CHAPTER IV

METHODOLOGY

The procedures of this study can be illustrated by the following:

4.1 *Data Collection*

4.1.1 Brewer Spectrophotometer

The Brewer Umkehr data during 2001-2003 was collected from Songkhla station. There is some limitation of good Umkehr record available, due to a clear weather condition is necessary for an Umkehr measurement, therefore the qualified data set (the iteration is not more than three times and the other condition as in flowchart) was considered from period of April to December in 2001, February-July in 2002 and February-April in 2003. The Brewer Umkehr observation is controlled routinely under schedule (SKC: the schedule which made by the operator for the Brewer measurement) which the operator determined. The Umkehr measurement operates routinely in the early morning or late afternoon between solar zenith angles 60 and 90 degree. Clear sky conditions are necessary for good results. The zenith prism is set skyward and the Brewer is oriented perpendicular to the solar azimuth. Observations must be terminated by the operator or in SKC by the next zenith angle entry. Umkehr measurements are made using two sets of wavelengths: 'short' (306.3, 310.0, 313.5, 316.8, and 320.1 nm) and 'long' (316.8, 320.1, 323.2, 326.4 and 329.5 nm) wavelengths. The data is put into the day file on disk. The Umkehr data is made when the summation (SUM) command. Observations must be terminated by the operator or in schedule operation by the next zenith angle entry. The Umkehr measurement is done in two steps. The first step is the pre-processing step wherein the raw data collected by the Brewer Control Program and stored in the Ujjjyy.nnn files of the data disk (see appendix A). The detail of Brewer processing and analysis can be seen in the appendix B.

4.1.2 Ozone Sonde

The Ozone Sonde data was selected from Sepang airport of Malaysia (Lat. 2.4 N, Long. 101.7 E) in 2001-2002 (the data contained within CD-ROM called "red book" from World Ozone and Ultraviolet Radiation Data Centre; WOUDC). With the frequency of observation is two times a month both in two years. The sensor of the Ozone Sonde is made from an Electrochemical Concentration Cell (ECC) which

solution of potassium iodide (KI). It is used to produce a weak electrical current. The current measured is proportional to the ozone concentration of the sampled air. The data of Ozone Sonde expressed as ozone partial pressure which the ozone amount can be determined with the equation:

$$P_{ozone} = C \cdot i \cdot T_p \cdot t \quad (4.1)$$

where:

P_{ozone} = ozone partial pressure (in nanobars);

C = instrumental constant;

i = current;

T_p = pump temperature; and

t = amount of time to force 100 milliliters of air through the system.

In a unit "number density (molecules/cm^3)" of ozone profile, it can be converted into "partial pressure (nb)" with the following relationship:

$$P_{ozone} = (\text{number density})\, kT \quad (4.2)$$

where:

P_{ozone} = number density

k = Boltzman's constant (1.38×10^{-23} J/K)

T = temperature measured in degree Kelvin (0° C= 273.15° K)

Then atmospheric partial pressure can be interpolated as a function of height at standard pressure with the following formula:

$$p = p_0 \exp(-z/h) \quad (4.3)$$

where:

h = scale height (using 6000 meters for the scale height)

p_0 = 1013.25 mb

z = height in meters

In addition, the data set from Malaysian Ozone Sonde was considered to be monthly average in a period of two years.

4.1.3 SAGE II

The measurement of SAGE II is using solar occultation technique (measured sunlight through the limb of the Earth's atmosphere) does not provide daily global coverage. It rather tracks over certain orbit and covers some range of latitudes and

longitudes. Therefore, this study is used as for a broader criteria (scan Lat.7.9-14.8 N, Long.163.6-167.1 W in 2001 and Lat.8.9-15.8 N, Long.137.6-133.5 E) [16] to find a match for Songkhla station and use averaged profile for comparison (the ozone in stratosphere does not change much over these conditions). The SAGE II raw data is expressed as ozone number density with pressure therefore the pressure can be interpolated as a function of height at standard pressure with Eq.4.3. The SAGE II data can be accessed and read by Fortran 90 complier [16].

4.2 Umkehr Analysis

The Umkehr measurement technique is strongly depended on scattering of radiation in the atmosphere. The variation of the mean scattering height of radiation reaching the instrument is a function of the solar zenith angle and total amount of ozone. There are three separate options which controlled through the output data namely, the first-guess ozone profile, the observation ozone profile and the a priori ozone profile. The set of first-guess (x_1) profiles are those of Mateer, DeLuisi and Porco (1980) for total ozone at low latitude, mid latitude and high latitude respectively. For observed total ozone intermediate between these values the first-guess profile is linearly interpolated to fit the observed total ozone. The first-guess to be compared against the actual observation ozone profile and their difference is resolved into change to the a priori ozone profile (or climatological profile) where the a priori ozone profile to be created with the Ozone Sonde observation (for the lower stratosphere) and SAGE II (for the upper stratosphere). The program will be stopped when the new adjusted profile is produced. The flowchart of Umkehr measurement is expressed as Fig. 4.1.

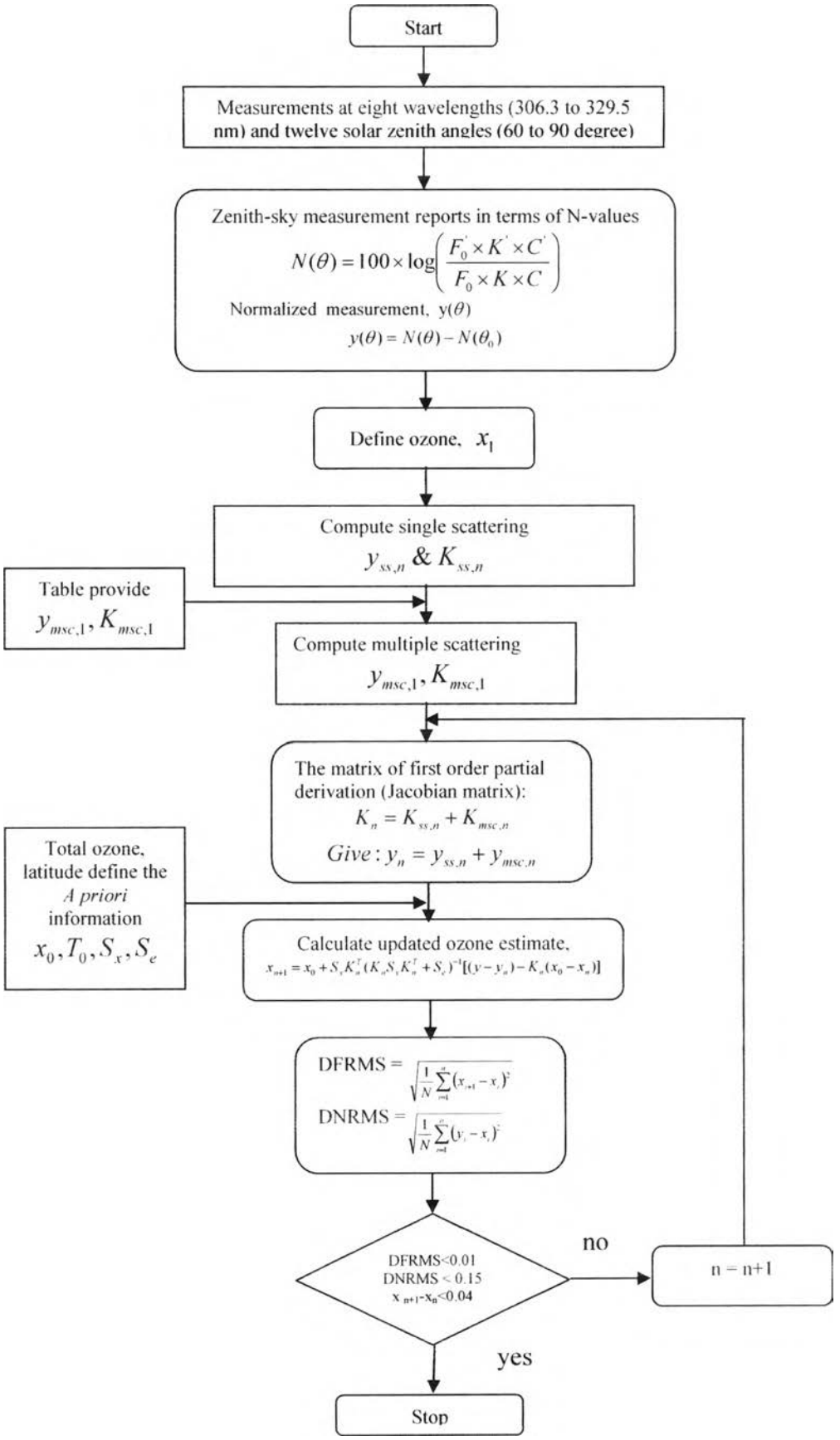

Fig. 4.1 Flowchart of the Brewer Umkher measurement

4.3 Internal Standard

The ozone profiles retrieved from the Brewer measurement at Songkhla station (Lat. 7.2 N., Long. 101.6 E.) were compared with the data set obtained from Ozone Sonde observation at Petaling Jaya station of Malaysia (Lat. 3.1, Long. 101.6 E.). To support this reason, total ozone were firstly compared. The results of the comparison are good agreement and the total ozone values are normally more different in summer season as shown in Figs. 4.2 and Fig.4.3.

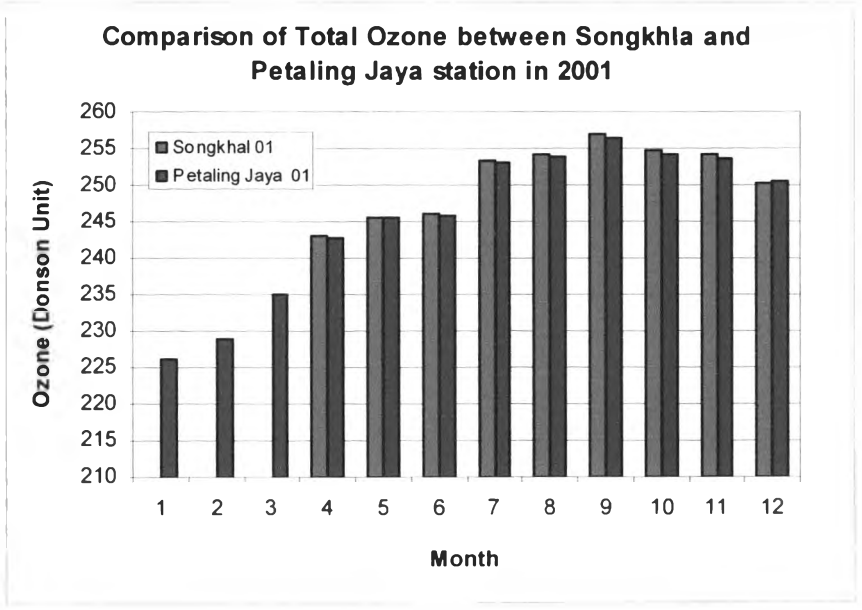

Fig. 4.2 Comparison of total ozone between Songkhla and Petaling Jaya station, 2001

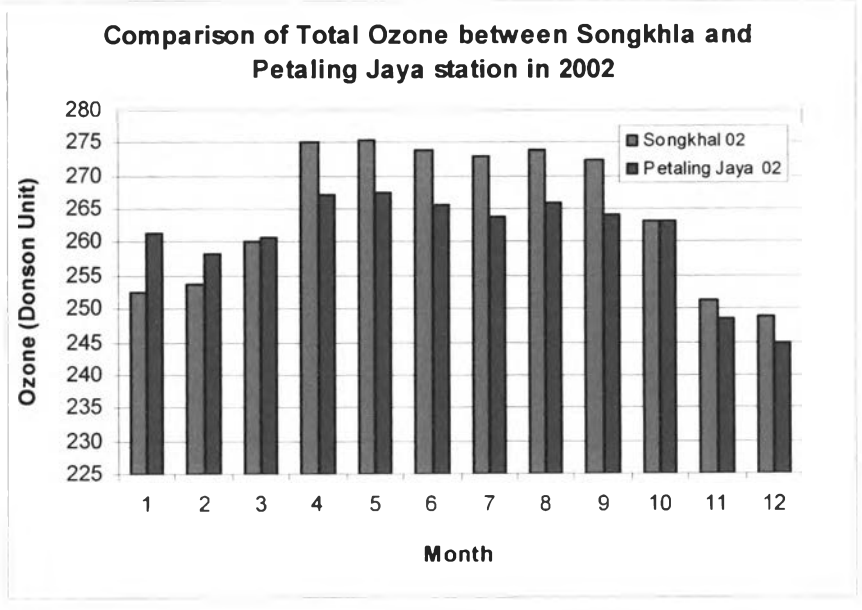

Fig. 4.3 Comparison of total ozone between Songkhla and Petaling Jaya station, 2002

Total ozone is latitudinal dependence. It is usually more concentrated when latitude of the station increases, for example in Figs. 4.1 and Fig. 4.2 which show that the values of total ozone measured at Songkhla station in 2002 are greater than at Petaling Jaya station with the values differed by 264 and 261 Dobson Units.

However, they are different in small percentage or close together as seen in the 2001 comparison and that the annual average values of total ozone at Songkhla station and Petaling Java station are equally 251 Dobson units.

Therefore the data set obtained from Ozone Sonde observations in Malaysia was selected to using to support study with the Brewer umkehr measurements.