next.

2.1 *Early Studies by Simiu (1974)*

In the early 1970's (ca. 1973), the National Bureau of Standards (now National Institute Standards and Technology) of the U.S. Department of Commerce conducted a joint U.S.-Philippines workshop entitled "Development of improved design criteria for low-rise buildings in developing countries to better resist the effects of extreme winds." Included in the workshop was a study conducted by Dr. Emil Simiu entitled "Estimation of Extreme Wind Speeds—Application to the Philippines." The study used annual maximum one-minute average wind speed data from 16 stations with varying periods of records. The study also applied data correction to account for instrumentation, anemometer elevation, and actual terrain exposure. Lastly, the study provided estimated extreme wind speeds for each station at different return periods, and grouped the stations according to three wind zones with Zone I as the highest wind zone. A plot is shown in Figure 4.

2.2 *Wind Zone Map of NSCP 1992*

The NSCP 1992 provided a wind zone map (Figure 5) for use in wind loading for structural design of buildings and other vertical structures in the Philippines. As previously mentioned, the wind zones correspond to basic wind speed defined as fastest-kilometer wind speed with a 50-year return period.

However, the problem with this wind zone map is that there are actually no direct measurements made of fastest-kilometer speeds in the Philippines. While the documentation as to how this wind zone map was developed is presently not available, it would seem that the map was converted from analysis of 10-minute average wind speed data. By converting these design or basic wind speeds, these are actually equivalent to wind speeds with an averaging time of about 20 seconds. [Rosaria, 2001]

After a 1996 meeting on loads on buildings by APEC (Asia-Pacific Economic Cooperation) member countries and following a release in the U.S. of the 1997 Uniform Building Code (UBC 1997) and the ASCE 7-95, the National Building Code of the Philippines Technical Committee (Lateral Loads sub-committee) reviewed and actively discussed the revision of the NSCP 1992, specifically on seismic and wind loading provisions. [Tanzo & Pacheco, 2004]

2.3 *Studies by Rosaria & Pacheco [1999], and Rosaria [2001]*

Studies by Rosaria and Pacheco in 1999 of a review of available PAGASA data for engineering use via some preliminary statistical analyses were first presented in the 8th ASEP International Convention.

In 2001, Rosaria completed his graduate thesis entitled, "Estimation of Extreme Wind Speeds for the Development of Wind Zone Map for the Philippines." In the Rosaria thesis, 35 years (1961 to 1995) of monthly maximum wind data from PAGASA were subjected to extreme value statistical analysis: the classical approach using the method of moments and the chi-square test; and the Peak-Over-Threshold approach using the de Haan method of parameter estimation. However, some data were missing, and some extreme wind speeds exceeding the maximum speed that could be measured by aerovanes at PAGASA stations were also discarded.

The study generated the wind contour map shown in Figure 6a. The map represents 3-second gust speeds at a 50-year return period. To maintain some similarity with the NSCP 1992 wind map which delineated different areas of the Philippines into three wind zones, Rosaria employed the concept of "superstations" to form three wind zones as shown in Figure 6b. The proposed map is actually a contour map, with a zone numbering similar to that for seismic loading, wherein a higher number corresponds to a higher design load. Rosaria also showed how to convert the basic wind speeds for return periods other than the 50-year return period.

2.4 *Wind Zone Map of NSCP 2001*

After much reviewing and many discussions, the NSCP 2001 was released in the early part of 2002, and consequently, it was approved in the same year to have legal standing as the minimum standard for loads on buildings and other vertical structures.

Table 5 compares the last two editions of the NSCP with codes from other countries in terms of definition of basic wind speed, and return period. Table 6 compares the basic wind speeds of NSCP 1992 and NSCP 2001.

The NSCP 2001 wind zone map, based almost entirely on Rosaria's thesis, tried to maintain a close similarity with the NSCP 1992 wind zone map in terms of the dividing lines between zones, in zone numbering, and in strictly being a zone map rather than a contour map.

Table 5. Comparison of Philippine Codes and Other Codes* Specifying Wind Loads

	Year	Short Name	Basic Wind Speed (Return Period)
NSCP, 4th ed.	1992	NSCP-1992	fastest-kilometer speed (50 years)
NSCP, 5th ed.	**2001**	**NSCP-2001**	**3-second gust speed (50 years)**
1988 UBC	1988	UBC-88	fastest-mile speed (50 years)
Australian Standard 1170	1989	AS 1170-1989	3-second gust speed (50 years***)
AIJ Recommendations**	1993	AIJ-RLB 1993	10-minute mean speed (100 years)
ASCE, Standard 7	1995	ASCE 7-95	3-second gust speed (50 years)
1997 UBC	1997	UBC-97	3-second gust speed (50 years)
ASCE, Standard 7	1998	ASCE 7-98	3-second gust speed (50 years)
2001 International Building Code	2001	IBC-2001	3-second gust speed (50 years)
ASCE, Standard 7	**2002**	**ASCE 7-02**	**3-second gust speed (50 years)**
Australian/New Zealand Standard 1170	**2002**	**AS/NZS 1170-2002**	**3-second gust speed (50 years***)**
2003 IBC	**2003**	**IBC-2003**	**3-second gust speed (50 years)**
AIJ-RLB	**2004**	**AIJ-RLB 2004**	**10-minute mean speed (100 years***)**

* The highlighted Philippine Structural Code is based on the similarly colored highlighted structural code from another country (for the last two editions, from USA codes). Codes in boldface are the current editions of each code.
** English version of AIJ-RLB 1993 was published in 1996.
*** For higher performance or importance level, other codes specify a longer return period. The AS 1170 specifies a return period of 1000 years, and the AIJ-RLB 2004 recommends a return period of 500 years. The AIJ-RLB 1993 recommends different return periods depending on the type/importance of the structure.

Table 6. Comparison of NSCP 1992 and NSCP 2001 basic wind speeds*

Wind Zone		NSCP-92 fastest km. speed		3-second gust speed, mps		3-second gust speed, kph	
NSCP-92	NSCP-01	V, kph	Equivalent Averaging Time, secs	NSCP-92	NSCP-01	NSCP-92	NSCP-01
I	I	200	18.00	61	70	220	250
II	II	175	20.57	54	55	195	200
III	III	150	24.00	46	35	165	125

* After [Rosaria, 2001]

2.5 *Australian Handbook for Design Wind Speeds in the Philippines (2002)*

A handbook entitled "Design Wind Speeds for the Asia-Pacific Region" (HB 212-2002) and co-authored by Holmes & Weller, was published in 2002 by Standards Australia. The document presents wind zone maps for various countries in the Asia-Pacific region, including the Philippines, that is intended to be compatible with provisions of the AS/NZS 1170-2002 (Part 2: Wind actions). In effect, the handbook combined with the Australian/New Zealand Standard could be considered a recommendation for determining wind loads for wind resistant structural design in the Philippines. And as the handbook states, wind loading in the Philippines could be directly compared with wind loading in Australia, New Zealand, and in other countries in the Asia-Pacific region.

The wind zone map provided by the handbook for the Philippines (Figure 8) recognizes, and shows some similarity to the NSCP 1992 wind zone map, with slight variation based on a "recent re-analysis." The handbook uses four zones for the Philippines (compared to the NSCP's three zones), noting that the basic wind speed given by the NSCP 1992 for Western Mindanao and Palawan maybe conservative. The handbook also seems to show that the wind speeds given in NSCP 1992 are more likely to be 1-minute average speeds, rather than fastest-kilometer speeds. Table 7 shows a comparison of the wind zones of the handbook and the two editions of the NSCP.

Table 7. Comparison of NSCP and HB 212-2002 wind zones

Wind Zone			Philippine Region/Area	3-second gust speed, mps			
NSCP-1992	HB 212-2002*	NSCP-2001		*NSCP-1992**	NSCP-1992**	HB 212-2002*	NSCP-2001**
I	V	I	Eastern Luzon & Eastern Visayas	56	61	60	70
II	IV	II	Rest of the Philippines	49	54	52	55
II	III	II	Eastern Mindanao	49	54	44	55
III	II	III	Western Mindanao & Palawan	42	46	39	35

* After [Holmes & Weller, 2002]. NSCP 1992 values in the column are 1-minute average speed.
** After [Rosaria, 2001]. NSCP 1992 values in the column are equivalent 3-second gust speed.

While the handbook may be updated to reflect the design wind speeds from NSCP 2001, the next edition of the NSCP may be updated to consider that Western Mindanao and Palawan could have lower design wind speeds.

2.6 *A Recent Study by Garciano, et al [2005]*

A study conducted by a group from the Department of Civil Engineering at Musashi Institute of Technology, Tokyo, Japan was published in the JSCE (Japan Society of Civil Engineers) Journal of Structural Mechanics and Earthquake Engineering in April 2005. The paper is entitled "Development of a Regional Map of Extreme Wind Speeds in the Philippines."

The study employed General Extreme Value or point process approach to model the extreme wind speeds in the Philippines on 35 years (1961 to 1995) of monthly maximum wind speeds from 5 stations, and 40 years (1961 to 2000) of daily maximum wind speeds from 45 stations. Additionally, Kriging method was used in mapping to assess spatial correlation of extreme wind speeds using a spherical semivariogram, and allowing for generation of a continuous prediction surface.

The group has proposed a new wind map for the Philippines with 6 zones and using an additional 5 years of data from at least 45 stations over the NSCP 2001 map. A significant highlight of the study includes a generally significant decrease in basic wind speeds (3-second gust speeds at 50-year return period) for all three zones in NSCP 2001, especially in

Zones II and III (low-wind zones). An area where the expected 50-year gust speed exceeds 250 kph or 70 mps is also identified. Additionally, regional boundaries were added for ease in using the map. The group also prepared maps for 30-year and 40-year return periods.

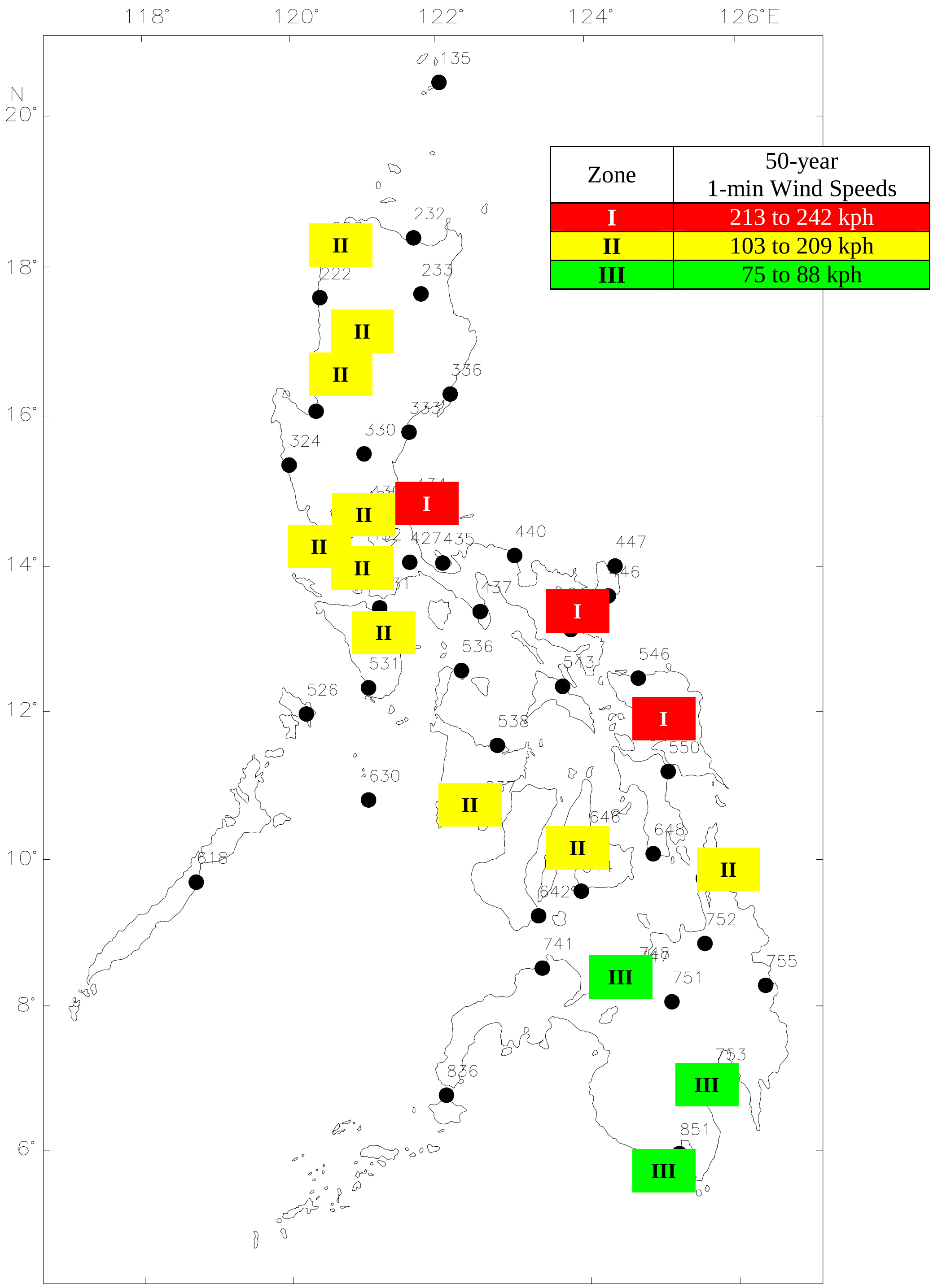


Figure 4. Wind zone from study by Simiu [~1973] on 16 synoptic stations superimposed on present network of synoptic stations.

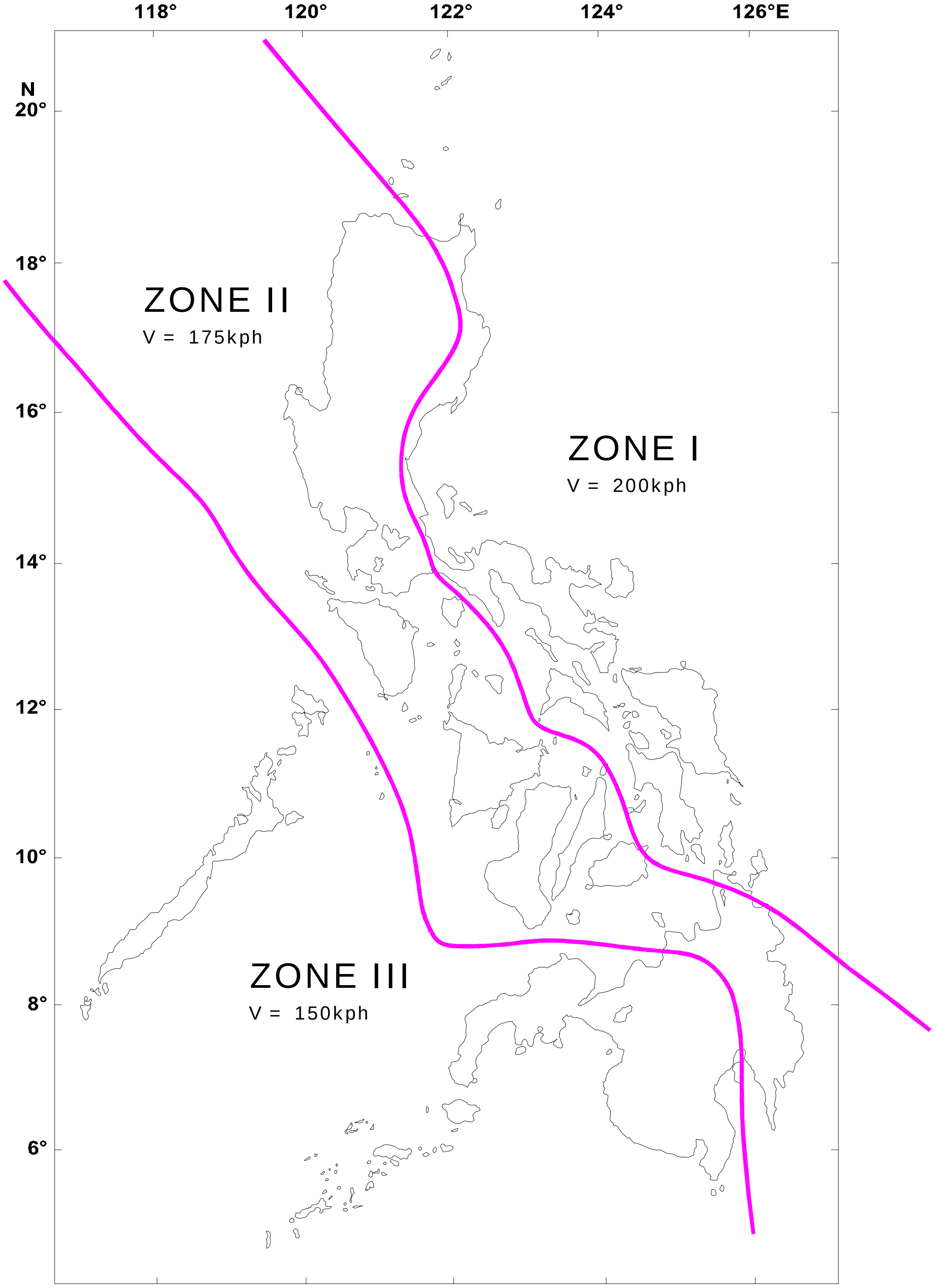


Figure 5. The NSCP 1992 Wind Zone Map adjusted to the same scale as the other maps presented herein
(courtesy of Nicetos Rosaria)

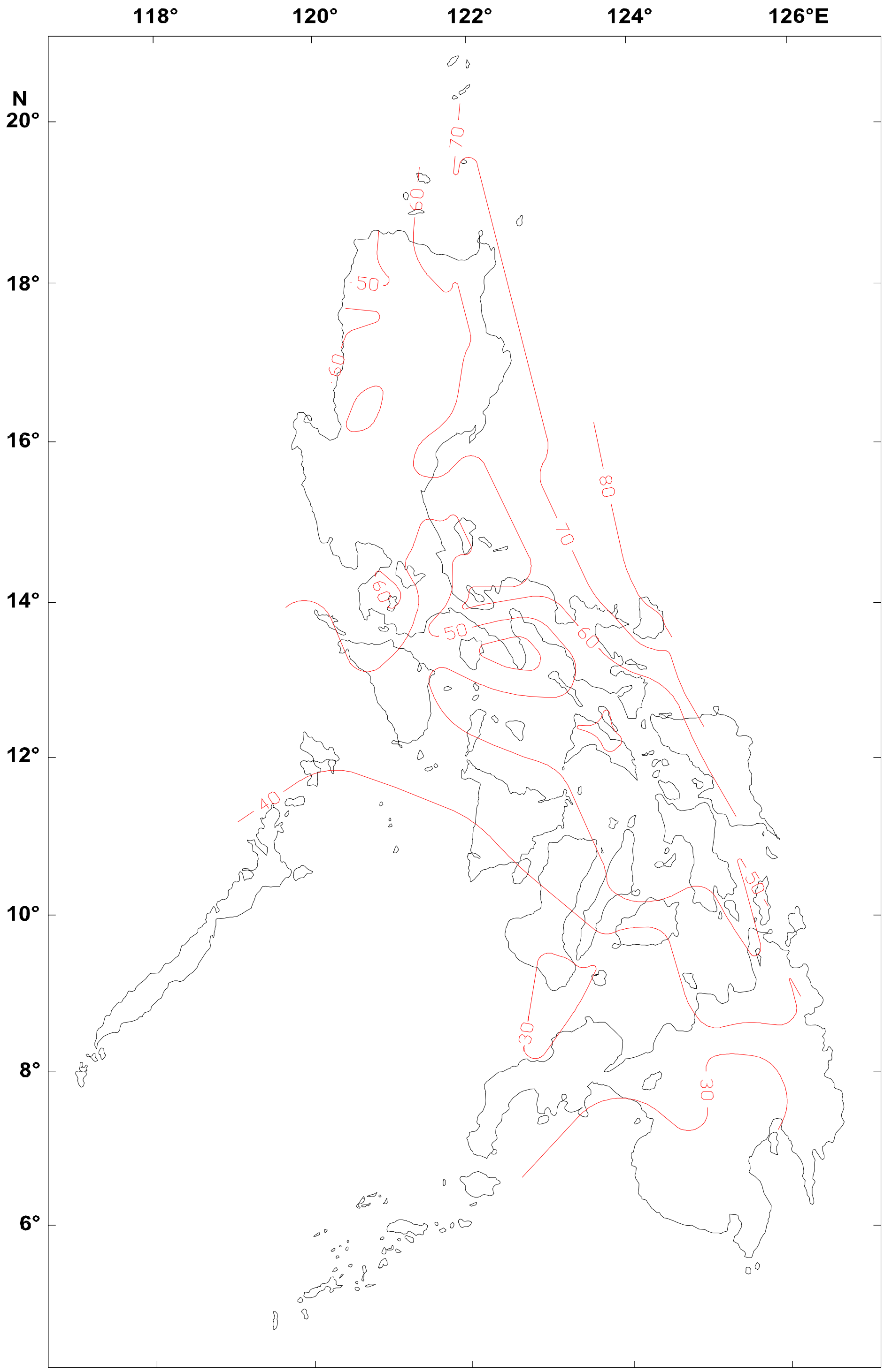


Figure 6a. Wind Contour Map by [Rosaria, 2001]

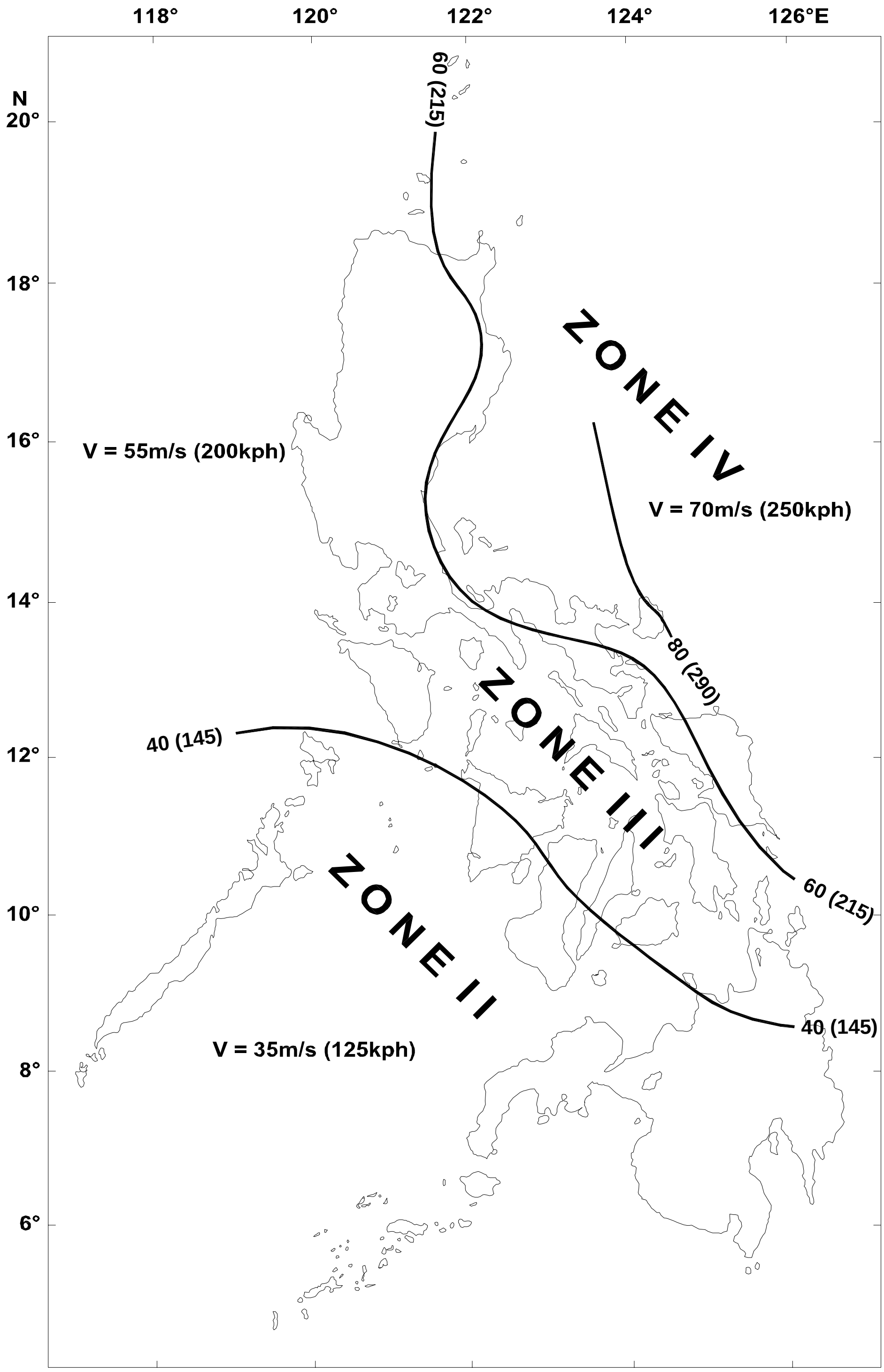


Figure 6b. Wind Zone/Contour Map by [Rosaria, 2001] Proposed for NSCP 2001

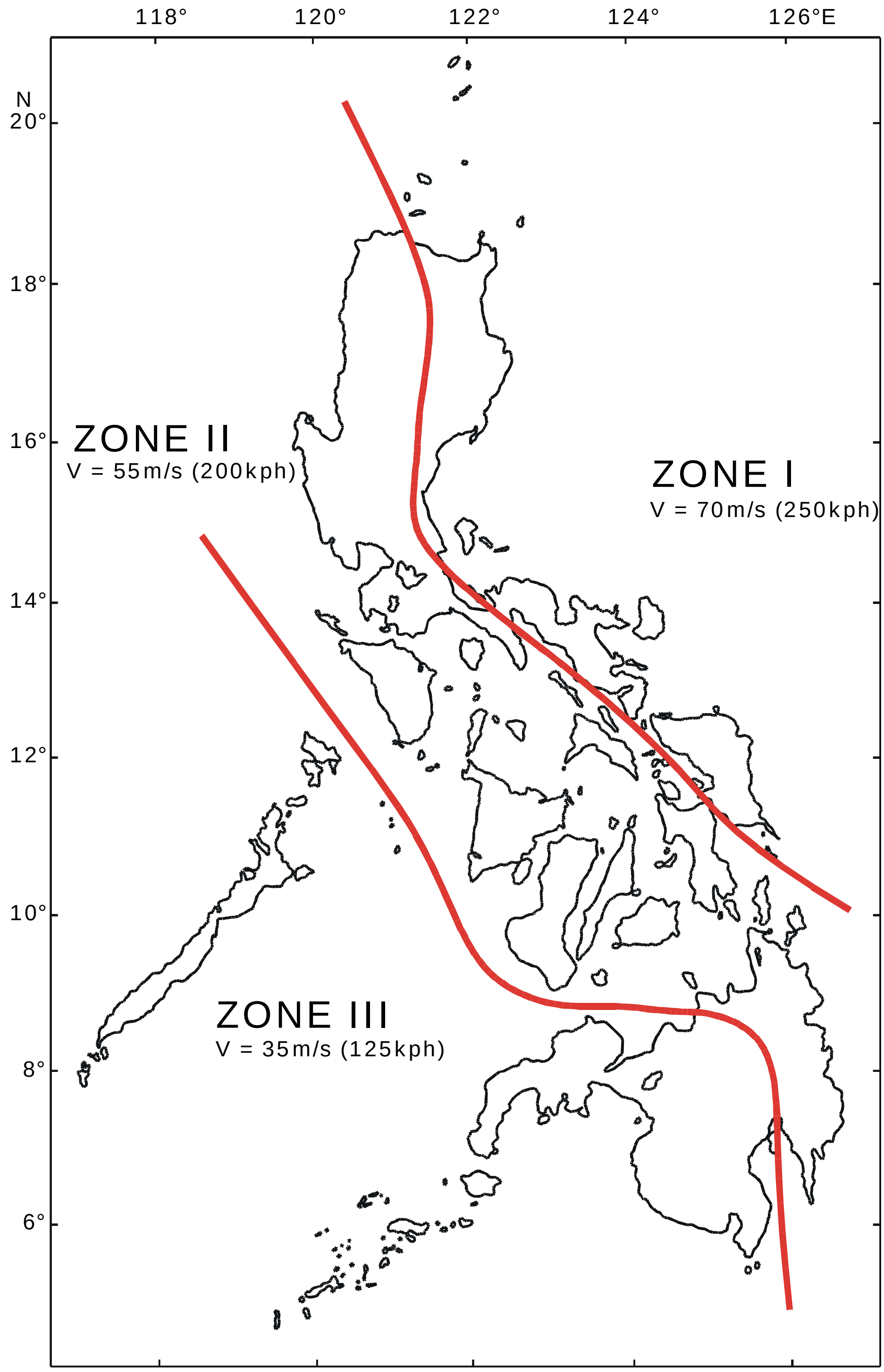


Figure 7. The NSCP 2001 Wind Zone Map [ASEP, 2001]
(courtesy of Nicetos Rosaria)

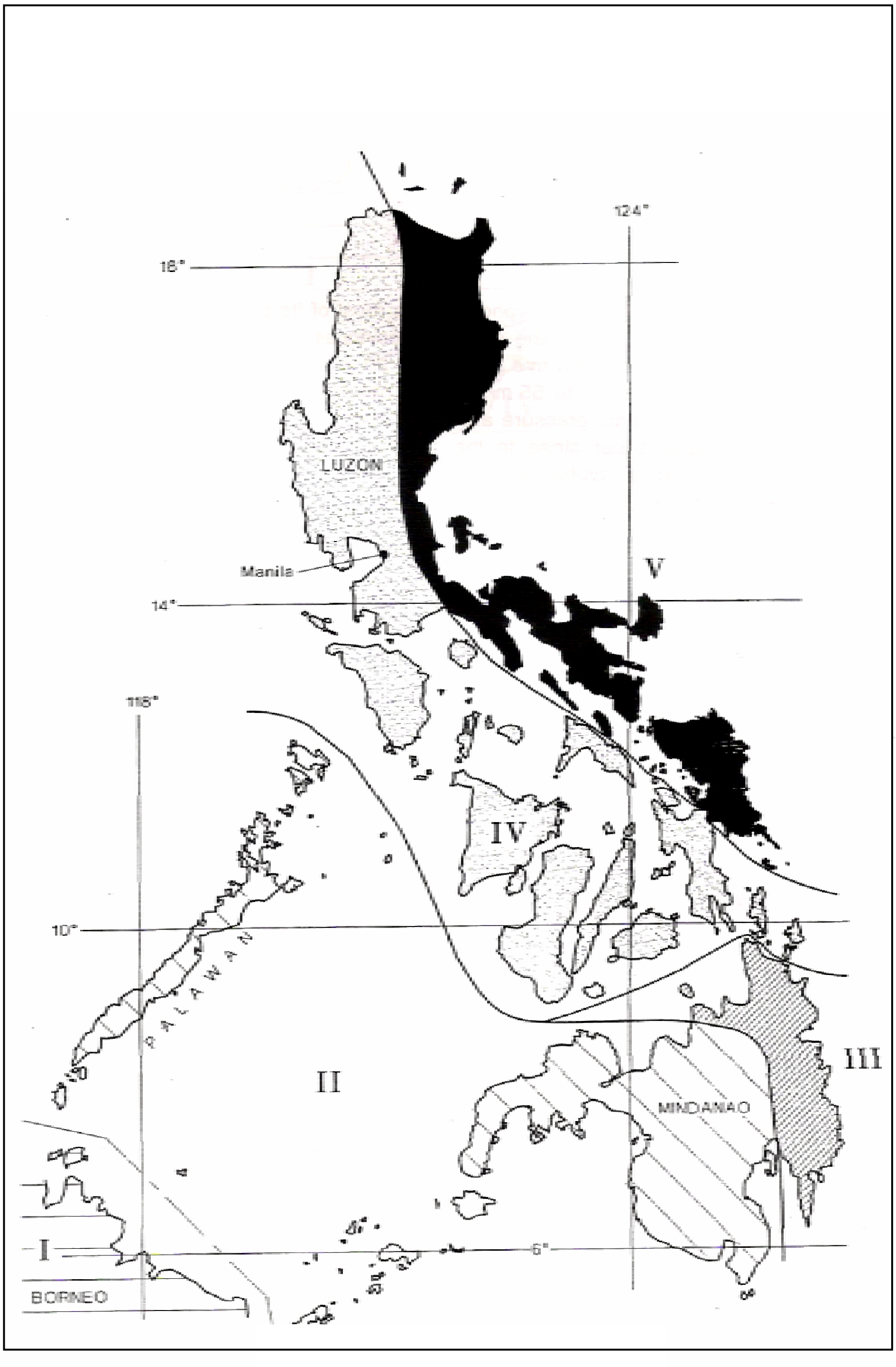


Figure 8. Philippine Wind Zone Map intended to be compatible with AS/NZS 1170
(from Holmes, J.D., and R. Weller (2001), "Design Wind Speeds for the Asia-Pacific Region
(AS/NZS Handbook HB212-2002)," Standards Australia International.)

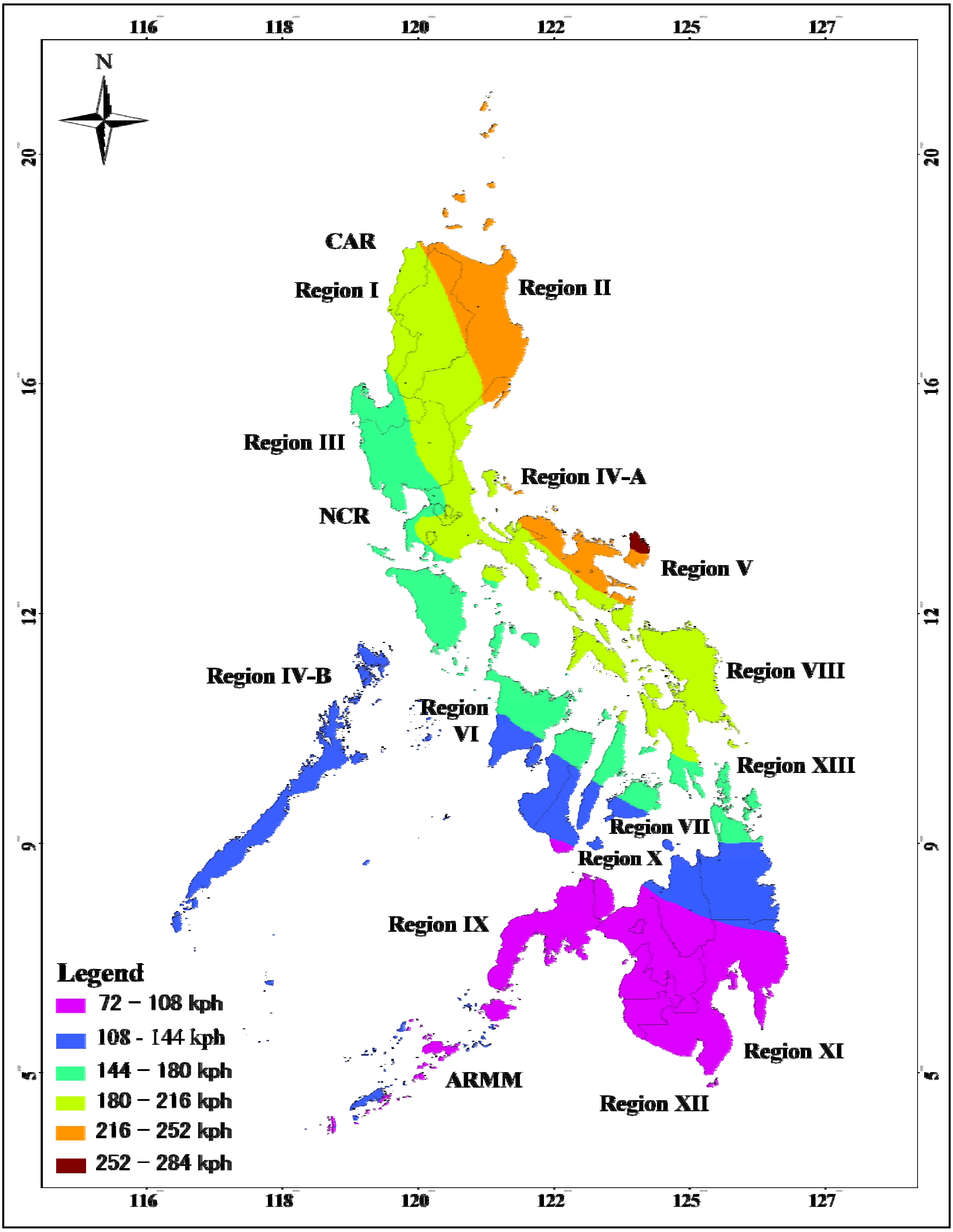


Figure 9. Regional Map of Extreme Wind Speeds in the Philippines proposed by Garciano, et al (2005)

3 WIND SPEED AND DIRECTION DATA FROM PAGASA

The Philippine Atmospheric, Geophysical and Astronomical Services Administration, or PAGASA for short, is a service institution of the Department of Science and Technology (DOST) of the Philippine government and member of the World Meteorological Organization (WMO). PAGASA, and specifically its Climatology and Agrometeorology Branch (PAGASA-CAB) is envisioning itself to be the center of excellence in meteorology (among other competencies in related sciences) in the Philippines, providing world-class capabilities in monitoring, analysis, forecasting and warning of tropical weather systems such as typhoons. PAGASA primarily complies with WMO requirements, and the PAGASA "Manual of Synoptic Surface Observations (MASSO)" along with other documents could be reviewed to show such compliance.

3.1 *Profile of PAGASA Synoptic Stations*

Synoptic stations are basically where observation of all meteorological elements is made at fixed observation times (every 3 hours starting at 08:00 Philippine standard time). PAGASA synoptic stations have aerovanes and anemographs for observation of wind direction and speed. [PAGASA, 2004] Assigned weather observers manually record what could be considered a 10-minute average wind speed and corresponding direction, as well as gust speed defined by: (a) three or more marked positive peaks exceeding 8 mps; (b) 5 mps or larger variation in speed between peaks and lull or negative gust; and (c) 20 seconds or less average time interval between peak and lull. (as cited by [Rosaria, 2001], and [Garciano et al, 2005])

In 2004, the PAGASA-CAB published a report entitled "Station Profile," which documents PAGASA's initiatives in maintaining a Philippines-wide basic synoptic network and other observational network of stations for international, regional, and national exchange of data. Different types of stations and observations are described, as well as times of observations, and instrumentation. The report presents a map showing the network of PAGASA synoptic stations, as well as a list detailing the station ID, station name and political location, latitude and longitude, altitude and altitude correction, relevant years with records, and assigned weather observing personnel. The "Station Profile" is available for purchase (approx. 1,000 JPY as of April 2005) at the Climate Data Section of PAGASA (PAGASA-CDS).

Figure 10 shows 50 PAGASA synoptic stations used by both Rosaria [2001] and Garciano et al [2005] in their analyses. All of these stations have data from as early as 1961. Some stations have data from as early as 1951 (or 1948, as the study by Rellen et al [2002] suggests), although the very first stations were set up in 1902. There are around 6 other stations that are not included in Figure 10 nor in the two studies mentioned, for which the earliest data were later than 1961. Some stations started collecting data as early as 1951 but have been closed or non-operational as early as in 1970.

However, as Rosaria & Pacheco [2002] have noted, the actual terrain exposure, surrounding roughness factor and other obstructions, and equipment at the stations have not been verified.

3.2 *Raw data files: the "MMWS" Monthly Data & "DMCD" Daily Data*

Available from the Climate Data Section of PAGASA as well are two types of raw data files: the "Monthly Maximum Wind Speed and Direction" (MMWS) data file, and the "Daily and Monthly Climatic Data" (DMCD) data file. See Figures 11 and 12 for sample printouts of these two data files.

The MMWS for a station tabulates the maximum gust speed per month and corresponding direction for specified years. The MMWS is available for purchase from the PAGASA-CDS (approx. 20 JPY per year per station as of April 2005). To request for a MMWS data file, simply specify for which station and which years of data to include. Rosaria [2001] validated the data in the MMWS against the data in the (more detailed) DMCD and used MMWS data in his statistical analysis. Garciano et al [2005] used MMWS data for 5 stations in their study.

The DMCD for a station is a tabulation of the daily recorded values of various climate indicators including (daily maximum) "10-minute average" wind speed and corresponding direction, and (daily maximum) gust speed and corresponding time and direction. One DMCD file contains data for all days (365 or 366 days) of one year for one station. The DMCD is available for purchase from the PAGASA-CDS (approx. 1,200 JPY per station per year as of April 2005). To request for a DMCD data file, simply specify for which station and which year. Garciano et al [2005] used DMCD data for 45 stations in their study.

3.3 *Wind-Rose Analyses*

There has been considerable development in recent years on the use of wind direction data for computing wind loads. The AIJ-RLB 2004 perhaps is a good model code which uses statistics of actual wind direction data (meteorological data during typhoon passage) and a typhoon simulation technique to come up with a wind directionality factor.

While the MMWS and DMCD tabulate the corresponding direction for recorded maximum gust speeds, PAGASA-CAB generates Wind-Rose Analyses for specified stations using 10 or 30 years of data. A Wind-Rose Analysis report for a certain station is available for purchase from the PAGASA-CDS (around 2,400 JPY per station for 30-years data, and around 1,000 JPY per station for 10-years data). However, the format of the wind-rose analysis report may not be directly useable for engineering purposes, and it may also not be directly compatible for use with the AIJ-RLB 2004 recommendations, aside from the fact that the AIJ-RLB combines the meteorological data with "virtual" or simulated data. The wind-rose analysis also provides the information as percentage of the time that the wind occurs in a given direction, and not corresponding wind speed for that direction. Perhaps, it could also be assumed that the return period for such percentages of occurrence is the same as the number of years of data that was included in the program (e.g. 30-year or 10-year return period).

3.4 *Climatological Normals and Climatological Extremes*

The PAGASA-CAB also prepares reports called "Climatological Extremes" and "Climatological Normals" as of a certain year, which simply presents recorded extreme and average conditions (extreme and average values of climate indicators such as maximum gust speed for a given month) for each of the stations respectively. While the document is useful for indicating recorded maximum (gust) or average wind speeds and the like and for defining extreme climate conditions in the Philippines for comparison with those recorded in other areas, it is not necessarily formatted for immediate engineering use. The "Climatological Normals" publication also includes prevailing wind velocity maps such as shown in Figures 13 and 14. The documents also show that the highest recorded gust speed is reported to be 77 mps, and an average wind speed below 10 mps. The reports are available for purchase at the PAGASA-CDS (approx. around 1,000 JPY for one copy).

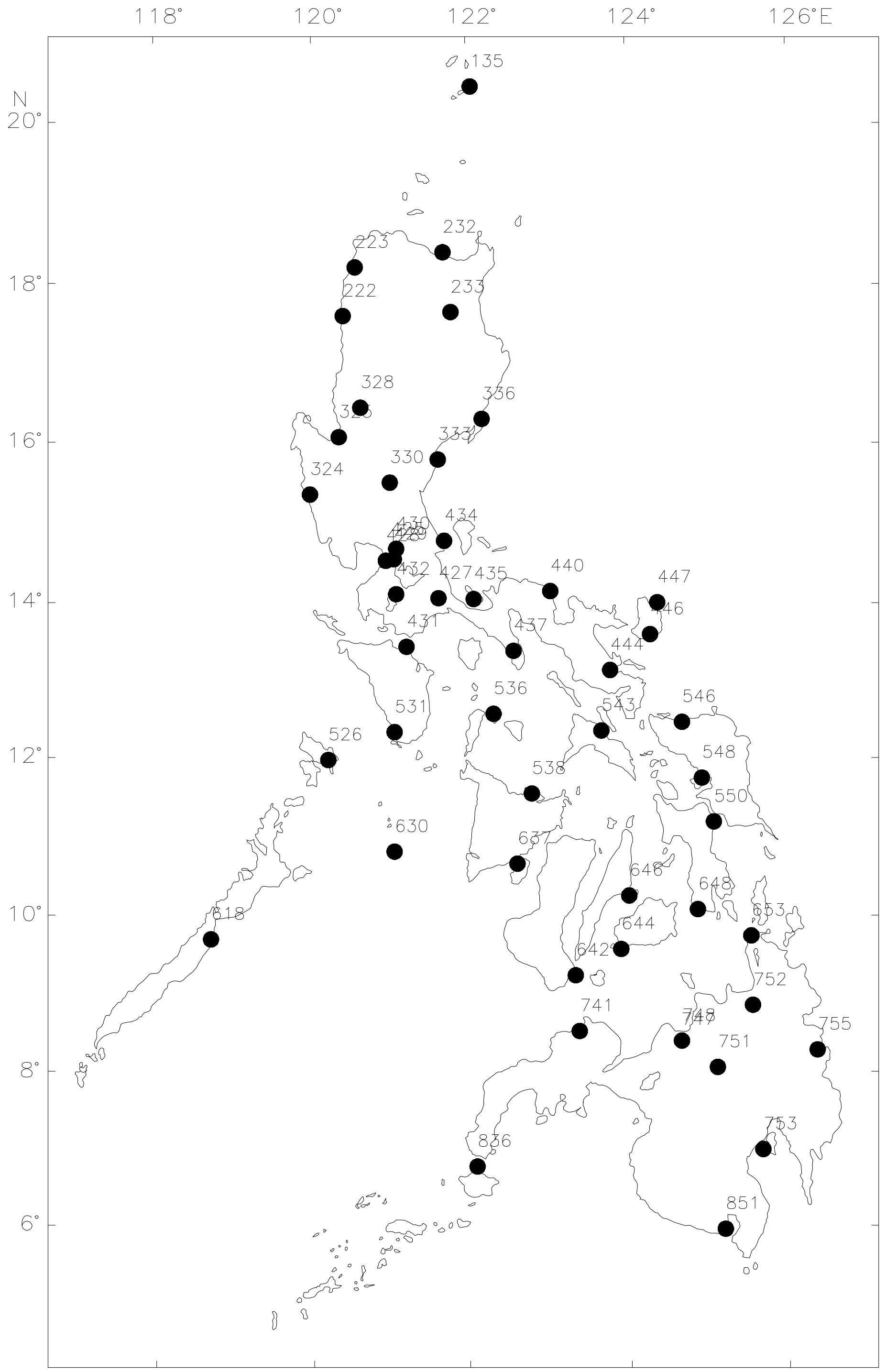


Figure 10. PAGASA synoptic stations used in the Rosaria [2001] and Garciano et al [2005] studies. Numbers indicate PAGASA station ID.

MONTHLY MAXIMUM WIND SPEED AND DIRECTION

STATION:DAET, CAMARINES NORTE
CMO :ANDY MOLINA
PERIOD :1996-2004

LATITUDE :14ø07' N
LONGITUDE:122ø59 E
ELEVATION: 4.0 M

YEAR/MON	JAN	FEB	MAR	APR	MAY	JUN
	SPD/DIR/TIME/DA	SPD/DIR/TIME/DA	SPD/DIR/TIME/DA	SPD/DIR/TIME/DA	SPD/DIR/TIME/DA	SPD/DIR/TIME/DA
1996	14/NE /1145/ 8	20/NE /1450/ 2	16/NE / 900/ 2	13/NE /1500/11	17/NW /1010/14	14/SE /1800/17
1997	15/NE / 0/ 9	13/E /2100/24	15/NNE/ 900/ 5	9/E / 0/ 1	10/WSW/ 600/30	17/S / 330/26
1998	14/E /1200/27	10/NE /1500/ 8	12/E /1200/29	10/E /1200/ 3	11/SW / 600/27	10/SE /1500/26
1999	16/E / 0/10	18/NE / 300/ 4	22/E /2330/28	9/N / 600/24	8/SE /1200/20	15/SSW/ 300/ 6
2000	17/E / 0/22	18/NE / 624/ 8	14/N /2100/19	8/NE / 600/ 2	10/SW / 300/19	9/S / 600/16
2001	14/NE /1500/17	14/ENE/ 900/18	15/ENE/1800/ 4	10/N /1200/23	9/SW / 600/28	11/SW / 300/19
2002	14/NE /2100/ 2	12/NE /1800/20	14/NE /1500/ 8	-20/-20/ -20/-2	9/W / 600/21	9/SW / 300/ 3
2003	15/ENE/2100/ 5	10/NE /1500/ 3	12/E /2100/25	10/SE /1800/27	14/SW / 300/27	13/SW / 600/ 2
2004	16/ENE/1500/25	12/N / 252/26	20/NE /2058/ 7	24/N /2046/16	24/N /2046/16	22/W / 639/29
MAX-	17/E / 0/22	20/NE /1450/ 2	22/E /2330/28	24/N /2046/16	24/N /2046/16	22/W / 639/29
	2000	1996	1999	2004	2004	2004
KPH-	61	71	79	86	86	79

Note: -20/-20/-2 means missing data

Page 1 of 2

Figure 11. Sample printout page of "Monthly Maximum Wind Speed and Direction" from PAGASA.

DAILY AND MONTHLY CLIMATIC DATA

STATION: DAET, CAMARINES NORTE — LAT : 14ø07 N — ELEVATION : 4.0 M
DATE : 2004 JANUARY — LONG: 122ø59 E — ALT. CORRECTION : .5

DAY	TEMPERATURE MAX (øC)	MIN (øC)	MEAN (øC)	DRY BULB (øC)	WET BULB (øC)	DEW PT (øC)	RH %	VP (mbs)	STN. PRESS. (mbs)	MSLP (mbs)	RAIN-FALL AMOUNT (mm)	CLD (okt)	SUN DUR (min)	WINDS PREV DIR 16pt	AVE SPD mps	GUSTINESS SPD mps	DIR 16pts	TIME gmt	TS (code)	LTG (code)
1	28.4	23.0	25.7	25.8	23.5	22.6	82	27.4	1013.0	1013.5	7.7	6	-20	NE	4	--	--	--	0	0
2	28.7	23.5	26.1	25.4	24.0	23.4	89	28.9	1012.0	1012.5	9.2	5	-20	E	3	--	--	--	0	0
3	28.2	23.5	25.9	25.0	23.9	23.4	91	29.0	1013.4	1013.9	7.9	8	-20	E	4	12	E	0600	0	0
4	28.9	23.5	26.2	26.7	24.0	22.9	80	28.1	1014.1	1014.6	1.8	6	-20	NE	4	--	--	--	0	0
5	28.6	24.3	26.5	26.0	24.8	24.3	91	30.5	1014.0	1014.5	15.8	7	-20	E	3	--	--	--	0	0
6	29.2	23.6	26.4	25.8	24.8	24.4	92	30.7	1013.6	1014.1	10.7	6	-20	E	4	--	--	--	0	0
7	26.2	24.3	25.3	25.1	24.2	23.8	93	29.6	1015.4	1015.9	29.7	7	-20	ENE	3	8	ENE	1500	0	0
8	29.3	25.0	27.1	26.4	24.0	23.1	82	28.3	1017.1	1017.6	2.3	5	-20	E	4	--	--	--	0	0
9	28.9	23.0	26.0	26.3	23.9	22.9	82	28.1	1016.4	1016.9	3.5	7	-20	E	5	9	E	1500	0	0
10	30.5	24.7	27.6	26.6	23.7	22.6	78	27.4	1015.0	1015.5	-1.0	6	-20	E	4	--	--	--	0	0
11	29.9	24.3	27.1	26.9	24.7	23.9	83	29.7	1014.2	1014.7	.0	7	-20	E	4	--	--	--	0	0
12	30.0	25.0	27.5	26.9	24.4	23.4	81	28.9	1013.4	1013.9	-1.0	5	-20	E	3	--	--	--	0	0
13	29.2	23.3	26.3	26.4	23.8	22.8	80	27.8	1010.4	1010.9	.0	3	-20	E	3	--	--	--	0	0
14	29.2	21.2	25.2	25.4	23.2	22.3	83	27.0	1012.6	1013.1	.0	3	-20	E	2	--	--	--	0	0
15	28.3	22.4	25.3	25.6	23.9	23.2	87	28.6	1013.1	1013.6	2.3	5	-20	E	2	--	--	--	0	0
16	30.0	25.2	27.6	26.8	25.4	24.8	89	31.5	1012.1	1012.6	1.3	6	-20	E	3	--	--	--	0	0
17	28.9	24.6	26.8	26.6	24.8	24.1	86	30.1	1011.8	1012.3	1.3	8	-20	NNE	4	--	--	--	0	0
18	27.8	24.7	26.3	26.2	24.8	24.2	89	30.4	1011.1	1011.6	7.7	7	-20	E	2	--	--	--	0	0
19	28.9	24.8	26.8	25.6	24.5	24.0	91	30.0	1010.9	1011.4	2.3	6	-20	E	3	--	--	--	1	0
20	28.4	23.5	26.0	25.4	24.4	24.0	92	29.9	1011.3	1011.8	7.2	7	-20	E	3	--	--	--	0	0
21	28.3	24.6	26.5	26.0	24.2	23.5	86	29.0	1011.9	1012.4	.3	7	-20	NE	3	10	ENE	2100	0	0
22	27.8	24.7	26.3	26.2	23.7	22.7	81	27.7	1012.6	1013.1	1.3	7	-20	E	5	--	--	--	0	0
23	30.6	24.0	27.3	27.0	24.9	24.1	84	30.1	1011.8	1012.3	.0	7	-20	E	3	--	--	--	0	0
24	27.5	22.5	25.0	25.8	24.1	23.4	87	28.9	1012.0	1012.5	4.4	8	-20	NE	6	13	NE	1200	0	0
25	26.7	22.1	24.4	24.0	22.1	21.2	85	25.4	1013.8	1014.3	6.4	8	-20	NE	8	16	ENE	1500	0	0
26	25.6	22.5	24.0	23.1	22.1	21.6	92	26.0	1013.7	1014.2	12.0	8	-20	NE	6	12	NE	0900	0	0
27	27.8	24.0	25.9	25.9	23.6	22.7	82	27.6	1011.6	1012.1	-1.0	8	-20	E	5	--	--	--	0	0
28	27.8	23.0	25.4	25.1	23.5	22.8	87	27.9	1011.1	1011.6	3.6	8	-20	E	6	9	E	1500	0	0
29	28.9	22.2	25.5	26.4	24.4	23.6	85	29.3	1011.0	1011.5	.0	3	-20	E	2	--	--	--	0	0
30	28.9	23.4	26.1	26.0	24.0	23.2	85	28.5	1011.7	1012.2	.0	7	-20	NE	3	--	--	--	0	0
31	29.8	25.8	27.8	27.1	24.8	23.9	83	29.8	1011.8	1012.3	.0	7	-20	E	4	--	--	--	0	0
MEAN :	28.6	23.7	26.1	25.9	24.0	23.3	86	28.8	1012.8	1013.3	138.7	6	-20	E	4	16	ENE	1500	1	0
NORMAL :	28.2	22.5	25.4	25.1	22.9	22.0	83	26.4	1013.0	1013.5	265.8	6		NE	4				0	0
STD.DEV:	1.1	1.1	.9	.9	.7	.8	4.2	1.4	1.6	1.6	6.3	1.5			1.4					

T E M P E R A T U R E

HIGHEST:30.6øC DAY:23 — LOWEST :21.2øC DAY:14 — DAYS WITH 35.0 øC OR MORE : 0 — DAYS WITH 20.0 øC OR LESS : 0

R A I N F A L L

DECADE 1: 88.6
DECADE 2: 22.1
DECADE 3: 28.0
TOTAL : 138.7

NO OF RAINY DAYS: 21
GREATEST 24-HR RR: 29.7
DAY: 7

DAYS WITH 1.0 MM OR MORE : 20
5.0 MM OR MORE : 10
10.0 MM OR MORE : 4
25.0 MM OR MORE : 1

C L O U D S

NO.OF CLEAR DAYS(0)- - : 0 — PARTLY CLOUDY DAYS(1-4): 3 — CLOUDY DAYS(5-7): 21 — OVERCAST(8)- - -: 7

** NOTE: -2.0/-20 : Means Missing or Instrument Defective. — -1.0 : Measured rainfall is less than 0.1 mm
1 : Occurrence of thunderstorm or lightning — 0 : No occurrence of thunderstorm or lightning

Figure 12. Sample printout page of “Daily and Monthly Climatic Data” from PAGASA

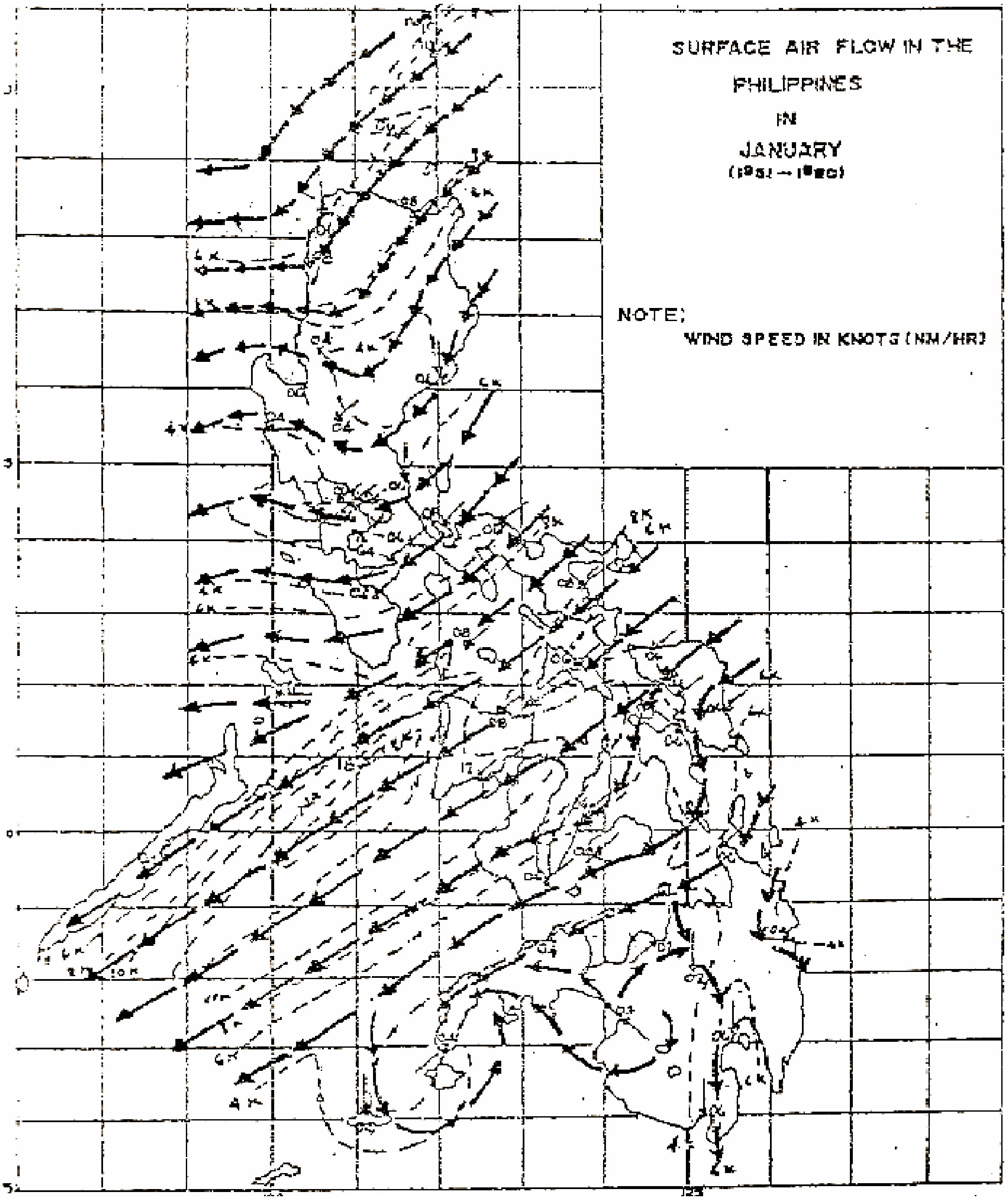


Figure 13. Prevailing Wind Velocity Map for January (1951-1980)

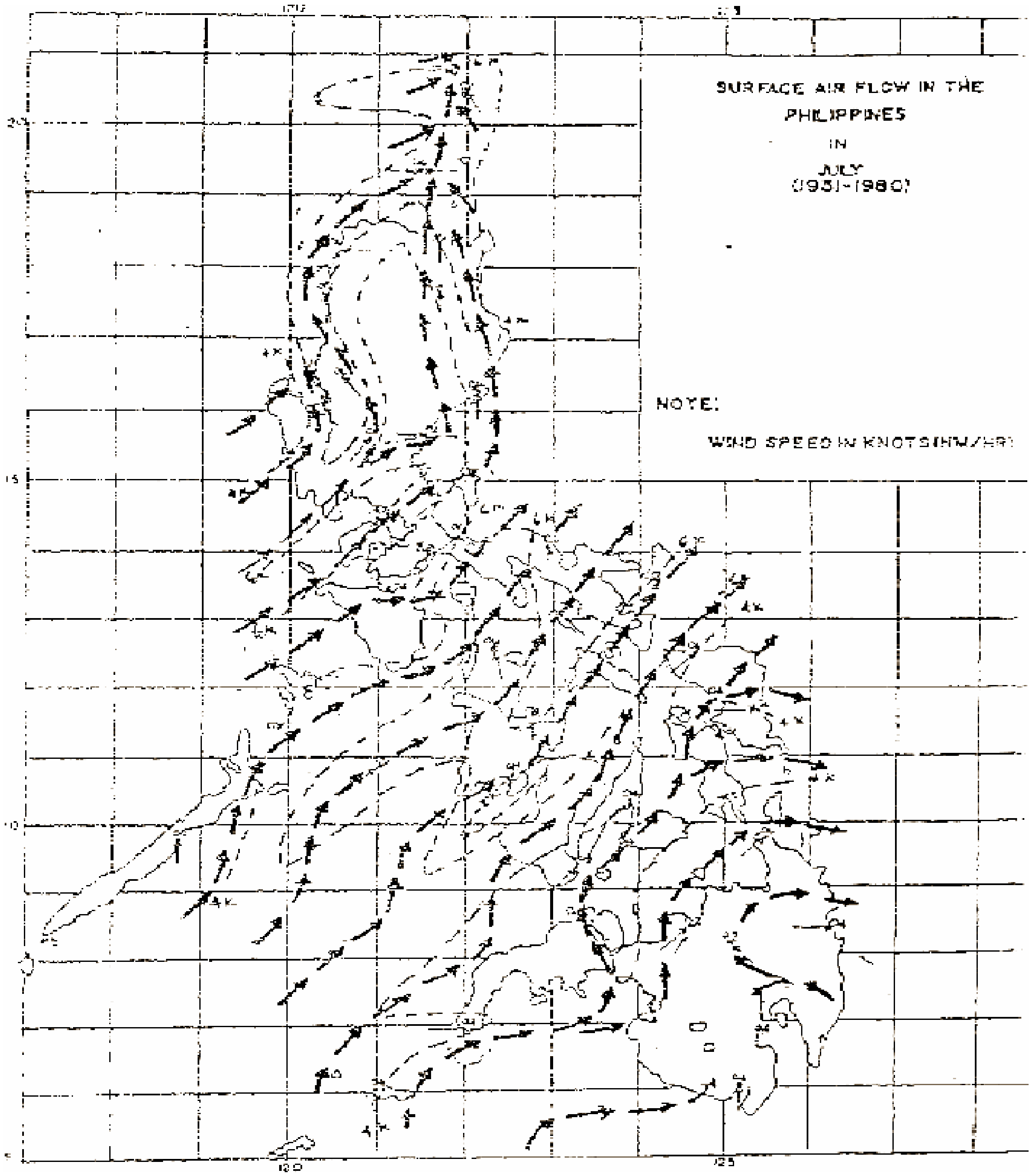


Figure 14. Prevailing wind velocity map in July (1951-1980)

3.5 *An Extreme Wind Hazard Map from PAGASA-NDRB*

One of the branches of PAGASA is the Natural Disaster Reduction Branch (PAGASA-NDRB). Among one of the activities of the PAGASA-NDRB is the preparation of technical reports which cover a variety of topics from hazard mitigation to social sciences, for a variety of usually typhoon-related natural disasters. (See next Section 3.6.)

In 2002, PAGASA-NDRB released a technical report, Technical Report No. 111 entitled "Extreme Wind Hazard Mapping in the Philippines." The study used 49 years (1948-1996) of data from 56 synoptic stations, with some stations with less number of years of data, although seemingly subjected only to a simple statistical analysis of obtaining maximum recorded values of gust speed (Figure 15), and generated an annual wind hazard map (Figure 16) although without any explicit indication of a return period. Perhaps it could be assumed that the return period for this map is 1 year. The contour shapes of the generated annual wind hazard map show some difference from those in the contour map by Rosaria [2001] or from the zone map by Garciano et al [2005]. It is also noticeable that wind speed values in the wind hazard map are generally lower than those in the maps by Rosaria or by Garciano et al, which could be attributed to a shorter return period.

The study has grouped locations according to maximum recorded wind speed: (a) moderately extreme winds (60 – 100 kph), (b) extreme winds (101 – 184 kph), and (c) severely extreme winds (> 185 kph). These groups actually correspond to typhoon warning signals of PAGASA (See Chapter 5 for more details).

The study also actually generated monthly wind hazard maps which could be just as helpful as the annual map for disaster planners and coordinating organizations; as well as describing seasonal trends. During the Northeast Monsoon Season from December to March, very strong (severely extreme) winds during typhoons are experienced and damage is severe in directly hit areas. In contrast, during the Southwest Monsoon Season from June to September, there are more tropical cyclone occurrences and generally most of the country experiences strong (extreme) winds. Periods from April to May and from October to November are called transition periods. [Rellin et al 2002, after Francisco et al, 1983]

The report could actually be considered only as a historical account of maximum recorded gust speeds, nonetheless it provides an insight into the wind climate in the country, and in its conclusion, it gives quite a good list of recommendations including one concern on non-engineered structures such as a majority of residential dwellings, and one recommendation on imposing a study of basic meteorology for architects and engineers. The study also cites that the Department of Social Welfare and Development (DSWD), a government agency, has a recommended "Typhoon Resistant Housing" design for low-income families.

3.6 *Other PAGASA Research Studies Related to Tropical Cyclone Winds*

Tables 8 & 9 lists some research studies related to tropical cyclones conducted by the Atmospheric Geophysical & Space Sciences Branch also of PAGASA (PAGASA-AGSSB) and by the PAGASA-NDRB respectively.

STATION	MONTH											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Itbayat	65	65	68	68	83	130	205	173	161	216	90	79
Basco	130	90	108	94	158	166	224	212	216	155	94	-
Vigan	65	68	65	94	90	130	216	122	158	151	94	126
Laoag	65	79	65	90	76	108	148	144	137	126	108	148
Aparri	94	108	90	122	79	198	180	161	180	209	191	90
Tuguegarao	76	90	83	169	144	140	140	144	205	176	130	94
Iba	65	58	58	87	148	169	130	104	108	144	118	65
Dagupan	58	65	68	83	96	87	118	126	83	202	148	68
Baguio	72	54	62	90	96	126	169	112	139	148	148	76
Munoz	54	54	72	72	76	90	104	126	58	158	209	87
Cabanatuan	79	90	101	72	79	90	126	108	65	158	158	87
Baler	54	43	-	-	65	36	90	54	76	54	-	31
Casiguran	112	65	54	65	108	130	194	234	270	216	161	101
Port Area	65	90	96	87	126	169	112	122	122	148	202	148
Tayabas	58	76	54	47	83	205	130	54	94	94	101	144
Sangley	51	54	54	58	96	130	101	108	115	161	176	79
NAIA	72	72	94	72	112	169	130	108	122	148	202	90
Sc. Garden	87	79	94	94	144	133	130	108	108	108	180	58
Calapan	72	54	51	51	108	83	130	166	144	133	158	126
Ambulong	72	87	79	65	289	144	270	144	194	152	161	194
Infanta	58	72	72	51	79	104	76	54	72	144	191	83
Alabat	54	65	54	43	115	79	216	79	90	289	248	79
Daet	68	65	83	65	87	90	72	94	96	234	248	173
Legaspi	115	94	65	76	148	205	104	148	104	176	234	130
Virac synop	94	224	79	83	108	130	112	112	169	277	198	133
Virac Radar	112	234	94	101	144	148	133	104	194	270	277	202
Coron	79	58	97	58	65	43	51	62	65	76	144	115
San Jose	68	90	79	68	108	83	94	90	128	101	118	118
Romblon	83	68	62	184	118	148	224	126	122	118	158	140
Roxas	94	72	90	79	130	81	94	83	79	83	176	108
Masbate	76	96	58	126	90	94	115	216	79	216	198	270
Catarman	79	94	65	144	104	76	108	155	79	101	194	169
Catbalogan	72	65	87	94	94	76	122	108	76	108	184	148
Tacloban	104	72	58	191	191	96	108	79	68	115	169	155
Guian	94	108	79	133	87	79	90	87	94	101	216	122
Prto.	68	65	65	47	51	65	54	58	65	83	176	87
Cuyo	90	76	76	72	72	96	83	79	101	101	101	76
Iloilo	76	87	79	90	72	94	90	90	72	130	161	122
Dumaguete	79	87	68	62	54	72	65	72	68	76	90	65
Tagbilaran	58	58	79	72	72	79	90	58	104	72	130	76
Mactan	108	79	90	108	72	65	65	90	173	90	198	151
Surigao	90	72	104	126	130	79	112	90	216	108	166	202
Dipolog	58	62	54	58	51	94	72	94	65	79	54	47
Cotabato	68	58	65	65	87	79	94	101	83	68	101	101
Lumbia	43	51	47	72	51	65	68	65	87	62	65	51
Cag. De Oro	51	47	108	108	133	51	79	65	94	43	43	43
Malaybalay	79	68	51	76	65	65	54	79	65	72	68	51
Butuan	65	65	65	79	61	79	79	108	108	87	68	65
Davao	79	65	54	65	112	76	58	54	72	58	54	54
Hinatuan	112	54	130	62	72	65	65	54	76	65	65	76
Zamboanga	79	58	62	51	72	76	72	83	79	83	79	65
Gen. Santos	72	58	65	68	51	62	62	62	65	62	54	51
Maasin	58	90	72	173	58	65	65	-	180	-	151	112

Legend:

60 - 100 KpH (Moderately Extreme Wind Speeds
101 - 184 KpH (Extreme Wind Speeds)
> 185 KpH (Severely Extreme Wind Speeds)

Figure 15. Maximum Wind (kph) Data in the Philippines (1948-1996)
(by Rellen et al, ~2002)

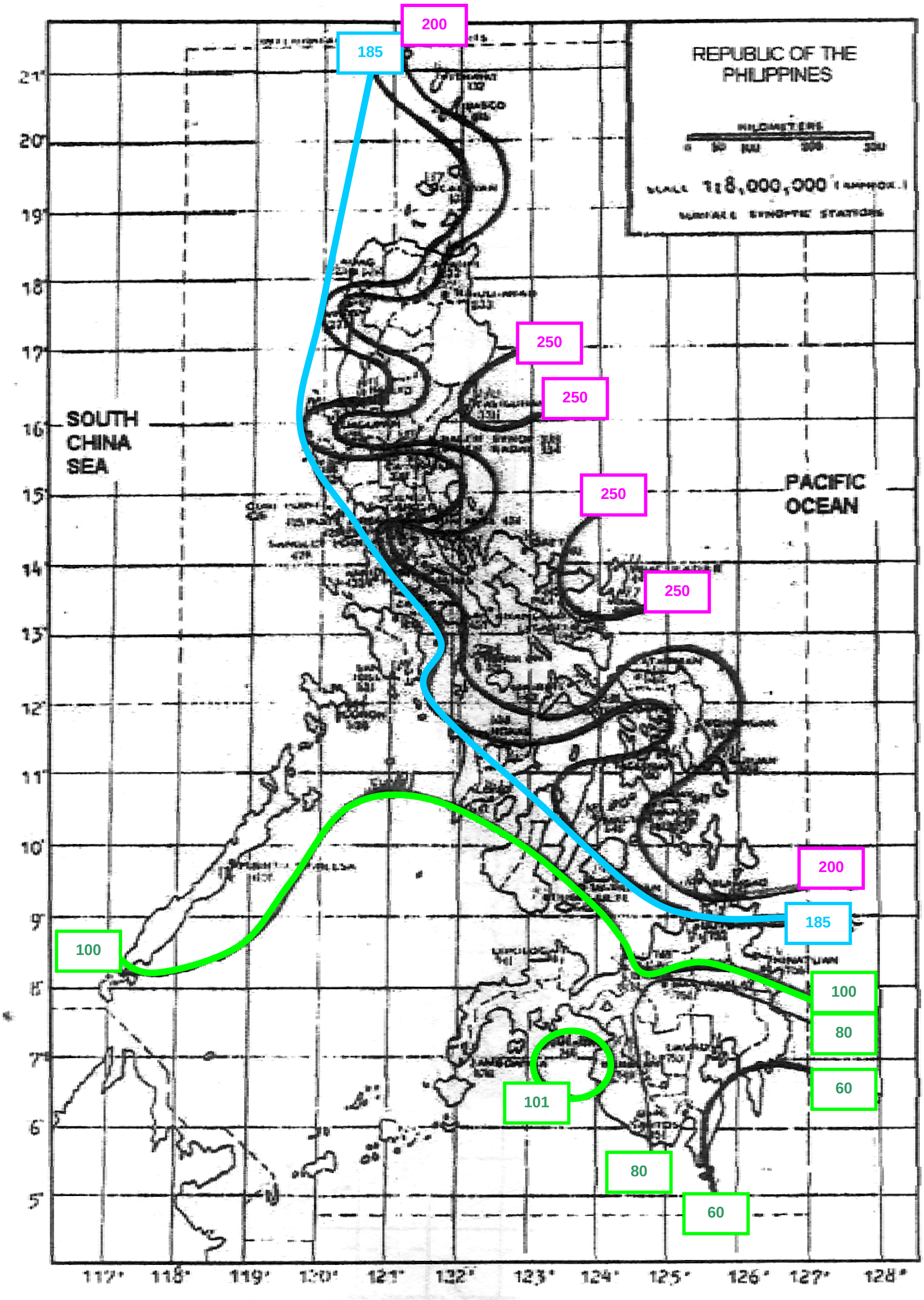


Figure 16. Annual Extreme Wind Hazard Map by PAGASA-NDRB (Rellen et al, ~2002); colored lines by the author

Table 8. Some Research Studies by PAGASA-AGSSB Related to Tropical Cyclone Winds
(http://www.pagasa.dost.gov.ph/researchAGSSB.html)

Year	Title of Research Study
Research on Tropical Cyclone Variations	
2003	A Study Of Tropical Cyclone Activity Over Northwest Pacific Before, During And After The 1997-1998 El Niño Episode
1990	Variations Of Tropical Cyclones In The Western North Pacific
1989	Long Period Variations Of Tropical Cyclones In The Western North Pacific
Research on Air Pollution	
1976	Air Pollution Model For Metropolitan Manila Area Using The Gaussian Distribution
Miscellaneous Research Related to Wind	
2004	Simulation Of Sea And Mountain Breezes Over Metro Manila
1970	An Analysis Of The Relationship Between The Position Of The Major Wind Discontinuity And The Position Of Areas Of Rainfall Over The Philippines
Research on Storm Surges	
2000	Analysis Of Storm Surge Potential Of Various Landfalling Tropical Cyclones
1999	Storm Surge Prediction For Leyte Gulf Area
1994	Numerical Model For Storm Surge Prediction Incorporating Overland Flooding
1985	Storm Surge Numerical Model For Manila Bay
1984	One Dimensional Numerical Model For Storm Surge Prediction
1978	Storm Surge Potentials Of Selected Philippine Coastal Basins

Table 9. Some Research Studies by PAGASA-NDRB Related to Tropical Cyclone Winds
(http://www.pagasa.dost.gov.ph/researchNDRB.html)

Year	Title of Technical Report (Number)
Research on Extreme Wind Speeds	
~2002	Extreme Wind Hazard Mapping in the Philippines (111)*
Research on Tropical Cyclone Variations	
~2002	A Study of Tropical Cyclones Originating from the South China Sea (110)
1997	Southwest Monsoon Surge Associated with Tropical Cyclone (93)
1996	Tropical Cyclone Wind Profiles (87)
Research on Tropical Cyclone Forecasting	
~2000	A Verification of 1994-1998 Tropical Cyclone Movement Forecasts of PAGASA (106)
1999	Analyses Of Vorticity, Omega And 850 HPa Wind of the FLM 12 in Relation to Tropical Cyclones Forecasting (104)
1999	The Revised Analog Method of Forecasting Tropical Cyclone Movement (101)
1998	The Development And Application Of The Direct Model Output Statistics (DMOS) to Improve Forecasting Of Tropical Cyclone Tracks (97)
Miscellaneous Research Related to Tropical Cyclone Hazard Mitigation	
1996	Tropical Cyclone Winds, Warnings and Damages (92)
2000	Socio-Economic Influence on Human Response to Tropical Cyclone Warning (107)

* Discussed in this report; see Chapter 3, Section 3.5.

4 WIND INFORMATION FROM OTHER SOURCES

4.1 *Wind Map used by Wind Power Companies*

Also cited by Rellin et al [2005], wind speed maps for the Philippines was prepared by the United States Department of Energy (US-DoE) – National Renewable Energy Laboratory (NREL) in collaboration with the Philippine Department of Energy (DOE) in 1999, in a publication called "Wind Energy Resource Atlas of the Philippines." A sample page is shown in Figure 17. It should be noted that the wind speed map shows average wind speed at 30 meters height as opposed to 10 meters standard height defined for basic wind speeds in wind load calculation. The map also shows corresponding wind power density, which is more for use by wind power companies. As Rellin et al states, the study does not include information on extreme wind speeds but nonetheless gives a good insight on the wind climatology in the region.

Wind power companies also actually conduct wind speed measurements for one to two straight years only, and usually only for a location known to be ideal for construction of a wind farm. Also, the wind measurements are usually conducted at heights of 30 meters or higher. The map in the NREL publication however used data from PAGASA (recorded at 10 meters height) as well as data measured by the National Power Corporation (NPC) of the Philippines.

4.2 *Wind Speed Data from Private Individuals*

A certain individual, Mr. Michael Padua of Naga City, called by the Philippine Daily Inquirer (PDI) as "Mr. Typhoon" in its December 2, 2004 issue, maintains his own private "weather station." The PDI article noted how Mr. Padua had sent a typhoon warning signal to Naga City officials even hours before the official warning from PAGASA. Mr. Padua maintains a website, Typhoon2000.ph, which contains a lot of information on tropical cyclones in the Philippines.

Among the information freely available at the website is a recording of wind speeds during the passing of Typhoon Muifa (Philippine Local Name: "Unding") in November 2004. A trimmed down version is shown in Figure 18. Although the data in itself is not directly suitable for engineering design purposes, nonetheless, this passion and effort of one person may well spell a big difference for wind hazard mitigation in the future.

4.3 *Other Wind-Related Information from the Internet*

Aside from the PAGASA and Mr. Padua's Typhoon2000.ph websites, weather and other wind-related information in the Philippines may also be taken from the Kochi University (Japan) website. The website compiles and processes different satellite images from various relevant sources such as the Japan Meteorological Association, the Institute of Industrial Science of the University of Tokyo, the Space Science Engineering Center of the University of Wisconsin-Madison, and from the National Oceanic and Atmospheric Administration (NOAA) among others. The Joint Typhoon Warning Center website as well as many other websites (see Appendix J) also provide valuable information.

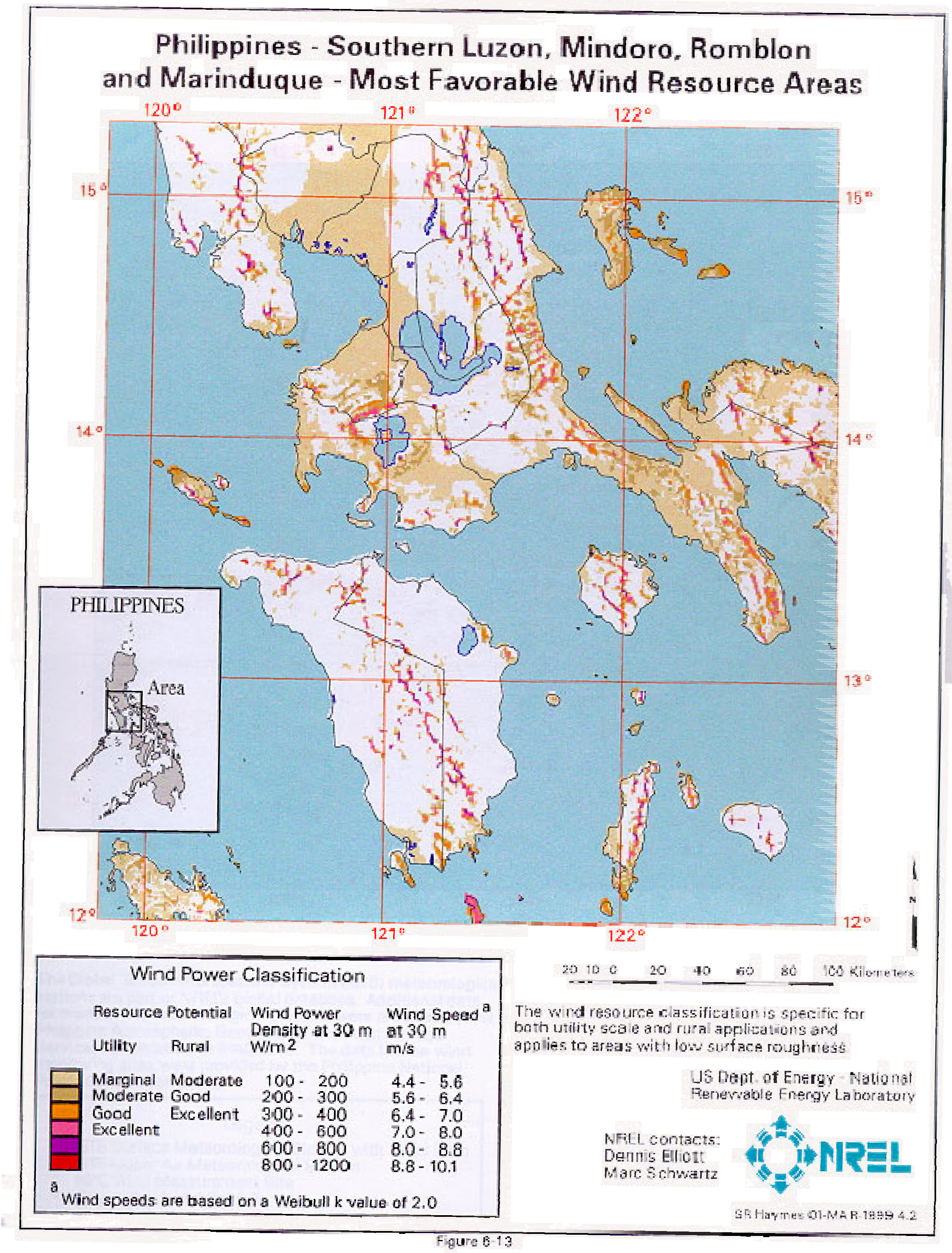


Figure 17. Sample page of Wind Speed/Wind Power Density Map from "Wind Resource Atlas of the Philippines" prepared by the US DOE-NREL [2001]
(from http://www.nrel.gov/international/rr_assessment.html#wind_atlases)

TYPHOON2000.COM POST OBSERVATION REPORT

NAME: MUIFA/UNDING/29W
DATE: November 19-20, 2004
LOCATION: NAGA CITY, PHILIPPINES
LAT/LON: 13.6N 123.2E
INSTRUMENTS: DAVIS VANTAGE PRO WEATHER STATION (MAR 2004 MODEL)

DTG (UTC)	RESSURE (hPa)	10-MIN. WIND AVE. (kph)	HOURLY WIND AVE. (kph)	HOURLY HIGHEST WIND SPEED (kph)
0411190000*	1008.9	..	06/NW	21/NW
0411190100	1009.0	..	06/NW	21/NW
0411190200	1008.7	..	10/NW	26/NW
		========= *information cut for presentation purposes* =========		
0411191130	1004.3	..	..	..
0411191145	1004.0	..	..	..
0411191200	1003.4	..	24/NW	56/NW
0411191215	1002.5	..	..	..
0411191250	..	34/NW	..	..
0411191300	999.7	43/NW	..	79/NW
		========= *information cut for presentation purposes* =========		
0411191500	992.7	53/N	..	130/N
0411200000**	1008.6	..	05/W	16/W

Legend:
* - start of observation
** - end of observation
.. - not available

Notes:
1. 15-min. Barometer readings began @ 08:30 UTC up to 1900 UTC Nov 19.
2. 10-min. Wind Ave. readings bgean @ 12:20 UTC up to 1900 UTC Nov 19.

Other Pertinent Data Recorded:
> Highest Wind Speed: 130 kph (70 knots)/North @ 10:00 PM (14:00 UTC) Nov 19.
> Highest Rainfall Rate: 18.00 inches per hour (457 mm. per hour) @ 9:43 PM (13:43 UTC) Nov 19.
> Lowest Barometric Pressure: 986.1 hPa @ 10:14 PM (14:14 UTC) Nov 19
> Rain Storm #01 (Nov 14-18): 8.26 inches (209 mm.)
> Rain Storm #02 (Nov 19-20): 3.84 inches (97.5 mm.)

Figure 18. Sample data from Mr. Padua’s weather station. Full data could be downloaded from http://typhoon2000.ph/muifa_naga_obs.txt

5 WIND DAMAGE INFORMATION

5.1 *Storm Warning Signals from PAGASA*

PAGASA issues Storm Warning Signals as well as Severe Weather Bulletins during the passage of a tropical cyclone in the PAR. A tropical cyclone maybe called different names according to its maximum sustained winds: a tropical depression (45 to 63 kph), a tropical storm (64 to 117 kph), a typhoon (118 to 239 kph), or a super typhoon (240 kph or faster). Similarly, PAGASA issues a storm signal for a specific area in the Philippines according to forecasted or recorded maximum sustained winds. PAGASA issues storm signals as appropriate, and severe weather bulletins every 6 hours until the cyclone has left PAR. Table 10 summarizes the different storm signals, and corresponding maximum sustained winds and expected damages.

5.2 *Wind Damage Information from OCD-NDCC*

The Office of Civil Defense – National Disaster Coordinating Council (OCD-NDCC) of the Philippines is an umbrella organization headed by the Secretary of National Defense and composed of about 17 branches of the government including the Armed Forces of the Philippines (military), the Philippine National Red Cross, the Department of Public Works and Highways, the Department of Justice, the Department of Health, the Department of Social Welfare and Development, the National Economic Development Agency, the Department of Education, Culture, & Sports, the Department of Agriculture, the Department of Finance, and many others. The OCD-NDCC covers a broad scope that includes preparedness, mitigation, response, and rehabilitation. It ties up with PAGASA in preparing for Severe Weather disasters (including tropical cyclones and wind storms), among other tie-ups and during other disasters.

One of the activities of the OCD-NDCC is the documentation of property damages and affected populations. In line with this, they have two documents prepared: a summary of damages due to “Destructive Tropical Cyclones from 1970 to 2003” plus an addendum “2004 Summary of Destructive Tropical Cyclones and their Effects”; a summary damages due to “Other Disaster Incidents from 1980 to 2003” plus an addendum “Summary of Disaster Incidents Monitored from January to December 2004.” These two documents are attached as Appendix A and Appendix B, respectively. Sample pages are shown as Figure 19.

The first document shows number of killed, injured, or missing persons, number of affected families and persons, number of totally or partially damaged houses, and cost of damages to agricultural properties, infrastructure, and to private properties per destructive tropical cyclone. The document describes the inclusive dates in which the tropical cyclone passed the PAR and regions of the Philippines affected. (Philippine regions are numbered from I to XII from north to south, with 3 special administrative regions such as the NCR (National Capital Region) which comprises Metro Manila. Garciano et al’s proposed map shows the locations of these regions.)

The second document shows practically the same information for different types of disasters including strong winds, storm surges, and tornado and minor tornado incidents.

Table 10. Philippine Public Storm Warning Signals (PSWS) issued by PAGASA

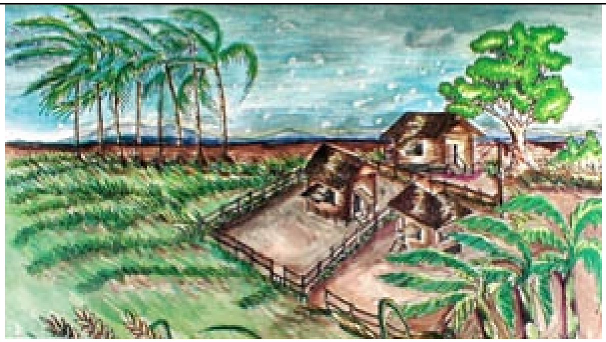
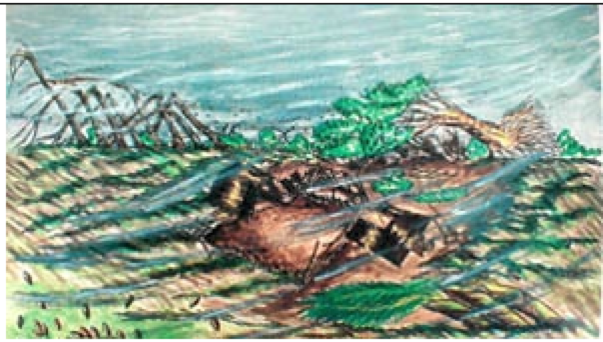
PSWS Number (Images and information from http://www.pagasa.dost.gov.ph/genmet/psws.html)		Expected Wind Speeds	Time expected to arrive	Expected Level of General Damages	Disaster Preparedness Agencies	Other Expected Damages	Recommended Precautionary Measures
1		30 to 60 kph	Within 36 hours	Very light or no damage	Alert status	Damage to small trees and rice crops, Banana plants tilted or downed, Houses with roofs made of light material may be partially unroofed	• If the cyclone intensifies and moves closer to the area, the PSWS may be upgraded. • Higher coastal waves • People advised to stay updated for next PAGASA bulletin
2		60 to 100 kph	Within 24 hours	Light to moderate damage	Action to alert the community	Damage to corn and rice, few big trees and banana plants, Coconut trees tilted or downed, Nipa and cogon houses partially or totally unroofed, Steel roofs partially unroofed	• Small seacrafts in danger • Special attention to cyclone advisory • Caution to sea and air travelers • Elementary and high school classes suspended • Secure properties before signal upgrade

Table 10. Philippine Public Storm Warning Signals (PSWS) issued by PAGASA (cont'd)

PSWS Number (Images and information from http://www.pagasa.dost.gov.ph/genmet/psws.html)		Expected Wind Speeds	Time expected to arrive	Expected Level of General Damages	Disaster Preparedness Agencies	Other Expected Damages	Recommended Precautionary Measures
3		100 to 185 kph	Within 18 hours	Moderate to heavy damage	Appropriate response for emergencies	Damage to coconut trees, all banana plants, and to rice and corn crops, Considerable damage to houses of light and medium construction, Disruption to power and communication	• Dangerous to communities and seacrafts • Risky sea and air travel • Advise to seek shelter in "strong buildings" • Watch out for the "eye" of the storm – stay in safe shelter • All classes suspended
4		Over 185 kph	Within 12 hours	Very heavy damage	Full response to emergencies; Full readiness to respond to calamities	Severe damage to plants, trees, and agricultural crops, Most buildings of mixed construction severely damaged, Power and communication down	• Potentially very destructive to community • All travels should be cancelled • Evacuation should be complete • The "eye" will hit the locality – dangerous afterwards

Department of National Defense
OFFICE OF CIVIL DEFENSE
Camp Emilio Aguinaldo, Quezon City

2004 SUMMARY OF DESTRUCTIVE TROPICAL CYCLONES AND THEIR EFFECTS

NAME	DATE OF OCCURRENCE	AREAS	AFFECTED POPULATION			CASUALTIES			DAMAGES					TOTAL COST
									HOUSES		PROPERTIES (PMILLIONS)			
		REG	PROV	FAM	PERS	DEAD	INJ	MIS	TOT	PART	AGRI	INFRA	PVT	
TY DINDO	13-20 May	4	11	76,715	355,214	35	23	6	10,574	56,223	97.668	214.686	10.840	323.194
TS FRANK	5-9 June	1	2	731	3,576	2		3			0.185	1.500		1.685
TD GENER	7-11 June	1	1	1,499	7,490	7	7	3	246	1,263	19.500	30.000	26.100	75.600
TY IGME	25 Jun - 2 Jul	6	18	166,540	805,723	55	47	20	4,821	33,310	1,375.255	1,067.979	3.980	2,447.214
TD LAWIN	15-17 Aug										2.861			2.861
TS MARCE	20-24 Aug	6	21	445,107	2,150,363	65	10	1	436	3,811	1,828.179	563.214		2,391.393
Sub-Total		**18**	**53**	**690,592**	**3,322,366**	**164**	**87**	**33**	**16,077**	**94,607**	**3,323.648**	**1,877.379**	**40.920**	**5,241.947**
TY UNDING	14-21 Nov	3	13	144,553	759,045	71	160	69	36,011	91,803		358.156	76.098	434.254
TD VIOLETA	22-26 Nov	2	4	21,151	99,461	31	187	17	369	900		71.635		71.635
TD WINNIE	28-30 Nov	5	8	170,036	845,429	893	648	443	8,889	12,578		696.906	4.782	701.688
TY YOYONG	30 Nov - 3 Dec	8	35	383,575	1,939,835	73	168	24	11,322	61,972		560.829		560.829
Sub-Total				**719,315**	**3,643,770**	**1,068**	**1,163**	**553**	**56,591**	**167,253**	**5,683.058**	**1,687.526**	**80.880**	**7,127.816**
											School faciities (last 4 typhoons)	461.846		461.846
											Health facilities -do-	72.900		72.900
											Transmission Lines -do-	34.300		34.300
Grand Total	10			**1,409,907**	**6,966,136**	**1,232**	**1,250**	**586**	**72,668**	**261,860**	**8,683.058**	**4,123.951**	**121.800**	**12.928.809**
					Breakdown :									
							Agriculture		8,683.058					
							Infracstructure		4,123.951					
							Private Properties		121.800					
					Grand -Total			P	**12,928.81**	or **P12.9 B**				

Figure 19a. Sample printout page of (2004) Summary of Damages due to Destructive Tropical Cyclones, by OCD-NDCC

SUMMARY OF DISASTER INCIDENTS MONITORED
FROM JANUARY TO DECEMBER 2004

NO.OF	DISASTERS	CASUALTIES			POP AFFECTED		POP EVACUATED		DAMAGED HOUSES		DAMAGED PROPERTIES (P MILLIONS)			
OCC		DEAD	INJ	MIS	FAM	PER	FAM	PER	TOTALLY	PARTIALLY	INFRA	AGRI	PVT	TOTAL
	A. MAN MADE INCIDENTS													
5	Air Mishaps	6	2	0	0	0	0	0	1	0	0	0	0	0
9	Bombing / Grenade Explosions	19	128	0	0	0	0	0	0	0	0	0	0	0
3	Chemical Explosions	4	14	3	9	44	9	44	0	0	0	0	0	0
4	Collapsed Structures	6	32	0	0	0	0	0	0	0	0	0	0	0
26	Complex Emergencies	51	115	3	1,722	8,897	1,227	6,422	0	0	0	0	0	0
11	Drowning Incidents	22	0	4	9	44	9	44	0	0	0	0	0	0
2	Electrocution Incidents	6	5	0	0	0	0	0	0	0	0	0	0	0
11	Epedemic / Disease Outbreak	73	46	0	184	921	0	48	0	0	0	0	0	0
4	Food Poisoning	2	270	0	178	902	0	0	0	0	0	0	0	0
3	Power Blackout	2	1	0	1	5	0	0	0	0	0	0	0	0
18	Sea Mishaps	41	35	50	170	851	32	160	0	0	0	0	0	0
12	Shooting Incidents	11	14	0	0	0	0	0	0	0	0	0	0	0
202	Structural Fire Incidents	194	187	25	16,870	84,020	8,061	40,470	9,129	437	93.750	0	493.086	586.786
1	Train Mishaps	6	150	0	0	0	0	0	0	0	0	0	0	0
50	Vehicular Accidents	117	476	32	0	0	0	0	0	0	0	0	0	0
361	**Sub- Total**	**560**	**1475**	**117**	**19,143**	**95,684**	**9,338**	**47,188**	**9,130**	**437**	**93.750**	**0**	**493.086**	**586.786**
	B. NATURAL INCIDENTS													
41	Flooding / Flasfloods	13	6	8	146,103	698,699	2,942	19,783	234	393	54.245	118.157	0.530	172.932
5	Heavy Downpour / Continous Rains	0	0	0	11	57	0	0		10	4.400	0	0	4.400
17	Landslides	34	17	12	5,418	25,948	2,000	10,000	4	41	0	10.720	15.000	25.720
1	Lightning Incident	1	0	0	0	0	0	0	0	0	0	0	0	0
2	Pest Infestations	0	0	0	6,949	34,745	0	0	0	0	0	70.086	0	70.086
3	Strong Winds	0	0	0	25	126	0	0	0		0	0	0	0
1	Storm Surge Incidents	0	0	0	44	220	0	0	44	0	0	0	0	0
22	Tornadoes	9	21	5	6,113	58,051	1,528	7,637	299	1,050	30.000	19.500	26.100	75.600
92	**Sub-Total**	**57**	**44**	**25**	**164,663**	**817,846**	**6,470**	**37,420**	**581**	**1,494**	**88.645**	**218.463**	**41.630**	**348.738**
10	**Tropical Cyclones (10 des)**	1,232	1,250	586	1,403,907	6,966,136	259,534	1,275,730	72,688	261,860	4,123.951	8,683.058	121.800	12,928.809
102	**Sub-Total**	**1,289**	**1,294**	**611**	**1,568,570**	**7,783,982**	**266,004**	**1,313,150**	**73,269**	**263,354**	**4,212.596**	**8,901.521**	**163.430**	**13,277.547**
463	**GRAND -TOTAL**	**1,849**	**2,769**	**728**	**1,587,713**	**7,879,666**	**275,342**	**1,360,338**	**82,399**	**263,791**	**4,306.346**	**8,901.521**	**656.516**	**13,864.383**

Figure 19b. Sample printout page of (2004) Summary of Damages due to Other Disaster Incidents (including strong winds not associated with a tropical cyclone, tornadoes, and storm surges), by OCD-NDCC

5.3 *Tropical Cyclone Summaries from PAGASA*

A document called "Tropical Cyclone Summary" for a given year, with 1978 as the earliest year and 2003 as the latest year (as of April 2005) with available summaries, is available for purchase from the PAGASA-CDS (less than JPY 1,000 for each year). The document shows the tropical cyclone classification (tropical depression, tropical storm, typhoon, or super typhoon) and usually the Philippine name and inclusive dates of occurrence; the highest recorded maximum wind/gust speeds and corresponding observed place and time; the lowest recorded mean sea level pressure and corresponding observed place and time; the maximum 24-hour rainfall rate and corresponding observed place and time; a brief summary of the cyclone, areas affected, raised storm warning signals, and for later years, a summary of affected persons and costs of damages; and finally, a plot of the tropical cyclone track with respect to the PAR. The summary of affected persons and costs of damages were taken from the OCD-NDCC report. Likewise, the OCD-NDCC uses this document and other similar sources of such information about the cyclones for publication or dissemination.

The 1978 Tropical Cyclone Summary is attached as Appendix C and the 2003 Tropical Cyclone Summary is attached as Appendix D, for information purposes. Sample pages are shown in Figure 20.

5.4 *Statistics of Tropical Cyclone Damages*

Mr. Padua has collected some interesting statistics of tropical cyclone damage info at his website at Typhoon2000.ph. These are presented in Tables 11a to 11e. A summary report of damages due to the Top 10 Worst Typhoons of the Philippines from 1947-2002 compiled by Dominic Alojado and Michael Padua (for Typhoon2000.ph) has been included as Appendix I.

5.5 *Selected Tropical Cyclone Damage Reports*

One certainly available source for wind damage news and information is from mass media such as newspapers, television and radio news, and internet news. We present here damage reports due to tropical cyclones of 2005, as well as five destructive typhoons in the last two months of 2004 (a year with 25 tropical cyclones). Damage reports by private individuals and from the OCD-NDCC are also presented.

5.5.1 First Tropical Cyclone of 2005

Tropical Cyclone 'Auring' (International Name: ROKE) was the first to hit the Philippines in 2005, after five straight destructive tropical cyclones in the last two months of 2004. It was March 15, 2005 when Auring first threatened the PAR. PAGASA issued 10 severe weather bulletins during the passage of 'Auring', and issued a storm warning signal as high as Signal Number 3 in central provinces of the Philippines. The Philippine Daily Inquirer (PDI), perhaps the top newspaper in the country, issued at least 5 news reports about Auring and its effects on their website at www.inq7.net; Appendix E shows printouts of these articles from the Internet. Auring's winds reached as fast as 105 kph with gusts as fast as 135 kph (a tropical storm), and generally damaged only some trees which unfortunately fell and killed a 72-year-old woman, a 5-year-old girl and one other person, and caused a ship and a fishing boat to capsize in which 12 persons were killed. Auring left at least 15 dead with 16 missing. The path of Auring was generally east to west, exiting the Philippines as a tropical depression into the South China Sea. (See Figure 21a)

Tropical Cyclone 'Bising' (International Name: SONCA) threatened the PAR starting in April 22, 2005, although it changed course away from the Philippines on the next day. (Figure 21b)

A tropical disturbance (named 'Crising' at first) was first spotted on May 16, 2005 to the east of Mindanao (Southern Philippines) but did not gain any strength and did not pose any significant hazard after turning into simply a low pressure area. (Figure 20b)

Table 11a. Worst Ancient Typhoons of the Philippines (Spanish Period/1617-1876)

Date	Damage
OCT 10-15, 1617	**6 large ships off Marinduque** were sunk due to high sea waves generated by a typhoon.
APR 28-MAY 5, 1866	A rampaging whirlwind smashed the provinces of the Bicol Region, Southern Luzon, Masbate, Panay and Mindoro. In Manila, the barometer plummeted to a record low of **746.62 mm**.
MAY 4-5, 1870	**400 houses and 15 bridges destroyed** by one typhoon, while another one **destroyed 247 houses** in Negros, and **sinking 13 fishing boats and 5 other boats**.
JUN 24, 1871	A very strong cyclone hit Southern Luzon, Central Luzon and Samar. **Big buildings were destroyed** and **several boats sunk or slammed against the shores**.
OCT 12, 1872	A strong cyclone hit Samar for eight whole hours, **crushing houses and drowning agricultural crops** with its floodwaters before **toppling tall trees** and **leveling down whole towns** in southern Luzon
MAR 4-5, 1874	This first cyclone of 1874 hit areas in Samar as it passed Panay Island; in one place, Laoang, **only two houses remained standing**, and as it hit Capiz province, **even strong buildings and churches were severely damaged**
DEC 25, 1874	A violent tornado came howling over Misamis, Northern Mindanao and Cebu; **"uprooting" a stone church and mortar buildings**; **running a large naval ship destroyer aground**; **dislodging massive stone docks** of Cebu
JAN 1, 1875	A strong tropical cyclone **destroyed bridges and roads** in Samar, as well as **destroying towns** on the far northern suburb of Manila
NOV 25-27, 1876	Surging tidal waves rampaging rivers **destroyed agricultural crops and livestock**, **swept away 2,500 houses** in the then still sparsely populated areas of Mindanao and the Visayas.

Source: PAGASA, "Everything You've Always Wanted to Know About Typhoons". FILIPINO HERITAGE: The Making of a Nation by Lahing Pilipino Publishing Inc.,1977. Archived, retrieved, and submitted for Typhoon2000.ph by Dominic Alojado (2005).

Table 11b. 30 Worst Typhoons of the Philippines (1947-2002)

NAME (*Int'l Name)*	**PERIOD OF OCCURRENCE**	**HIGHEST WIND SPEED RECORDED**	**PLACE**	**DEATHS**	**DAMAGE IN BILLION PESOS**
1. URING *(Thelma)*[1]	NOV 2-7, 1991	095 kph	Tacloban	***5,101-8,000+***	1.045
2. ROSING *(Angela)*[2]	OCT 30-NOV 4, 1995	260 kph	Virac Radar	936	10.829
3. NITANG *(Ike)*	AUG 31-SEP 4, 1984	220 kph	Surigao	*1,363-3,000*	4.100
4. RUPING *(Mike)*[3]	NOV 10-14, 1990	220 kph	Cebu	748	10.846
5. SENING *(Joan)*[4]	OCT 11-15, 1970	275 kph	Virac	768	1.890
6. LOLENG *(Babs)*	OCT 15-24, 1998	250 kph	Virac	303	6.787
7. UNDANG *(Agnes)*	NOV 3-6, 1984	230 kph	Tacloban	895	1.900
8. SISANG *(Nina)*	NOV 23-27, 1987	240 kph	Legazpi	979	1.119
9. KADIANG *(Flo)*	SEP 30-OCT 7, 1993	130 kph	**over water**	576	8.752
10. AMY	DEC 6-19, 1951	240 kph	Cebu	991	0.700
11. TRIX	OCT 16-23, 1952	215 kph	Legazpi	995	0.880
12. UNSANG *(Ruby)*	OCT 21-26, 1988	215 kph	Virac	157	5.636
13. KADING *(Rita)*	OCT 25-27, 1978	185 kph	Virac	444	1.900
14. YONING *(Skip)*	NOV 5-8, 1988	230 kph	**over water**	217	2.767
15. DINANG *(Lee)*	DEC 23-28, 1981	175 kph	Catarman	*2,764*	0.640
16. ANDING *(Irma)*	NOV 21-27, 1981	260 kph	Daet	409	0.650
17. MONANG *(Lola)*	DEC 2-7, 1993	170 kph	Virac	363	2.463
18. HERMING *(Betty)*	AUG 7-14, 1987	240 kph	Catarman	200+	2.066
19. ILIANG *(Zeb)*	OCT 7-18, 1998	260 kph	**over water**	75	5.375
20. SALING *(Dot)*	OCT 15-20, 1985	240 kph	Daet	118	2.133
21. TITANG *(Kate)*	OCT 16-23, 1970	095 kph	Cuyo	631	1.750
22. FERIA *(Utor)*	JUL 2-7, 2001	150 kph	**over water**	188	3.586
23. DIDANG *(Olga)*	MAY 12-17, 1976	150 kph	Iba	374	1.160
24. NANANG *(Ling-Ling)*	NOV 6-9, 2001	090 kph	**over water**	236	3.200
25. YOLING *(Patsy)*	NOV 17-20, 1970	200 kph	Manila (Airport)	611	0.460
26. INING *(Louise)*	NOV 15-20, 1964	*240 kph*	Cebu	*400*	0.010
27. MAMENG *(Sybil)*	SEP 27-OCT 1, 1995	140 kph	**over water**	116	3.170

Table 11b. 30 Worst Typhoons of the Philippines (1947-2002) (cont'd)

NAME (*Int'l Name)*	PERIOD OF OCCURRENCE	HIGHEST WIND SPEED RECORDED	PLACE	DEATHS	DAMAGE IN BILLION PESOS
28. TRINING *(Ruth)*[5]	OCT 16-31, 1991	204 kph	Laoag	82	3.072
29. WELING *(Nancy)*	OCT 11-15, 1982	130 kph	Tuguegarao	309	0.630
30. GADING *(Peggy)*	JUL 6-10, 1986	220 kph	Vigan	106	0.679

LEGEND:
1 - The deadliest storm in the country (also the deadliest natural disaster of the Philippines).
2 - Probably the strongest typhoon in the Pacific rivaling Super Typhoon TIP in 1979.
3 - The costliest typhoon up-to-date.
4 - The typhoon with the strongest winds ever recorded and inflicted significant damage (although other typhoons have higher wind speed but did
not hit land or inflict any damage).
5 - The first typhoon to raise Public Storm Signal # 4 in PAGASA's 1991 Revised Public Storm Signal from the former PSS# 1-3 to PSS# 1-4.
over water – typhoon's strongest winds were recorded while typhoon was still at sea but is closely approaching land.
Underlined figures - are courtesy of PAGASA.
Bold and italicized figures - are combined information courtesy of NDCC, reliefweb.com, Manila Bulletin, Reuters and Unisys.
The rest of the figures came from NDCC and/or Typhoon2000.com

NOTES:
> RUPING - this monstrous typhoon directly hit highly-urbanized cities of Cebu, Lapu-Lapu, Mandaue, Bacolod, Iloilo and the most densely populated provinces of Visayas and Mindanao affecting 1,010,004 families or total affected persons of 5,498,290.

> URING - although a weak tropical storm, it unleashed its fury in Leyte and Negros Occidental, creating flashfloods. Ormoc City, Leyte suffered the worst with almost 75% of the city destroyed, killing more than 5,000 people with more than 2,000 missing and were presumed dead.

SOURCES: www.ndcc.gov.ph , www.pagasa.dost.gov.ph , www.typhoon2000.com, http://weather.unisys.com , www.reliefweb.com , www.npmoc.navy.mil/jtwc,
Compiled by Dominic Alojado with additional information by David Michael V. Padua of Typhoon2000.com (2004 NOV 06)

Additional Note by the Author: Top 10 Worst Typhoons highlighted are included in the Appendix I summary report also by Dominic Alojado and Michael Padua.

Table 11c. 20 Costliest Typhoons of the Philippines (1947-2002)

NAME (Int'l Name)	PERIOD OF OCCURRENCE	DAMAGE IN BILLION PESOS
1. RUPING (Mike)	NOV 10-14, 1990	10.846
2. ROSING (Angela)	OCT 30-NOV 4, 1995	10.829
3. KADIANG (Flo)	SEP 30-OCT 7, 1993	8.752
4. LOLENG (Babs)	OCT 15-24, 1998	6.787
5. UNSANG (Ruby)	OCT 21-26, 1988	5.636
6. ILIANG (Zeb)	OCT 7-18, 1998	5.375
7. NITANG (Ike)	AUG 31-SEP 4, 1984	4.100
8. FERIA (Utor)	JUL 2-7, 2001	3.586
9. NANANG (Lingling)	NOV 6-9, 2001	3.200
10. MAMENG (Sybil)	SEP 27-OCT 1, 1995	3.170
11. TRINING (Ruth)	OCT 16-31, 1991	3.072
12. YONING (Skip)	NOV 5-8, 1988	2.767
13. MONANG (Lola)	DEC 2-7, 1993	2.463
14. SALING (Dot)	OCT 15-20, 1985	2.133
15. HERMING (Betty)	AUG 7-14, 1987	2.066
16. KADING (Rita)	OCT 25-27, 1978	1.900
17. UNDANG (Agnes)	NOV 3-6, 1984	1.900
18. SENING (Joan)	OCT 11-15, 1970	1.890
19. TITANG (Kate)	OCT 16-23, 1970	1.750
20. ARING (Betty)	NOV 2-7, 1980	1.610

*This summary is taken from NDCC publications, and historical archives. Compiled in 2004 by Dominic Alojado with additional information by David Michael V. Padua of Typhoon2000.com.

Table 11d. 20 Deadliest Typhoons of The Philippines (1947 - 2002)

NAME (Int'l Name)	PERIOD OF OCCURRENCE	DEATHS
1. URING *(Thelma)**	November 2-7, 1991	5,101-8,000+
2. NITANG *(Ike)*	August 31–September 4, 1984	1,363-3,000
3. DINANG *(Lee)*	December 23-28, 1981	2,764
4. TRIX	October 16-23, 1952	995
5. AMY	December 6-19, 1951	991
6. SISANG *(Nina)*	November 23-27, 1987	979
7. ROSING *(Angela)*	October 30 – November 4, 1995	936
8. UNDANG *(Agnes)*	November 3-6, 1984	895
9. SENING *(Joan)*	October 11-15, 1970	768
10. RUPING *(Mike)*	November 10-14, 1990	748
11. TITANG *(Kate)*	October 16-23, 1970	631
12. YOLING *(Patsy)*	November 17-20, 1970	611
13. KADIANG *(Flo)*	September 30 - October 7, 1993	576
14. KADING *(Rita)*	October 25-27, 1978	444
15. ANDING *(Irma)*	November 21-27, 1981	409
16. INING *(Louise)*	November 15-20, 1964	400
17. DIDANG *(Olga)*	May 12-17, 1976	374
18. MONANG *(Lola)*	December 2-7, 1993	363
19. WELING *(Nancy)*	October 11-15, 1982	309
20. LOLENG *(Babs)*	October 15-24, 1998	303

***** - *only a* ***Tropical Storm*** *. The unusual high number of deaths was attributed to massive flash floods that swept across parts of Leyte and Negros Occidental. Majority of deaths occurred in the city of Ormoc, Leyte after being overwhelmed a ten feet flashflood in the mid-morning of November 5, 1991, spawned by a continuous, torrential rainfall occurring for a 10-12 hour period (about 140 mm in 6 hours).*

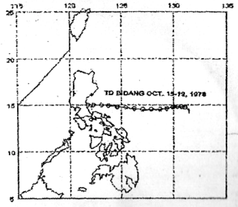
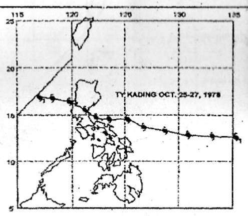
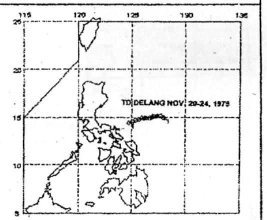
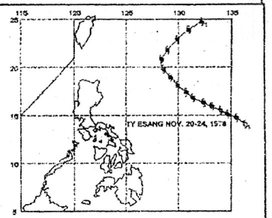
This summary is taken from NDCC publications, and historical archives. Compiled by Dominic Alojado with additional information by David Michael V. Padua of Typhoon2000.com (October 29, 2004).

Table 11e. 20 Strongest Typhoons of The Philippines (1947 - 2002)

NAME	**PERIOD OF OCCURRENCE**	**HIGHEST WIND SPEED RECORDED**	**PLACE OBSERVED**
1. SENING *(Joan)*	October 11-15, 1970	275 kph	Virac
2. ROSING *(Angela)*	October 30-November 4, 1995	260 kph	Virac Radar
3. ANDING *(Irma)*	November 21-27, 1981	260 kph	Daet
4. LOLENG *(Babs)*	October 15-24, 1998	250 kph	Virac
5. AMY	December 6-19, 1951	240 kph	Cebu
6. SISANG *(Nina)*	November 23-27, 1987	240 kph	Legazpi
7. SALING *(Dot)*	October 15-20, 1985	240 kph	Daet
8. HERMING *(Betty)*	August 7-14, 1987	240 kph	Catarman
9. INING *(Louise)*	November 15-20, 1964	240 kph	Cebu
10. UNDANG*(Agnes)*	November 3-6, 1984	230 kph	Tacloban
11. HARRIET	December 28, 1959-January 2, 1960	225 kph	Virac
12. NITANG *(Ike)*	August 31-September 4, 1984	220 kph	Surigao
13. RUPING *(Mike)*	November 10-14, 1990	220 kph	Cebu
14. GADING *(Peggy)*	July 6-10, 1986	220 kph	Vigan
15. TRIX	October 16-23, 1952	215 kph	Legazpi
16. UNSANG *(Ruby)*	October 21-26, 1988	215 kph	Virac
17. GILDA	December 13-22, 1959	212 kph	Catbalogan
18. ARING *(Betty)*	November 2-7, 1980	210 kph	Casiguran
19. TRINING *(Ruth)*	October 16-31, 1991	204 kph	Laoag
20. YOLING *(Patsy)*	November 17-20, 1970	200 kph	Manila **(MIA)**

MIA - *Manila International Airport (now Ninoy Aquino International Airport).*
Data are taken from PAGASA summaries. Compiled by Dominic Alojado with additional information by David Michael V. Padua of Typhoon2000.com (November 03, 2004).

1978 TROPICAL CYCLONE SUMMARY

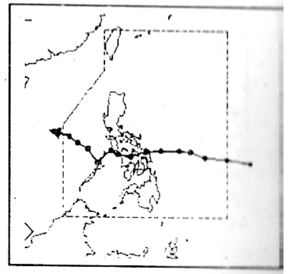
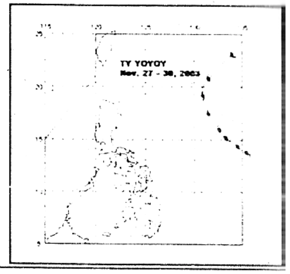
TC Classification and Name Date of Occurrence	Highest Maximum Winds/Gusts Kph) Observed & Place	Lowest MSLP (hpa) Recorded & Place	Maximum 24-hr RR (mm) Recorded & Place	Brief Summary, Areas Affected and Storm Warning Signals	Track
21. TROPICAL DEPRESSION BIDANG OCTOBER 15-19	65 kph over water 75 kph Baguio City Oct. 18 , 11 PM	1006.7 mb. over water	117.5-Alabat 10/18 101.0-Daet 10/17 88.5-Basco 10/15 63.8-Romblon 10/18 60.7-Masbate 10/18	Weakened rapidly into a low pressure area as it crossed Central Luzon and dissipated over land.	
22. TYPHOON KADING OCTOBER 25-27	185 kph at Virac Radar Ocotber 26 11:32 AM	887 mb. over water October 25	304.4-Infanta 10/26 266.5-Daet 10/26 230.6-Cabanatuan 10/26 210.5-Baler 10/26 108.0-Alabat 10/26	Crossed Central Luzon as a typhoon on October 27. Heavy rains and strong winds caused havoc.	
23. TROPICAL DEPRESSION DELANG NOVEMBER 16-20	46 kph at Daet Nov 17 11:00 AM	1002.8 mb. at Virac November 19	193.5-Virac Synop 11/19 157.7-Virac Radar 11/20 82.5-Aparri 11/20 81.2-Tuguegarao 11/20 76.2-Casiguran 11/20	Weakened into a low pressure area, dissipated before it could crossed. It brought occasional rains over Luzon and Visayas.	
24. TYPHOON ESANG NOVEMBER 20-24	195 kph over water	911.0 mb over water Nov. 21	157.7-Virac Radar 11/20 131.3-Virac Synop 11/20 82.5-Aparri 11/20 81.2-Tuguegarao 11/20 76.2-Casiguran 11/20	Recurved at about 650 kms. east of Baler with no significant effect.	

444 749 1,02 280

Source:PAGASA/CAB/CDS

Figure 20a. Sample printout page from 1978 Tropical Cyclone Summary (by PAGASA).

2003 TROPICAL CYCLONE SUMMARY

TC Classification and Name Date of Occurrence	Highest Maximum Winds/Gusts Kph) Observed & Place	Lowest MSLP (hpa) Recorded & Place	Maximum 24-hr RR (mm) Recorded & Place	Number of			Brief Summary, Areas Affected and Storm Warning Signals	Track
				Adv	SWB	IW		
23. **TROPICAL STORM WENG (NEPARTAK 0320)** **Nov. 12 – 15, 2003** **Maximum Winds:** **110 – 140 kph**	**Land:** 94–Daet (98440) Nov. 14, 2003 8:00 AM **Water:** 75 - JNVU 14.2°N 128.8°E Nov. 13, 2003 2:00 PM	**Land:** 995.7–Catbalogan (98548) Nov. 13, 2003 3:00AM **Water:** 1002.5 - JNVU 14.2°N 128.8°E Nov. 13, 2003 2:00 PM	166.2- Catbalogan (98540) Nov. 13, 2003	01	13	13	Weng is the 2nd tropical cyclone that crossed the Visayas. It originated from a low pressure area in the vicinity of the Caroline Islands. On the 12th of November, tropical depression Weng entered the Philippine Area of Responsibility and moved westward. It made landfall in Northern Samar and traversed Northern Visayas passing thru Masbate, the Visayan Sea, Southern Mindoro and the Calamian Group of Islands. It intensified further as it moved into the South China Sea with maximum sustained winds of 110 kph. It left the western border of the Philippine Area of Responsibility on the 30th and headed towards Northern Vietnam. PSWS #2 – Samar Provinces, Leyte Provinces, Biliran, Northern Cebu, Northern Iloilo, Northern Antique, Capiz, Aklan, Surigao del Sur, Surigao del Norte including Dinagat Island, Bicol Region, Burias Island, Marinduque, Mindoro Provinces, Northern Palawan including Calamian and Cuyo Islands, Romblon PSWS #1 – Southern Quezon including Polillo Island, Rest of Cebu, Bohol, Negros Provinces, Siquijor, Southern Iloilo, Southern Antique, Rest of Palawan, Laguna, Cavite, Lubang, Batangas, Guimaras Island Affected Persons: 443 Dead: 13 ; Injured: 5 ; Missing: 11 Total Cost of Damage: 0.045M	
24. **TYPHOON YOYOY (LUPIT) (0321)** **Nov. 27 - 30, 2003** **Maximum Winds:** **205 - 250 kph**	**Land:** 47–Aparri (98232) Nov. 28, 2003 11:00 PM **Water:** 100 - 8KSI 20.2°N 128.7°E Nov. 29, 2003 2:00 PM	**Land:** 1001.2–Gen. Santos (98851) Nov. 28, 2003 5:00 PM **Water:** 988.3 - 8KSI 19.5°N 129.1°E Nov. 29, 2003 8:00 AM	9.7-Infanta, Quezon (98434) Nov. 27, 2003	00	8	15	Yoyoy is the strongest tropical cyclone for 2003 but it did not affect any part of the country. It entered the Philippine Area of Responsibility with maximum sustained winds of 205 kph in the early morning of November 27. Yoyoy moved northwestward until it began to recurved by November 29. At the same time it weakened to sustained winds of 185 kph. Yoyoy then accelerated to the northeast then exited the Philippine Area of Responsibility on November 30. **SIGNALS: NONE**	

Source: PAGASA/CAB/CDS

Figure 20b. Sample printout page from 2003 Tropical Cyclone Summary (by PAGASA).

Figure 21a. Track of Tropical Cyclone 'Auring' (ROKE) of March 2005
from http://typhoon2000.ph/stormarchives/2005/trax/auring05_01tx.gif

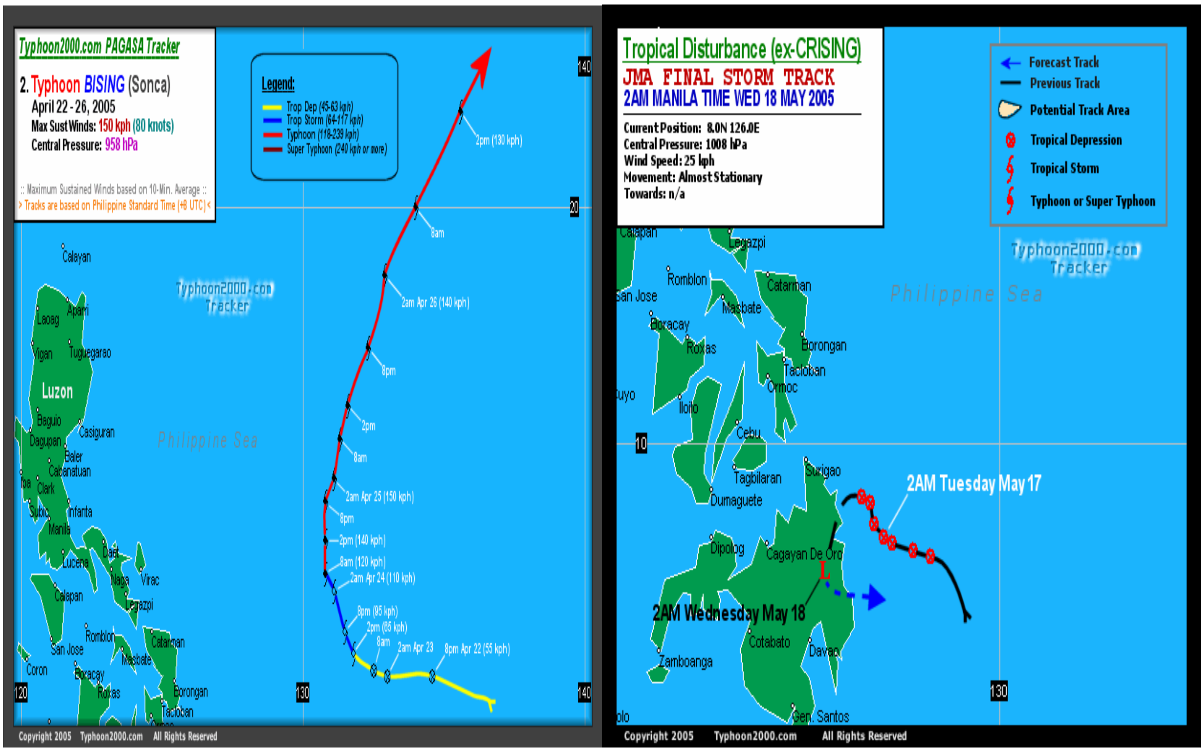


Figure 21b. Tracks of Tropical Cyclone 'Bising' (SONCA, April 2005)
and ex-'Crising' (May 2005)
from http://typhoon2000.ph/stormarchives/2005/trax/bising05_02tx.gif
and http://typhoon2000.ph/crising05_trak.gif

5.5.2 Destructive Tropical Cyclones of November 2004

Typhoon 'Unding' (International name: MUIFA/29W) was the first of four consecutive destructive tropical cyclones that hit the Philippines from November to December 2004 (Table 12). The four typhoons accounted for a total of about 1,000 deaths, 1,100 injuries, 500 missing persons, around 57,000 totally damaged houses, around 167,000 partially damaged houses, and about PHP 1.6 Billion (US$ 29 Million) in total cost of damages in a span of one month (Table 13). Unding went in an east-to-west direction, slightly making a circle around northeast Philippines where it caused a lot of damage. (Figure 22) 'Violeta' passed through central Luzon, the largest island in northern Philippines. (Figure 23) 'Winnie' basically scaled the land areas in southern Luzon from eastern Philippines to just a few kilometers off Manila Bay. (Figure 24) 'Yoyong' was a typhoon from the Pacific that went in a northwest direction crossing Luzon again. (Figure 25) 'Zosimo' threatened the PAR in the east but was in a north direction and never really fell on land. (Figure 26)

These tropical cyclone tracks were actually taken from the Typhoon2000.ph website, where there are other interesting information about these cyclones, most specially about Unding. Mr. Padua, who owns the website, also has his own eyewitness accounts of some damages within the vicinity of his residence in Naga City in southern Luzon (east central Philippines), including some *video clips* of strong winds raging coconut trees with rain water. Mr. Padua has a detailed "Full Passage Report" on Unding which is printed and attached as Appendix F, and can be found online at http://typhoon2000.ph/stormarchives/2004/unding_report. The site also has links to other websites with similar information. There are also video clips taken by Mr. Padua during the passing of Yoyong. Photos of some damages are available as well at http://typhoon2000.ph/stormarchives/2004/galleries/photos/unding/index.htm (a selection is in Appendix G). It is important to note here that Unding's eye passed over Naga City.

It is also important to note that while Violeta and Winnie had much lower maximum sustained winds than Unding, but because they passed through Philippine land one after the other bringing more winds and more rain, disaster response efforts were limited until after the last of these five tropical cyclones hit the Philippines. These tropical cyclones also brought about floods and landslides, aside from strong winds. A report on the after-effects of these tropical cyclones was also prepared by OCD-NDCC. (Appendix H)

Table 12. Summary of Tropical Cyclones in the PAR from November to December 2004*

Tropical Cyclone class, 'Name' (International Name/Code)	Inclusive dates of existence	Maximum sustained winds	Landfalling?
Typhoon 'Unding' (MUIFA/29W)	November 14 to November 21	215 kph	Yes
Tropical Depression 'Violeta' (MERBOK)	November 22 to November 23	55 kph	Yes
Tropical Depression 'Winnie'	November 27 to November 29	55 kph	Yes
Super Typhoon 'Yoyong' (NANMADOL/30W)	November 30 to December 3	240 kph	Yes
Tropical Storm 'Zosimo' (TALAS/31W)	December 15 to December 19	85 kph	No

* As summarized in http://typhoon2000.ph/season04-5.htm

Table 13. Damages from Tropical Cyclones in the PAR in November 2004*

Tropical Cyclone class, 'Name' (International Name/Code)	Affected Population	Casualties	Damages
Typhoon 'Unding' (MUIFA/29W)	3 regions, 13 provinces, 145,000 families, 760,000 persons	71 deaths 160 injuries 69 missing	36,000 full damage 92,000 partial PHP 434 M total (US$ 7.9M)
Tropical Depression 'Violeta' (MERBOK)	2 regions, 4 provinces, 21,000 families, 99,000 persons	31 deaths 187 injuries 17 missing	370 full damage 900 partial PHP 72 M total (US$ 1.3M)
Tropical Depression 'Winnie'	5 regions, 8 provinces, 170,000 families, 845,000 persons	893 deaths 648 injuries 443 missing	9,000 full damage 12,000 partial PHP 701 M total (US$ 12.75M)
Super Typhoon 'Yoyong' (NANMADOL/30W)	5 regions, 8 provinces, 383,000 families, 1.9 M persons	73 deaths 168 injuries 24 missing	36,000 full damage 92,000 partial PHP 434 M total (US$ 10.1M)

* As given in "2004 Summary of Destructive Tropical Cyclones and their Effects," see Appendix A

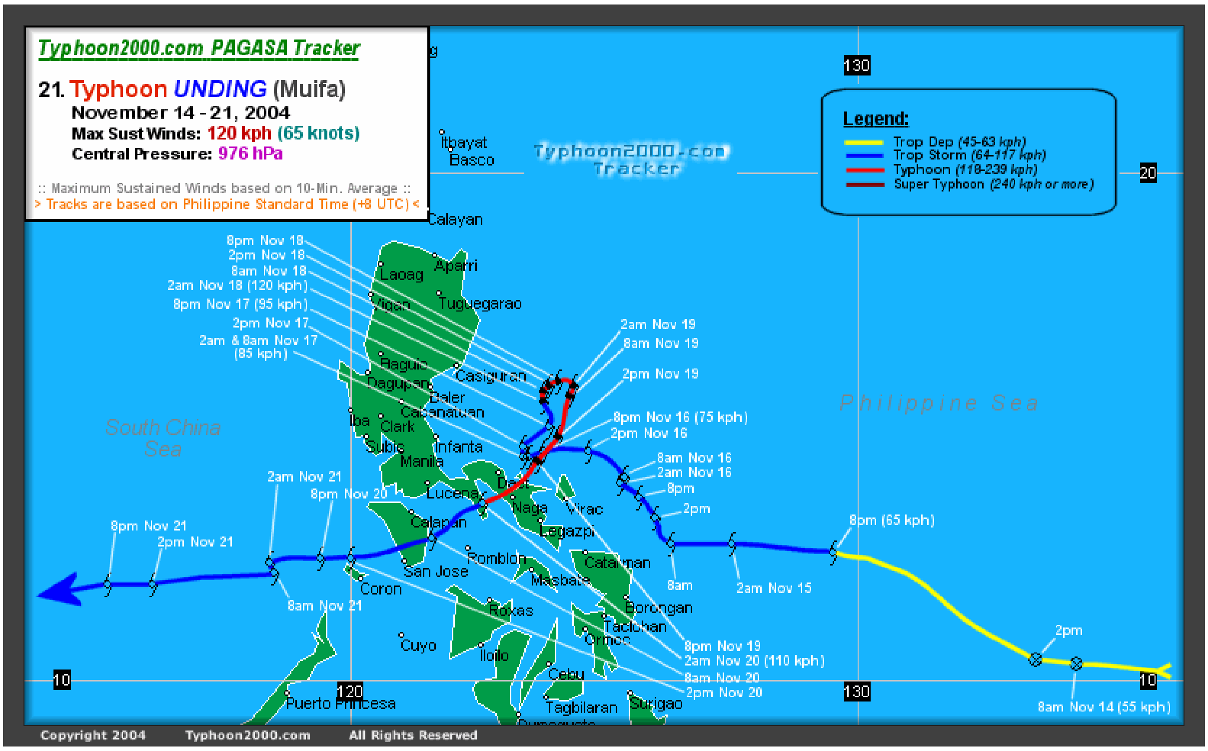


Figure 22. Track of Tropical Cyclone 'Unding'.
from http://typhoon2000.ph/stormarchives/2004/trax/unding04_21tx.gif

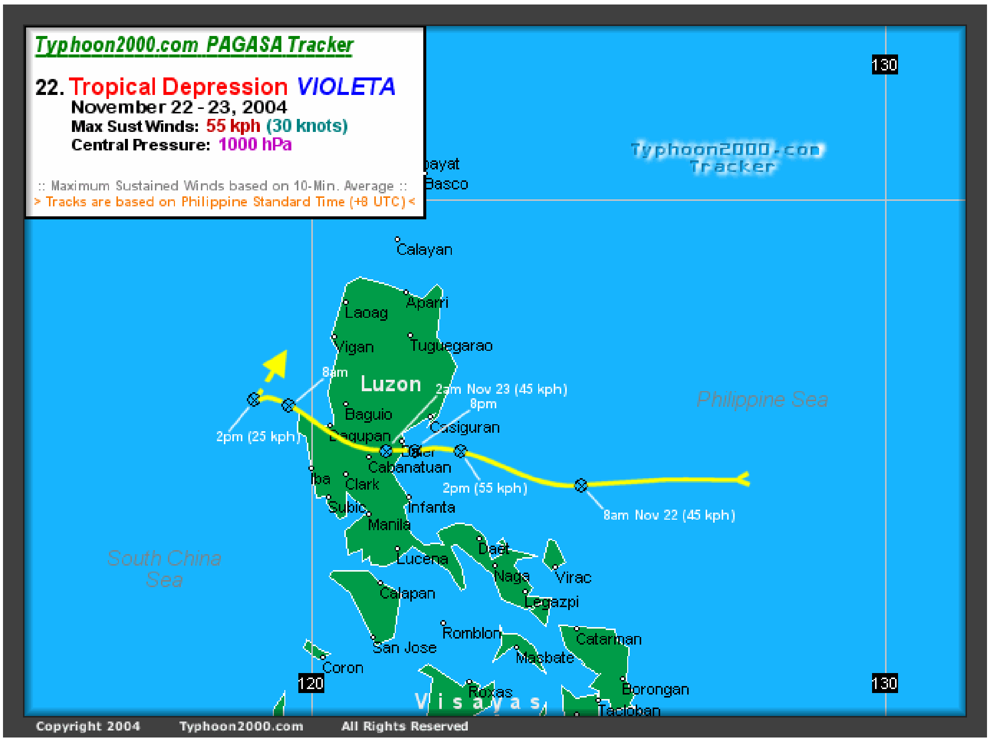


Figure 23. Track of Tropical Cyclone 'Violeta'.
from http://typhoon2000.ph/stormarchives/2004/trax/violeta04_22tx.gif

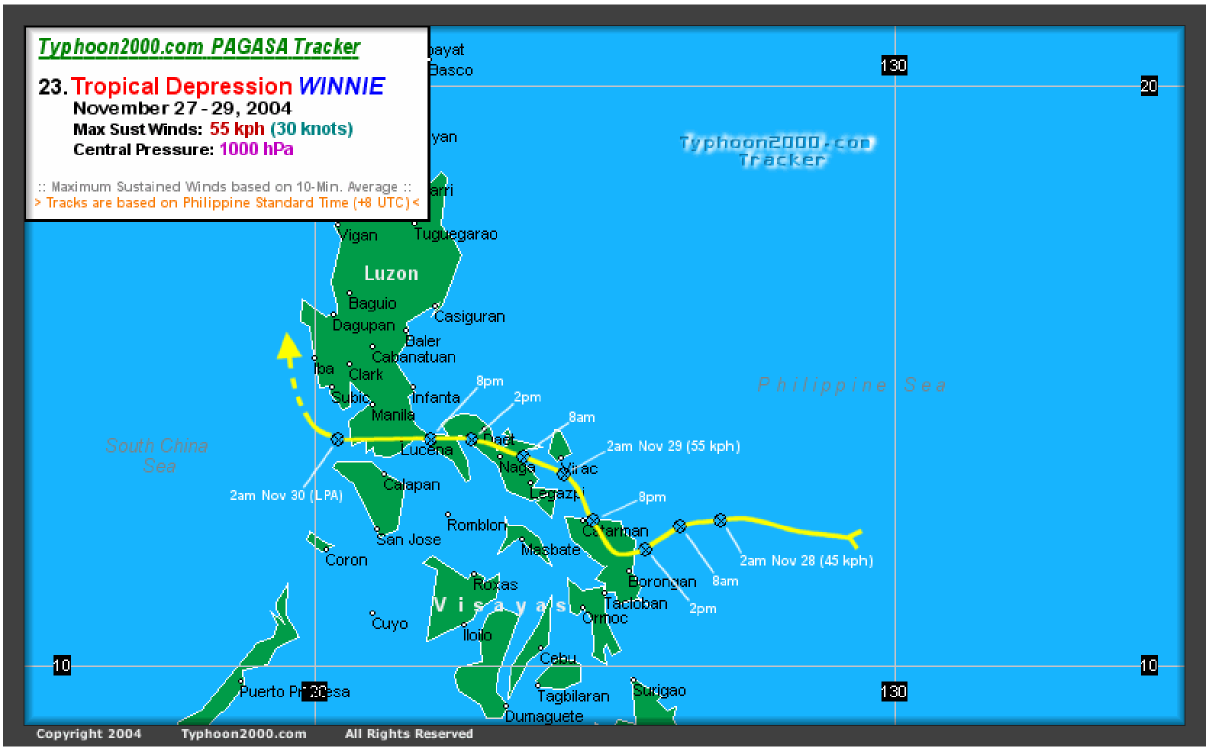


Figure 24. Track of Tropical Cyclone 'Winnie'.
from http://typhoon2000.ph/stormarchives/2004/trax/winnie04_23tx.gif

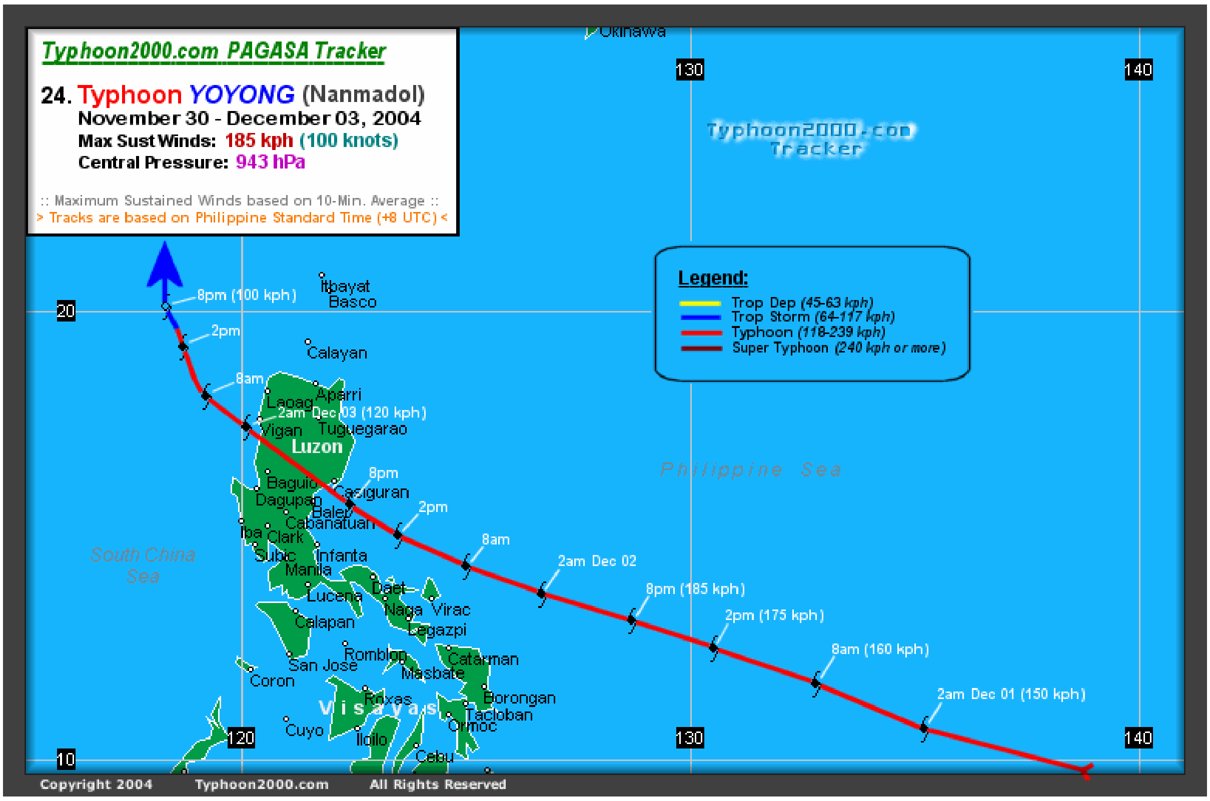


Figure 25. Track of Tropical Cyclone 'Yoyong'.
from http://typhoon2000.ph/stormarchives/2004/trax/yoyong04_24tx.gif

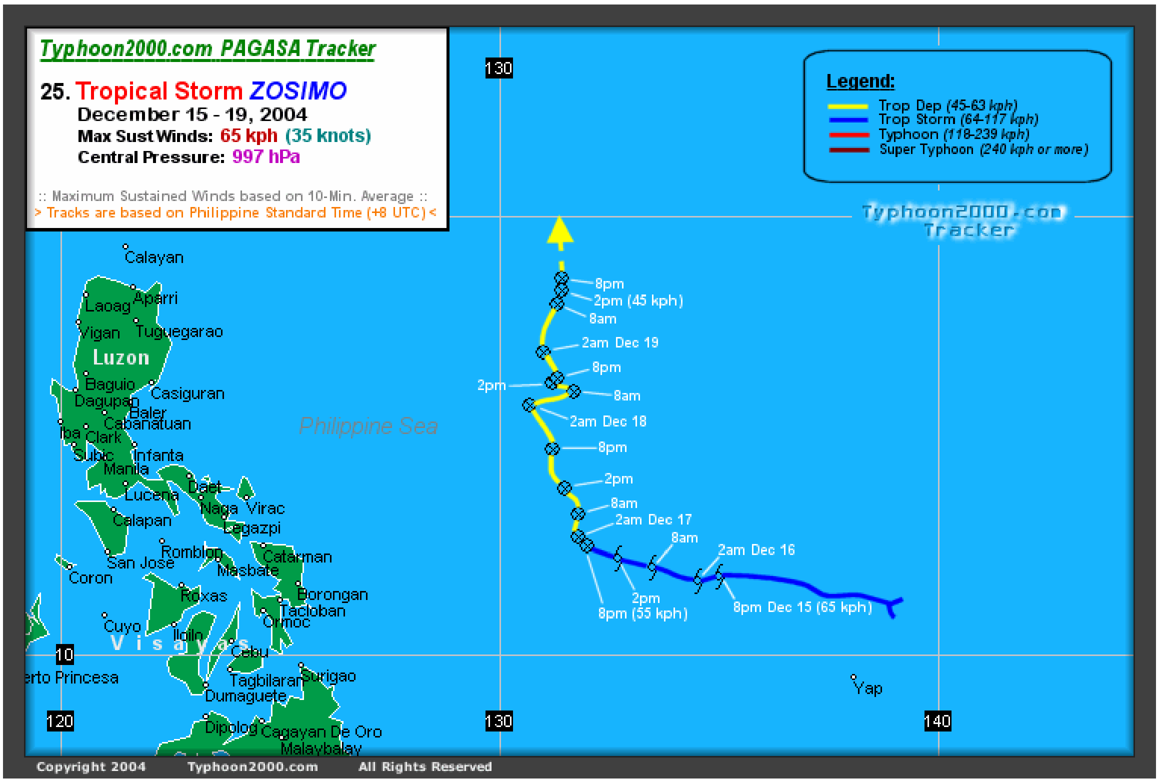


Figure 26. Track of Tropical Cyclone 'Zosimo'.
from http://www.typhoon2000.ph/stormarchives/2004/trax/zosimo04_25tx.gif

6 WIND INFORMATION FOR ENGINEERING, RESEARCH, & MITIGATION

This report has so far presented various wind information from the Philippines, including their availability (or unavailability). As presented in this report, damages due to tropical cyclones which bring about strong winds, among others, are quite significant such that engineering, research, & mitigation as tools in minimizing and hopefully eliminating the effects become important. While in recent years, there have been a number of research studies related to wind engineering in the Philippines, as well as related to wind disaster mitigation (e.g. due to tropical cyclones), there are still more possible activities and studies that may be conducted in the Philippines.

6.1 *Collaboration of Groups with Common Goals and Integration/Harmonization of Data*

The report has so far mentioned government agencies dealing with wind hazards such as PAGASA, and the OCD-NDCC, as well as non-government agencies and individuals such as ASEP and Mr. Michael Padua of Naga City. There is also the Philippine Institute of Civil Engineers (PICE), which has formed a specialty committee on Disaster Mitigation and Preparedness Strategies & Disaster Quick Response Program (PICE – DMAPS & DQRP).

Some of these groups have formed some tie-ups, most notable and most recently is the tie-up between the OCD-NDCC, the PICE, and ASEP on a Disaster Quick Response Program (DQRP). Of course, the OCD-NDCC can quickly tap the resources of PAGASA for information. Meanwhile, the PICE and/or the ASEP have been historically more involved in the “Response” aspect, after a disaster. Of course, civil engineers in general, and specifically ASEP, have been updating the NSCP which could be considered as an activity for “Mitigation,” as a referral document of the National Building Code of the Philippines. Civil and structural engineers are involved as well in “Rehabilitation,” specifically of buildings, and other structures.

However, as Pacheco [2004] states, civil and structural engineers could contribute to “Preparedness” as well in terms of contingency evacuation plans, public information campaigns, and risk evaluation of structures and facilities. And thus, the DMAPS committee was formed. A study by PAGASA-NDRB illustrates that out of 687 survey respondents, around 70% claim full comprehension of PAGASA’s storm warning signals, but only 4% actually fully comprehend the warnings. Certainly, there is more to be done in terms of public information campaigns, and engineers also being community members could contribute a lot.

In any case, these groups: PAGASA, the OCD-NDCC, the PICE, ASEP, and even private individuals, including perhaps members of the Philippine Meteorological Society, have their own specific goals, but all with a common ground in terms of wind hazard mitigation. These groups could very well do some collaboration, and integrate and harmonize data.

For example, this report has cited many very important documents and information prepared by PAGASA, but some of these are not immediately useable for engineering analysis. In the future, collaboration and close coordination between PAGASA and PICE/ASEP engineers in research on wind hazard mitigation would benefit both parties and the general public as well.

This is not something new in the Philippines. In 2004, a research collaboration by eight different groups from the academe, from the government, and from the private sector set-up a research network & alliance for urban regeneration of the city of Manila. [Pacheco et al, 2004]

6.2 *Building Code Update for Disaster Preparedness and Hazard Mitigation*

In the "Mitigation" aspect, the NSCP may soon be updated and revised within the next few years. In Chapter 2 of this report, it was shown that the latest NSCP (2001) is based on an American code released in 1995. Meanwhile, that code was updated two times already, with the latest version released in 2002. Codes from other countries have been updated as well, such as that in Japan (1993 version updated in 2004), and Australia/New Zealand (1989 version updated in 2002). It will be worthwhile to study new updates in the American code, as well as new features from codes of other countries such as Japan and Australia/New Zealand, for integration in the next NSCP update. The National Building Code of the Philippines itself, which was passed in 1972 (and still unedited since then), is in the process of being considered for revision.

Likewise, the wind zone map used in NSCP 2001 was based on statistical analysis of monthly data up to 1995. A recent study has analyzed daily data up to 2000 and has proposed a more refined wind zone map. Meanwhile, the American and Japanese codes both use wind contour maps.

Rosaria & Pacheco [2002] have also noted that the actual terrain exposure, surrounding roughness factor and other obstructions, and equipment at the stations have not been verified. As suggested by Holmes & Weller [2002], these should be taken into account when conducting extreme wind analysis.

Lastly, similar to the style of recent American (ASCE) and Japanese (AIJ) codes, an attached commentary would benefit engineer-users of the NSCP, and ultimately the general public. Or, similar to the style of the Australian code (of 1989), commentaries in separate documents were prepared by experts.

6.3 *Formal Organization of Professionals on Wind Engineering*

There are many organizations of professionals on wind engineering around the world. There is of course the International Association of Wind Engineering. There is also the American Association for Wind Engineering, the Japan Association for Wind Engineering, the Australasian Wind Engineering Society, the UK Wind Engineering Society, the Indian Society on Wind Engineering, among others.

There are also many research centers on wind engineering, mostly in prestigious universities, and also as private research companies such as the Wind Engineering Research Center at the Tokyo Polytechnic University (presently the only one of its kind in Asia), the NatHaz (Natural Hazards) Modeling Laboratory at the University of Notre Dame, among many others. Most of these research centers have wind tunnel testing facilities.

Considering that wind storms affect the Philippines more than any other disaster (around 32 thousand people killed, 8 billion made homeless, and around 7 billion U.S. dollars in total cost of damage for all wind disasters in the 20th century), an organization of professionals on wind engineering, or an establishment of a wind engineering research center right inside the Philippines could prove quite beneficial in wind hazard mitigation studies in the Philippines.

However, even as the Philippines is also an earthquake-prone country, there are no pre-dominant organizations on earthquake engineering per se. There have been recent studies related to earthquake engineering in the Philippines, and some of the methodologies used may be applied to wind engineering as well. So far, the ASEP has provided a venue for professional learning and discussion on earthquake engineering, by organizing the 1st Asia Conference on Earthquake Engineering (ACEE) in 2004. Perhaps ASEP, and also the PICE, could be in the best position to spearhead a similar venue for wind engineering in the Philippines.

6.4 *Some Possible Research and Studies for Wind Engineering in the Philippines*

6.4.1 Wind Hazard Mapping

As previously mentioned, an engineering survey of PAGASA synoptic stations should be done in order to determine actual terrain and topography, and for instrument calibration as well as anemometer height. Correction of data for statistical analysis should be applied based on the survey of the PAGASA stations. (Suggested by Rosaria [2001])

Likewise, and as previously mentioned, collaboration between PAGASA, PICE & ASEP engineers, and other groups on research and on preparation of some reports would contribute to efforts on wind hazard mitigation. Perhaps the collaboration could focus more on hazard mitigation and risk reduction, more than disaster mitigation.

An updated wind hazard map based on appropriate extreme value statistical analysis that is suitable for use by engineers and disaster management experts is probably of primary importance. Re-analysis similar to those conducted by Rosaria [2001] and Garciano et al [2005] may be done again, using daily data of up to the most recent year with available data (e.g. 2004).

Rosaria's proposal to use hybrid wind zone/wind contour map may be studied. It could also benefit structural designers in coming up with more economical designs at locations near the boundary of a lower wind zone, or with more consideration for higher wind forces for locations near the boundary of a higher wind zone.

The definition of wind zones could also be studied. Perhaps wind zones could be defined to correspond either to wind speeds associated with PAGASA's Public Storm Warning Signals, or to the corresponding wind speeds in the definitions of tropical storm, tropical depression, typhoon, and super typhoon. With such a definition, engineers, meteorologists, and laymen could easily relate to each other.

It is ideal of course, as suggested by Garciano et al [2005], that the number of years of data could match the intended recurrence period: e.g., 50 years data for 50-year-recurrence period. A digital dynamic wind hazard map that could be accessed on the internet, and that could be continuously updated with new data coming in daily, might be a good idea. A digital version of the map could also help structural designers come up with a more up-to-date and more site-specific value for basic design wind speed, especially for critical structures.

In lieu of a digital version, it would be beneficial to have a separately published wind zone/wind speed map similar to the Australian handbook (HB 212), that could be updated more frequently than the NSCP. The HB 212 (2002) is scheduled for an update by the end of 2005, or early 2006.

A study on update frequency of wind speed maps could be beneficial in defining how often wind speed maps are to be updated.

Lastly, different wind speed maps for different structural performance levels intended could be generated (e.g., habitability, safe use, continuous use, etc.) as proposed by Garciano et al [2005].

6.4.2 Possible Studies Related to the NSCP

Related to wind resistant structural design, the NSCP specifies that a gust factor G_f for flexible structures different from the specified gust factor G for rigid structures shall be determined by a rational analysis. The ASCE 7-95, which is the basis for the NSCP wind load provisions, specifies the same. However in the Commentary accompanying ASCE 7-95, a suggested method is provided. Thus a research into a method of determining G_f that is appropriate for local conditions in the Philippines, and ideally compatible with the present NSCP, would be necessary. Presently, the author is undertaking such research. The current or the next edition of the NSCP may also do well to have an accompanying Commentary such as in the ASCE standard or in the AIJ recommendation, or a separately published Commentary such as in the case of the Australian code of 1989.

The ASCE 7-95 bases its velocity pressure equation on the “mass density of air for the standard atmosphere.” The NSCP has so far only converted the said equation into the SI units for use in the Philippines. Adjusting the numerical constant of the NSCP velocity pressure equation to suit local conditions may be studied (suggested o the author by N. Rosaria), as the mass density of air varies with altitude, latitude, and temperature. [ASCE, 2000]

Curved roofs have become a trend of late, for more “stylish” and modern looking architecture such as those for large gymnasiums, pedestrian footbridges, and other low-rise buildings. This is the case not only in the Philippines, and a research on pressure distribution coefficients for curved roofs could be done that could be used as well in other countries. (Suggested to the author by N. Rosaria) Of course, assuming gable or hip roofs and providing an additional factor of safety could be done in lieu of this, but a research on such topic could reduce such assumptions.

In the current edition of the NSCP, it is also not very clear how to differentiate between “Solid Signs” and “Open Signs.” Similarly, the code specifies quite a large eccentricity for wind loading for solid signs. These parts of the code should be consulted in the reference code (ASCE 7-95) or in other codes. (Suggested to the author by Prof. F. Germar)

This report has presented that wind direction data is available from PAGASA. The recent AIJ-RLB has shown a method in calculating wind directionality factor with hybrid use of meteorological data and simulated/virtual typhoon data. Such method may be used in the Philippines as well.

AIJ Recommendations also suggest the use of a shorter recurrence period for determining habitability of buildings due to vibrations. Although high-rise buildings are not yet as many in the Philippines as in other countries, the numbers could certainly increase in the coming years. In terms of habitability or serviceability, the NSCP controls such by specifying deflection limits only, and as for vibrations, the NSCP does not explicitly explain how it is to be controlled.

6.4.3 Other Possible Studies

Of course, similar to other urban areas, air pollution in Metro Manila has become quite a big problem. Air pollution dispersion in Metro Manila or in other large metropolitan areas in the Philippines such as in Metro Cebu and Metro Davao, as well as other similar topics, could be studied.

PAGASA has its own quick response team, the STRIDE (short for Special Tropical Cyclone Reconnaissance, Information Dissemination and Damage Evaluation), which could very well coordinate with the DQRP teams of ASEP & PICE for an engineering reconnaissance of wind-induced damages. In this way, damages due to wind could be documented for use by engineers in appropriately updating the NSCP for wind-resistant structural design. A manual for such could be drafted and then used by the ASEP & PICE engineers together with PAGASA researchers and volunteers. Of course, there are usually other disasters involved with tropical cyclones such as floods, landslides, and mudslides, and these could be included as part of a larger scope. Similarly, an engineering documentation of damages due typhoons could also be conducted.

Presently, there is one Filipino company, Vibrametrics Inc., that specializes in vibration monitoring of buildings and other structures, using mainly accelerometers. Response monitoring of buildings and other structures due to strong winds could be done. There are recent studies on the use of RTK-GPS in wind-response monitoring, and the feasibility of the use of such, and possible correlation with locally available accelerometer data, could be studied.

Presently, there are no known wind tunnel facilities in the Philippines for wind engineering research. There is one wind tunnel at the National Hydraulics Research Center inside the University of the Philippines, Diliman, Quezon City campus, although it may not provide enough features for more complex wind flow studies around a variety of structures. The feasibility of setting up a wind tunnel for extensive wind engineering research in the Philippines could also be studied.

Sometimes, lack of financial sources for construction is a problem, and construction in rural areas which are usually hit by typhoons are not exactly typhoon-resistant. Research on Low-cost Typhoon-Resistant Construction Materials using locally available materials and Easy-to-follow Typhoon-Resistant Construction Methods possibly in the local language would benefit the population in the said areas, in coordination with the DSWD.

In other countries, there are specially constructed Tropical Cyclone Shelters. These could benefit in evacuation of large communities even prior to the arrival of tropical cyclones, to prevent potential injuries or massive loss of lives. Of course, school buildings and other government or public buildings are presently being used as evacuation sites.

Lastly, the PAGASA-NDRB technical report suggested that basic meteorology be given as a course for architects and engineers. This could be part of a larger-scope one-semester compulsory course on introduction to wind effects on buildings and urban environment for architects and engineers.

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Appendix A

OCD-NDCC Summary of Damages due to Destructive Tropical Cyclones from 1970-2003, and 2004

Appendix B

OCD-NDCC Summary of Damages due to Other Disaster Incidents from 1980-2003, and 2004

Appendix C

1978 Tropical Cyclone Summary (from PAGASA)

Appendix D

2003 Tropical Cyclone Summary (from PAGASA)

Appendix E

News Clippings on Typhoon 'Auring' (ROKE) from the Philippine Daily Inquirer Website

(www.inq7.net)

http://news.inq7.net/breaking/index.php?index=2&story_id=30698

http://news.inq7.net/breaking/index.php?index=2&story_id=30795

http://news.inq7.net/breaking/index.php?index=2&story_id=30796

http://news.inq7.net/breaking/index.php?index=2&story_id=30895

Appendix F

Mr. Michael Padua's Full Detailed Report on Typhoon MUIFA ('Unding')

Available from http://typhoon2000.ph/stormarchives/2004/unding_report/

Appendix G

Photos of Damages due to Typhoon MUIFA ('Unding') taken by Mr. Michael Padua

Available from http://typhoon2000.ph/stormarchives/2004/galleries/photos/unding/index.htm

Appendix H

OCD-NDCC
Final Report on the After-Effects of Destructive Tropical Cyclones (November-December 2004)

Appendix I

Summary of Damages due to Top 10 Worst Typhoons (by D. Alojada & M. Padua for Typhoon2000.ph)

http://typhoon2000.ph/stats/10WorstPhilippineTyphoons.htm

Appendix J

Collection of Internet Resources on Philippine Wind Information