CHAPTER III

METHOD OF CALCULATION

The observed stations are chosen at Bangkok, Chiengmai and Songkhla to collect the data of atmospheric pressure, temperature and humidity. These stations are located at different parts of Thailand. Bangkok located in the central part of the country at Lat. 13° 44' N, Long. 100° 30' E while Chiengmai in the northern part at Lat. 18° 47'N, Long. 98° 59' E and Songkhla in the southern part at Lat. 7°11' N, Long. 100° 37' E. Beside the location in various region, they are the only weather stations in Thailand using radiosonde to take the data of the atmosphere. The balloon carrying radiosonde is launched every day at 0.00 GMT. at each station. It sends the data from the ascending balloon to the receiving ground station by radio wave in FM system with frequency of 403 MHz. The data appear at the ground station in the form of graph. From graph, the data are converted into discrete height and the corresponding atmospheric temperature and dew - point temperature at the different atmospheric pressure levels. The data are shown at surface of the earth and at the pressure level of 100 mb, 850 mb, 700 mb, 500 mb, 400 mb, 300 mb, 200 mb, 150 mb, 100 mb, 70 mb, 50 mb, 30 mb, and 20 mb, respectively. The balloon carrying radiosonde weighted 500 grams with ascending rate of 300 metres per minute. Before launching the base line of baroswitch , temperature element and hygrister are checked to make sure that the correct measurement will be obtained.

The data of atmospheric temperature, dew - point temperature and height are recorded daily. Then these data are averaged and published monthly for distribution to the public. Only the data during the period of 1954 to 1960 for the weather stations at Bangkok, Chiengmai and Songkhla are made available. The data during other period and of Ubon Ratchathani were lost and some appeared in graph form.

From the available data, the value of refractivity, the gradient of the refractive index of air and the effective earth's radius factor can be obtained by the following steps.

i) Changing the dew - point temperature and atmospheric pressure shown in degree centigrade to degree Kelvin (T) by adding 273 to each value

ii) Adding 1000 to every value of pressure shown to get the value in millibar

iii) Using the meteorological sliderule to calculate the relative humidity expressed in per - cent, from the values of dew - point temperature and atmospheric temperature expressed in degree centigrade.

iv) Obtaining the values of saturated vapor pressure (e_s) from Smithsonian Meteorological Table 94 (see Appendix B1) when the atmospheric temperature is higher than or equal to zero degree centigrade. The values for the temperature below zero degree centigrade is tabulated in Smithsonian Meteorological Table 96. The values obtained from these two table are saturation vapor pressures over water and over ice respectively.

v) After getting the saturated vapor pressure at different temperature, the vapor pressure can be calculated by using the formula

$$\text{Vapor pressure } (e) = e_s \times \frac{RH}{100} \text{ mb}$$

where RH, expressed in per - cent, is obtained in step iii)

vi) Once the value of temperature, T (^oK), pressure, P (mb), and vapor pressure, e (mb), are known, The refractivity at different elevation can be evaluated from the formula

$$N = \frac{77.6}{T} \left(P + \frac{4810e}{T} \right)$$

vii) Plot N versus height on graph papers. Use height as abscissa and refractivity N as ordinate.

viii) Evaluate the gradient of refractivity $\frac{dN}{dH}$. To the first approximation, this can be done by assuming that $\frac{dN}{dH} = \frac{\Delta N}{\Delta H}$. This assumption is quite reasonable if the graph is approximately linear in the interval. The values of N_s, H_s and $N_{s + 1km}$, $H_{s + 1km}$ are the values at the surface of the earth and at the height of 1 kilometer above the earth surface respectively. Thus

$$\Delta N = N_s - N_{s + 1 km}$$

$$\Delta H = H_s - H_{s + 1km}$$

Only the troposphere within one kilometer above the earth surface is of interest since radio wave propagation in the lower atmosphere is normally confined within this region.

Since $N = (n - 1) \times 10^{-6}$, therefore $\frac{dn}{dh} = 10^{-6} \frac{dN}{dH} = 10^{-6} \frac{\Delta N}{\Delta H}$. Note that h equals H.

ix) Finally, the value of effective earth radius factor k can be evaluated by substitution of $\frac{dn}{dh}$ obtained in step (viii) into the formula

$$k = \frac{1}{1 + a \frac{dn}{dh}}$$

where a = 6,370 km

The values of k obtained will be subjected to variation when the atmospheric conditions change. To the radio engineers, the statistical average of k is of utmost important. This average corresponds to the fifty per-cent of the time value. Since it is impossible to evaluate the above mentioned average, therfore, the mean value is calculated instead. However, in order to check that the mean value is appropriate to represent the fifty per-cent of the time value, the standard deviation or variant is also calculated. If the result shows that the variant is small as compare to the mean value, then it is reasonable to say that the mean value and the fifty per-cent of the time value are approximately the same. In addition, the mean value of k obtained in this manner will also be suitable to atmospheric conditions in Thailand.

3.1 Sample of Calculation

Shown below, Table 1, are portions of the meteorological data measured at Chiengmai weather station in January averaging over the period of 7 year.

Table 1 Meteorological data of Chiengmai weather station in January.

Elevation	Mean Pressure	Mean Temperature	Mean Dew-poirt
M	Mb	^{o}C	^{o}C
314	1014.6	21.0	14.7
1532	850	14.5	8.4
3147	700	6.8	-5.4

From the above data the values of k are calculated following the procedure outlined in the previous section.

i) Adding 273 to mean temperature, the values in degree Kelvin are obtained as 294 ^{o}K, 287.8 ^{o}K, 279.8 ^{o}K respectively.

ii) From mean temperatures and dew-point temperature, meteorological sliderule is used to calculate the values of relative humidity (RH), which are 67.9%, 67%, 38.5% respectively.

iii) From Smithsonian Table 94 the value of saturation vapor pressure over water (e_s) of the mean temperature which is above zero degree centigrade, $T > 0$, are 24.861 mb, 16.503 mb, 9.8765 mb respectively.

iv) The data obtained is used for the calculation of the vapor pressure from the formula $e = e_s \times \frac{RH}{100}$. The vapor-pressures are 16.656870 mb, 11.057010 mb, and 3.802452 mb.

v) The refractivity, N, at different height are calculated by using the formula

$$N = \frac{77.6}{T}\left(P + \frac{4810e}{T} \right)$$

They are 340, 279, 212

All of the above results are tabulated in the table belows, Table 2

Table 2 Results calculated from meteorological data of Chiengmai weather station in January.

H m	T oK	e_s mb	e mb	RH %	N
314	294	24.8610	16.656870	67	340
1532	287.5	16.5030	11.057010	67	279
3147	279.8	9.8765	3.802452	38.5	212

From the table the values of refractivity N and height H are plotted on a graph paper. Plot N a abscissa and H as ordinate. The resulting curve is show in Fig. 2.

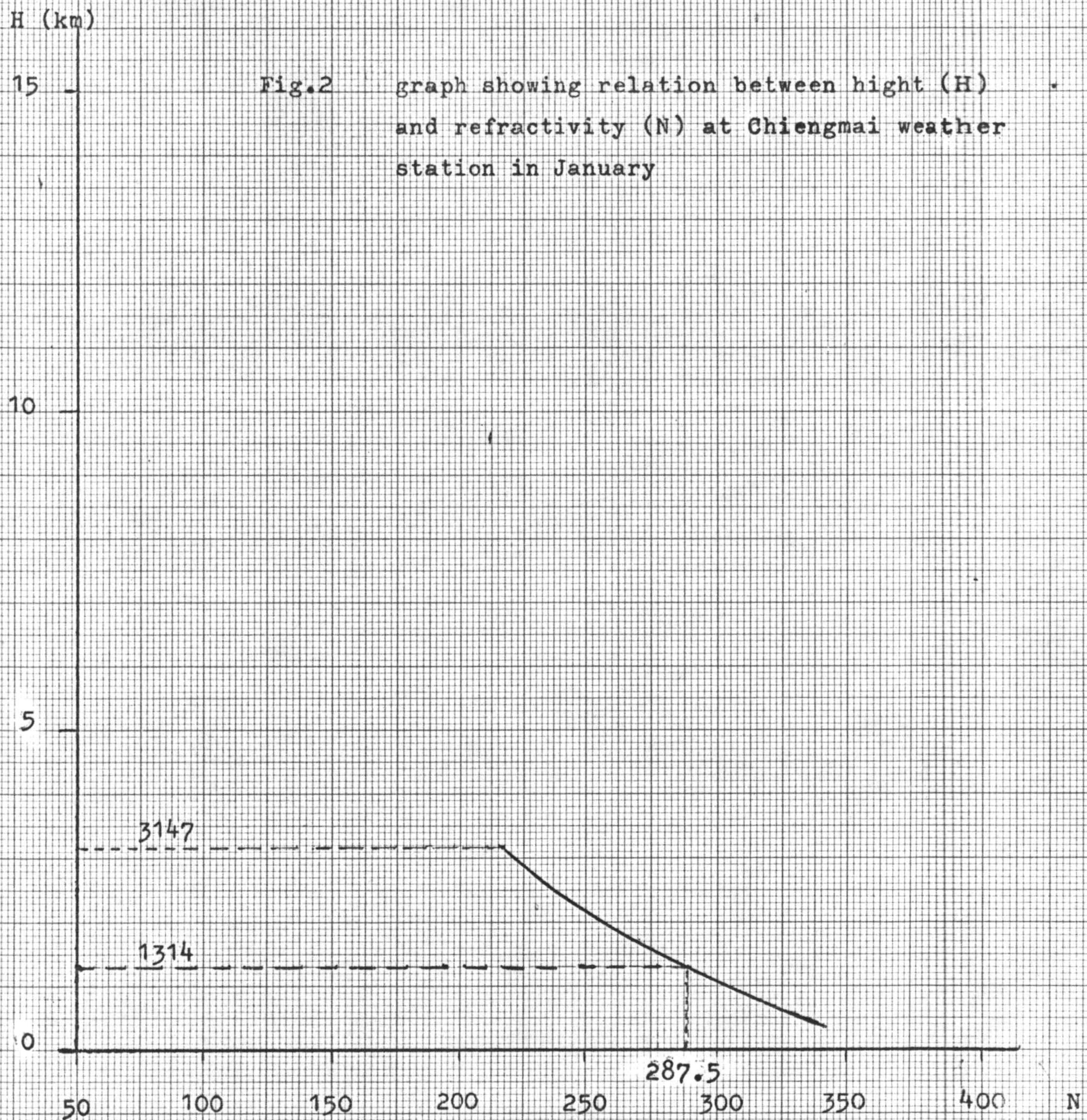

Fig.2 graph showing relation between hight (H) and refractivity (N) at Chiengmai weather station in January

From graph the value of N at elevation of 1314 metres above mean sea level or at the height of 1 kilometre above the earth's surface is 287.5

The value of Δ N is obtained by

$$\Delta N = N_s - N_{1314}$$
$$= 340 - 287.5$$
$$= 52.5$$

The value of Δ H is obtained by

$$\Delta H = H_s - H_{1314}$$
$$= 314 - 1314$$
$$= -1 \text{ km}$$

So the value of $\frac{\Delta N}{\Delta H} = -52.5 / \text{km}$

Then $\frac{dn}{dh} = -52.5 \times 10^{-6} / \text{km}$

They are then substituted into the equation

$$k = \frac{1}{1 + a\frac{dn}{dh}}$$

By using $a = 6{,}370$ km

$$k = \frac{1}{1 + 6370\,(-52.5 \times 10^{-6})}$$
$$= 1.50$$

This is the value of k for Chiengmai weather station in January. Another values of k in each month of each weather station are calculated in the same way.

From the data obtained, twelve values of k for Chiengmai, Bangkok and Songkhla are obtained. They are shown in the Table 3

Table 3 Values of k at Chingmai, Bangkok and Songkhla weather statian.

Month	Chiengmai	Bangkok	Songkhla
January	1.50	1.50	1.60
February	1.51	1.66	1.65
March	1.45	1.68	1.58
April	1.51	1.66	1.51
May	1.51	1.66	1.60
June	1.63	1.72	1.68
July	1.69	1.59	1.66
August	1.53	1.46	1.52
September	1.63	1.51	1.65
October	1.49	1.53	1.55
November	1.54	1.67	1.54
December	1.51	1.59	1.60
Σ	18.49	19.28	19.24

All of these values of k are then calculated to get the fifty per-cent of the time value. It is done by getting the average value of k first by using the formula

$$\bar{k} = \frac{18.49 + 19.28 + 19.24}{36}$$

$$= 1.59$$

Then the variant is calculated by the formula

$$\sigma^2 = \frac{\Sigma (k - \bar{k})^2}{(n - 1)}$$

by σ = variant and n = number = 36

$$\sigma^2 = \frac{0.1859}{35} = 5.3 \times 10^{-3}$$

$$\sigma = (0.53)^{\frac{1}{2}} \times 10^{-2}$$

It is seen that variant is very much less than the average value, $\sigma \ll \bar{k}$, $\left[(0.53)^{\frac{1}{2}} \times 10^{-2} \ll 1.59 \right]$. Therefore, it is reasonable to conclude that in this case the average value of k is the fifty per-cent of the time value, that is $\bar{k} = k_{50\%} = 1.59$

In addition, the data used in the evaluation of k's value are taken from various parts of Thailand and represent different atmospheric condition in the country. Consequentely, the value of k obtained, i.e. 1.59, is appropriate as a representative value for the atmosphere in Thailand.