CHAPTER IV

CLIMATIC TEMPERATURE CHANGE SIMULATION AND EXAMPLE

Climatic temperature change program developed in this work is a simulator for calculating sea-surface temperature, including theoretical data about global warming base for environmist and one who is interested in this field. The simulation can be used to predict the increasing sea-surface temperature in two patterns. One is prediction of average global temperature at any time. The other is prediction of global temperature change subject to any greenhouse gas concentration. This chapter presents details of climatic temperature change simulation program which was developed by Visual Basic language.

4.1 Simulation Procedures

Robert D.Cess and *Steven D.Goldenberg* proposed an ocean-land global climate model in 1981. The simulation result from this model agrees well with more detailed model studies, such as the $2.93^{\circ}C$ global warming for $2xCO_2$ predicted by *Manabe and Wetherald* [1975] employing a general circulation model. Ocean heat capacity is incorporated by means of a global ocean model. Then time-dependent global warming due to increasing levels of atmospheric carbon dioxide has been estimated. The model applied for simulating the climatic temperature change in this thesis is similar to that of *Cess* and *Goldenberg*, however, the effect of other greenhouse gases including methane, nitrous oxide and chlorofluorocarbon are considered. With this extended model,

the user can estimate temperature change taking place by changes in concentration of various greenhouse gases. The simulation will cover global temperature since 1860 (preindustrial) and atmospheric concentration of carbon dioxide greater than 287 ppm.

The following procedures are used in this simulation:

a) Study and analyse climatic temperature change equation, by considering the energy balance, with all variables and parameters.

b) Classify variables and parameters into an appropriate group of database for calculation in the simulation.

c) Create or select data file of simulation factor, simulation variables and parameters, and simulation result form and display.

d) Create calculating loop to determine sea-surface temperature by using data file and model's equation of each simulation factor.

e) Show the calculation results of sea-surface temperature occurred from each simulation factor.

4.2   Simulation Data

There are a lot of essential data to be collected for calculation in this simulation. They can be classified into three groups of data as presented below:

The first group of data is the simulation factor. In this group, the sea-surface temperature can be calculated as a function of time factor or greenhouse gas factor up to the user, respectively.

The second group is simulation variables and parameters which are time relative to the year of 1860, greenhouse gas concentration, greenhouse gas

growth rate, heat capacity, specific heat, density, and thermal diffusivity of sea water.

The last group of data is simulation result form and display. The numerical or graphical data result form, only simulation result or simulation result compared with reference result can be chose by users.

These data input are useful for calculation sea-surface temperature by using equations in atmospheric-oceanic model from chapter III.

4.3   Simulation Flow Diagram

4.3.1   Temperature change with respect to time
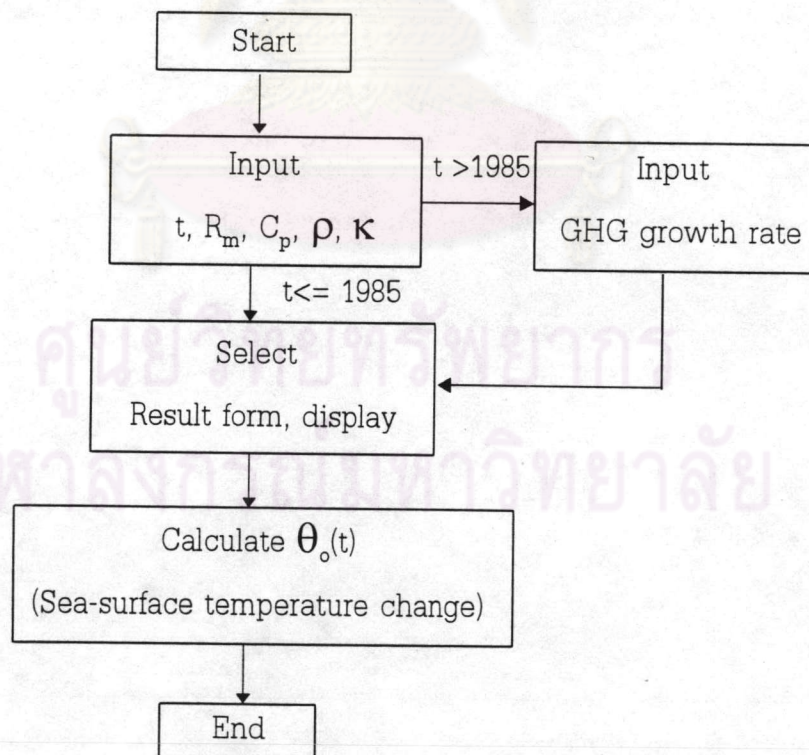
Figure 4.1   Flow Diagram for Time Simulation Factor

4.3.2 Temperature change with respect to concentration of greenhouse gases

A flowchart with the following boxes connected top to bottom:

- Start
- Input R_m, C_p, ρ, κ, GHG
- Input $[CO_2]$, $[CH_4]$, $[N_2O]$, $[CFC]$
- Select Result form, display
- Calculate $\theta_o([GHG], t)$ (Sea-surface temperature change)
- End
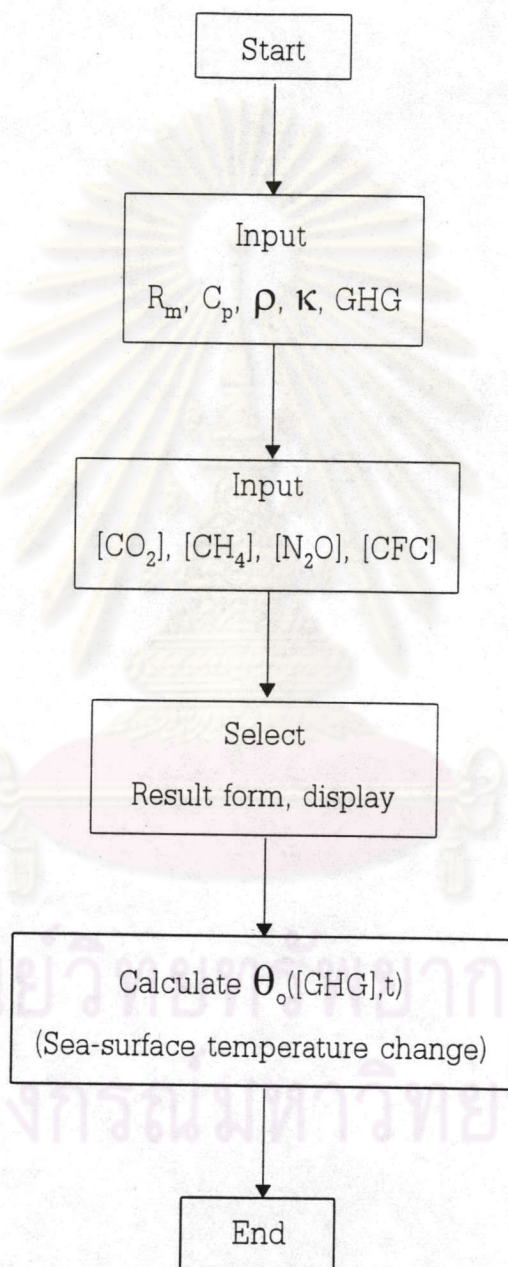
Figure 4.2   Flow Diagram for Greenhouse Gas Simulation Factor

4.4   Simulation Program Menu

4.4.1   Main menu

The program starts from **Main** menu as shown in Figure 4.3. There are two types of simulation factors in this menu. Select factor and then click **Next** button to continue to input data for calculation.
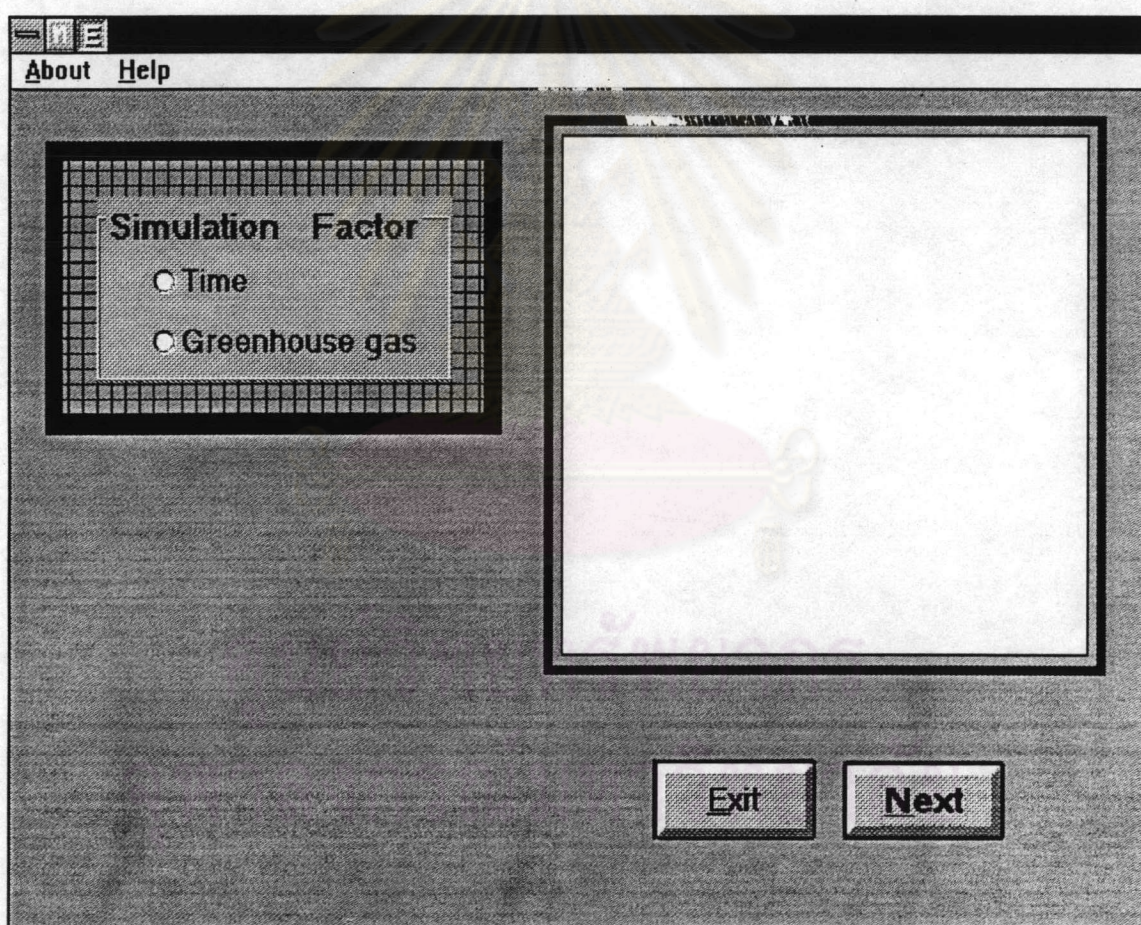
Figure 4.3   Main Menu

4.4.2   Simulation variables and parameters data menu

This menu consists of the following items of data for selection and input for each simulation factor.

4.4.2.1   Temperature change with respect to time

a)   Time

b)   Heat capacity of sea water

c)   Specific heat of sea water

d)   Density of sea water

e)   Thermal diffusivity of sea water
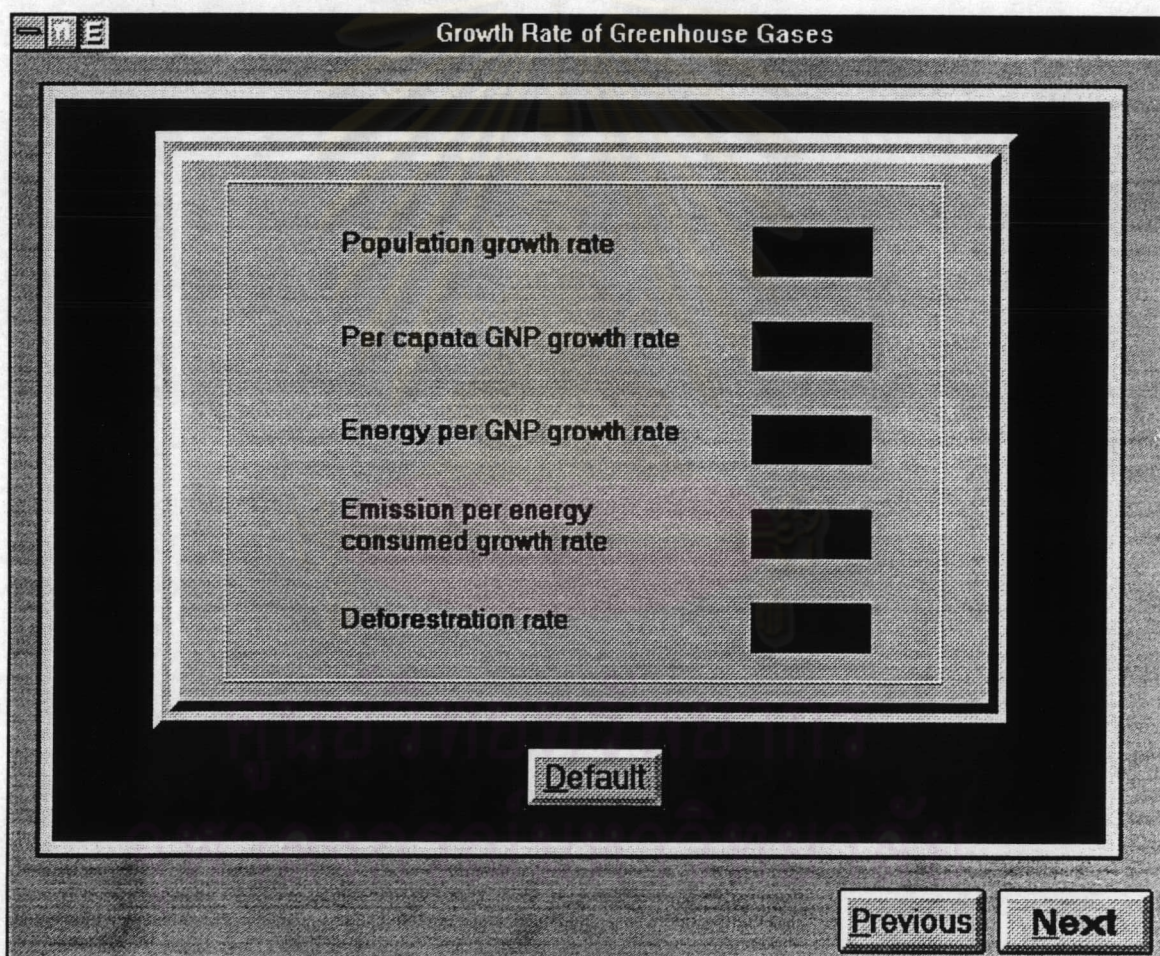
Figure 4.4   Simulation Variables and Parameters Data Menu
for Time Simulation Factor

The calculation of this simulation will be started from inputting the considered year, heat capacity, specific heat, density, and thermal diffusivity of sea water. When all data in this menu are inputted, click **Next** button to continue.

f)   Greenhouse gas growth rate

Figure 4.5   Greenhouse Gas Growth Rate Data Menu
for Time Simulation Factor

If the user would like to estimate the sea-surface temperature change since 1986, the growth rate of each considered greenhouse gas must be define in the above menu.

4.4.2.2) Greenhouse gas simulation factor

a) Type of greenhouse gas

b) Heat capacity of sea water

c) Specific heat of sea water

d) Density of sea water

e) Thermal diffusivity of sea water

Figure 4.6　Simulation Variables and Parameters Data Menu
for Greenhouse Gas Simulation Factor

The calculation of this simulation will be started from selecting the considered greenhouse gas type, at least carbon dioxide, inputting heat capacity, specific heat of sea water, density of sea water, and thermal diffusivity. When all data in this menu are selected and inputted, click **Next** button to continue.
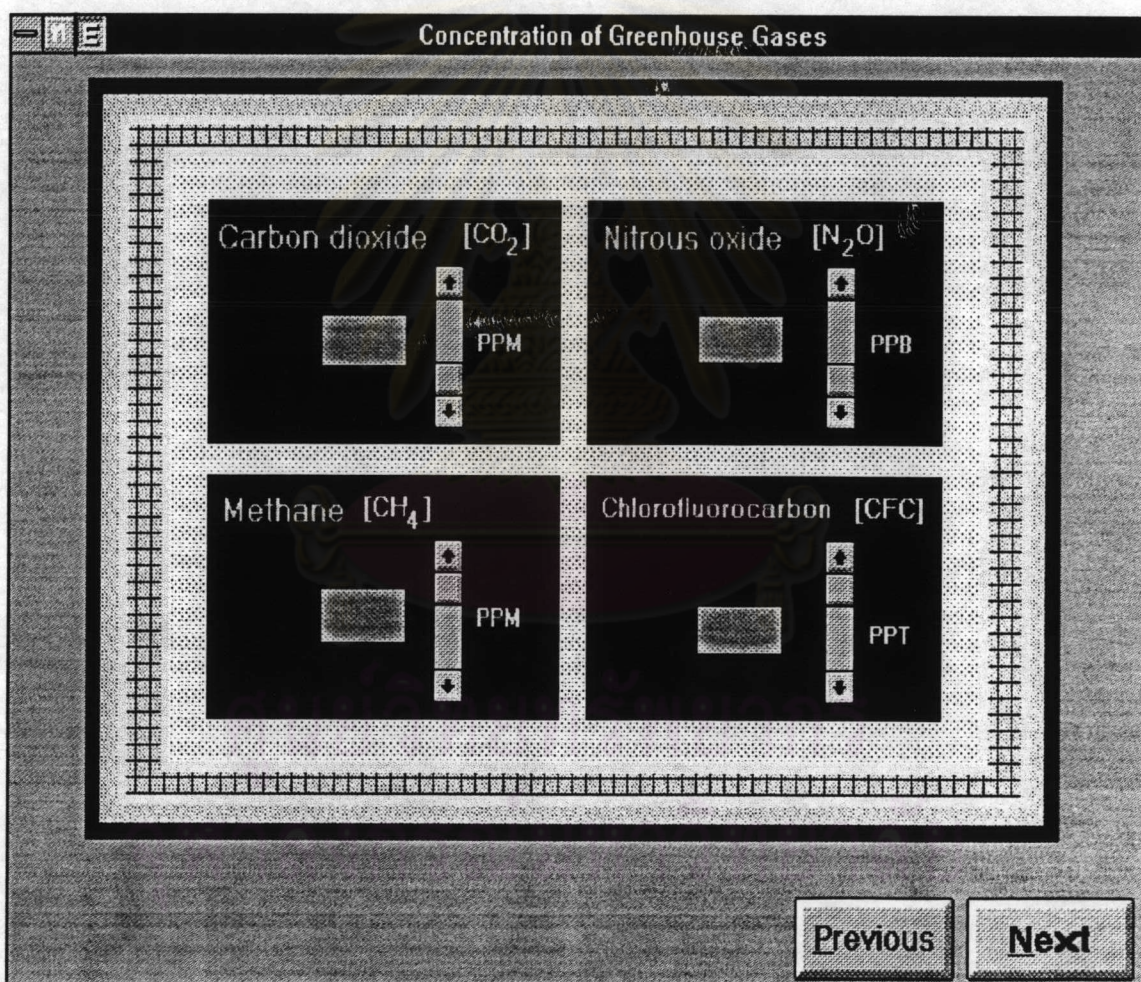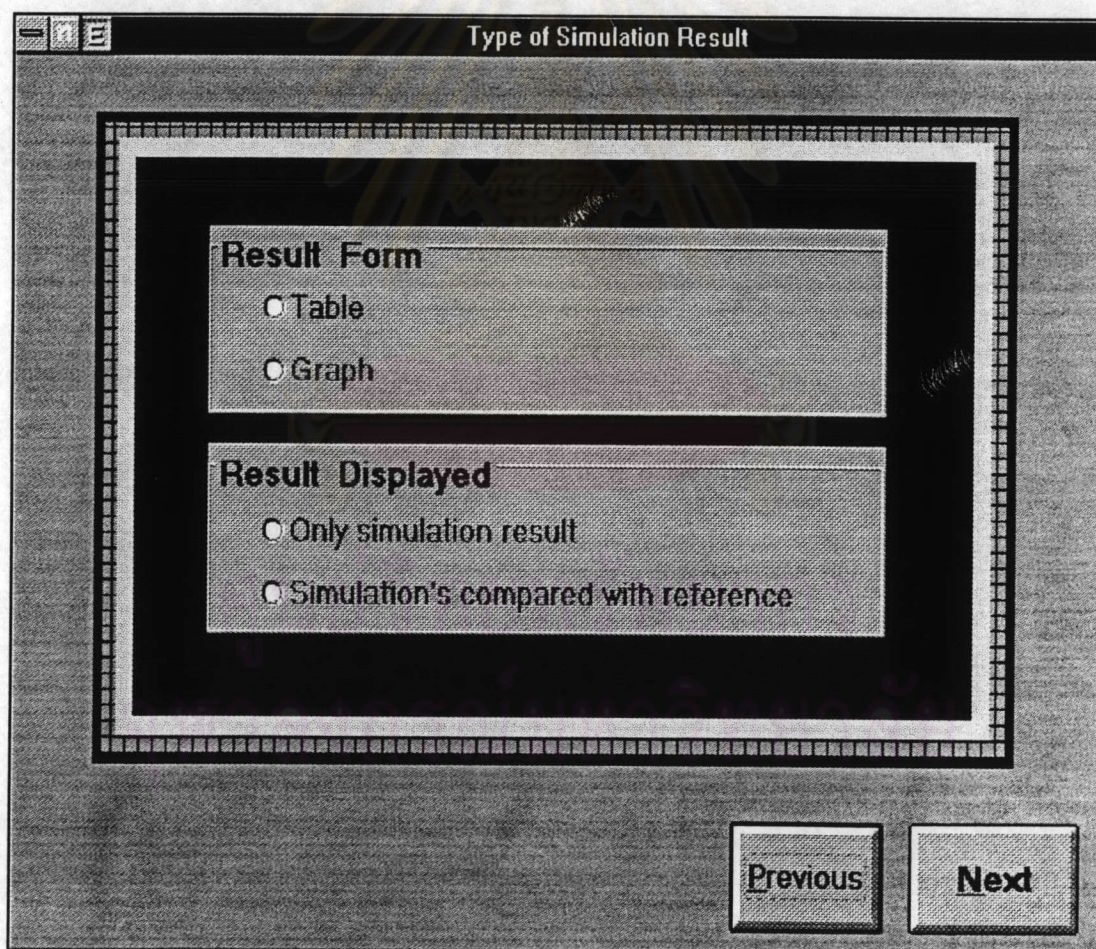
f)   Greenhouse gas concentration

Figure 4.7   Greenhouse Gas Concentration Data Menu
for Greenhouse Gas Simulation Factor

When inputting the selected atmospheric greenhouse gas concentration as Figure 4.7 already, click **Next** button to continue.

4.4.3 Simulation result form and display menu

In this stage, users can choose form of results to be displayed as numerical or graphical results. Then, this result can be compared with the observed value of sea-surface temperature as shown in Figure 4.8.

Figure 4.8 Simulation Result Form and Display Menu

4.4.4   Climatic temperature change result menu

This last menu indicates the change of sea-surface temperature from 1860 's to the time specified in time simulation factor (Figure 4.4) or in the function of carbon dioxide (including the other greenhouse gases) from the industrial revolution until the specified value in greenhouse gas simulation factor.

4.5   **Program Running**

When the simulation is selected to calculate climatic temperature change from one of the above types in **Main** menu, the following menu of data entry will appear consecutively.

4.5.1   Simulation of sea-surface temperature with respect to time

The program will be executed by clicking selection time simulation factor button on the **Main** menu. Then input simulation variables and parameters data as mentioned in 4.4.2.1 and choose simulation result form and display data menu. This menu has two boxes of simulation data select as follows:
- Result form
- Result display

When all necessary data are input, Click **Next** button in simulation result form and display menu to execute the simulation. The program will calculate the sea-surface temperature and show the results in the **Climatic Temperature Change Result** menu (Figure 4.9).
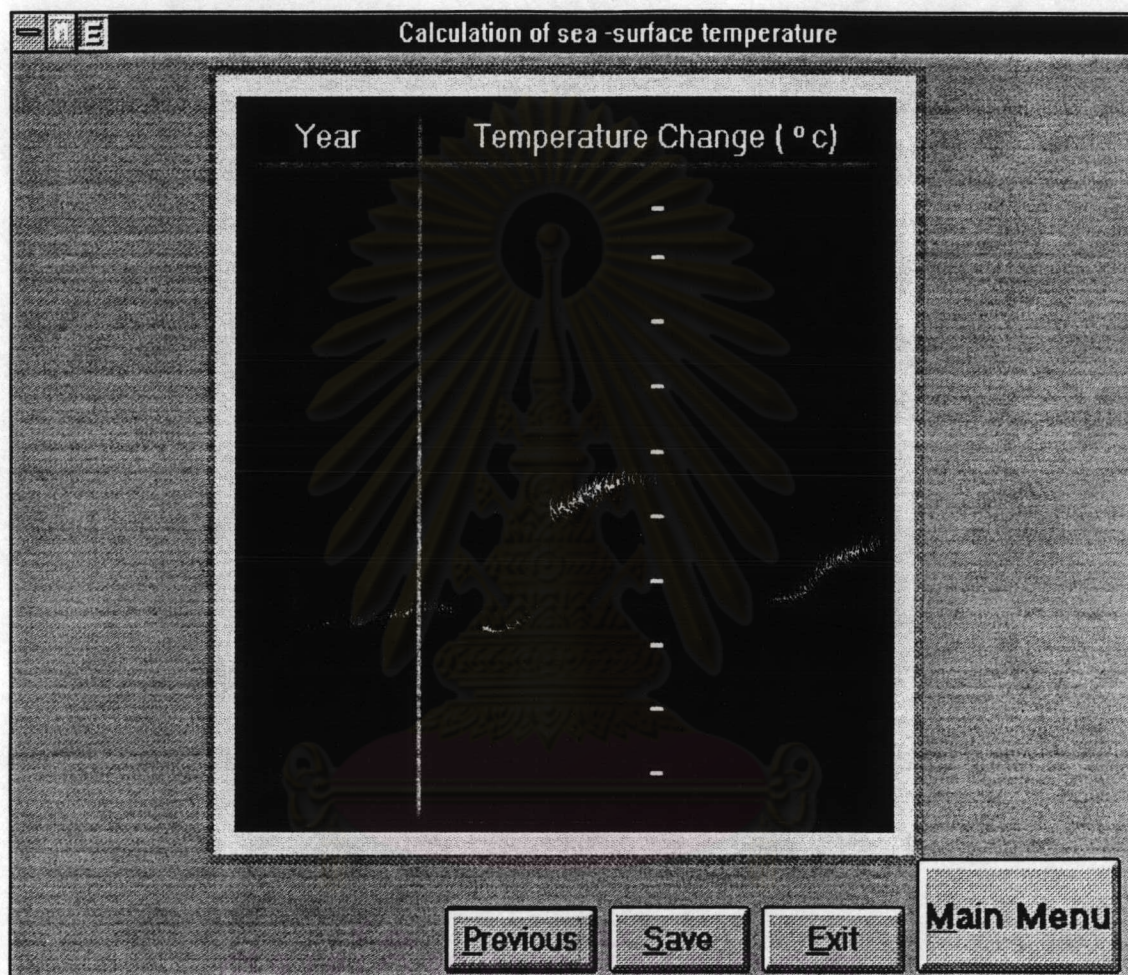
Figure 4.9 Climatic Temperature Change Result Menu
for Time Simulation Factor

4.5.2 Simulation of sea-surface temperature with respect to concentration of greenhouse gas

The calculation will be started from **Main** menu by selecting greenhouse gas simulation factor and simulation variables and parameters data will be input as mentioned in 4.4.2.2, simulation result form and display menu will appear to allow users to choose. Finally, the simulation result will be shown as in Figure 4.10.

Figure 4.10   Climatic Temperature Change Result Menu
for Greenhouse Gas Simulation Factor

4.6   Simulation Examples

4.6.1   Using time factor, display only numerical simulation result

Figure 4.11   Climatic Temperature Change Numerical Results Menu
(using Time Factor)

4.6.2 Using time factor, display numerical simulation result compared
with reference

Year	Sea-surface temperature (°C)			
	Thesis			Reference
1860	13.7864	–	13.7864	13.78
1874	13.7943	–	13.7956	13.74
1888	13.8063	–	13.8096	13.79
1902	13.8246	–	13.8310	13.99
1916	13.8526	–	13.8638	14.15
1930	13.8955	–	0.3667	14.14
1944	13.9610	–	13.9903	14.32
1958	14.0611	–	14.1072	14.29
1972	14.2141	–	14.2859	14.18
1988	14.4902	–	14.6084	14.5

Previous | Save | Exit | Main Menu

Figure 4.12   Climatic Temperature Change Numerical Results Menu
compared with Reference (using Time Factor)

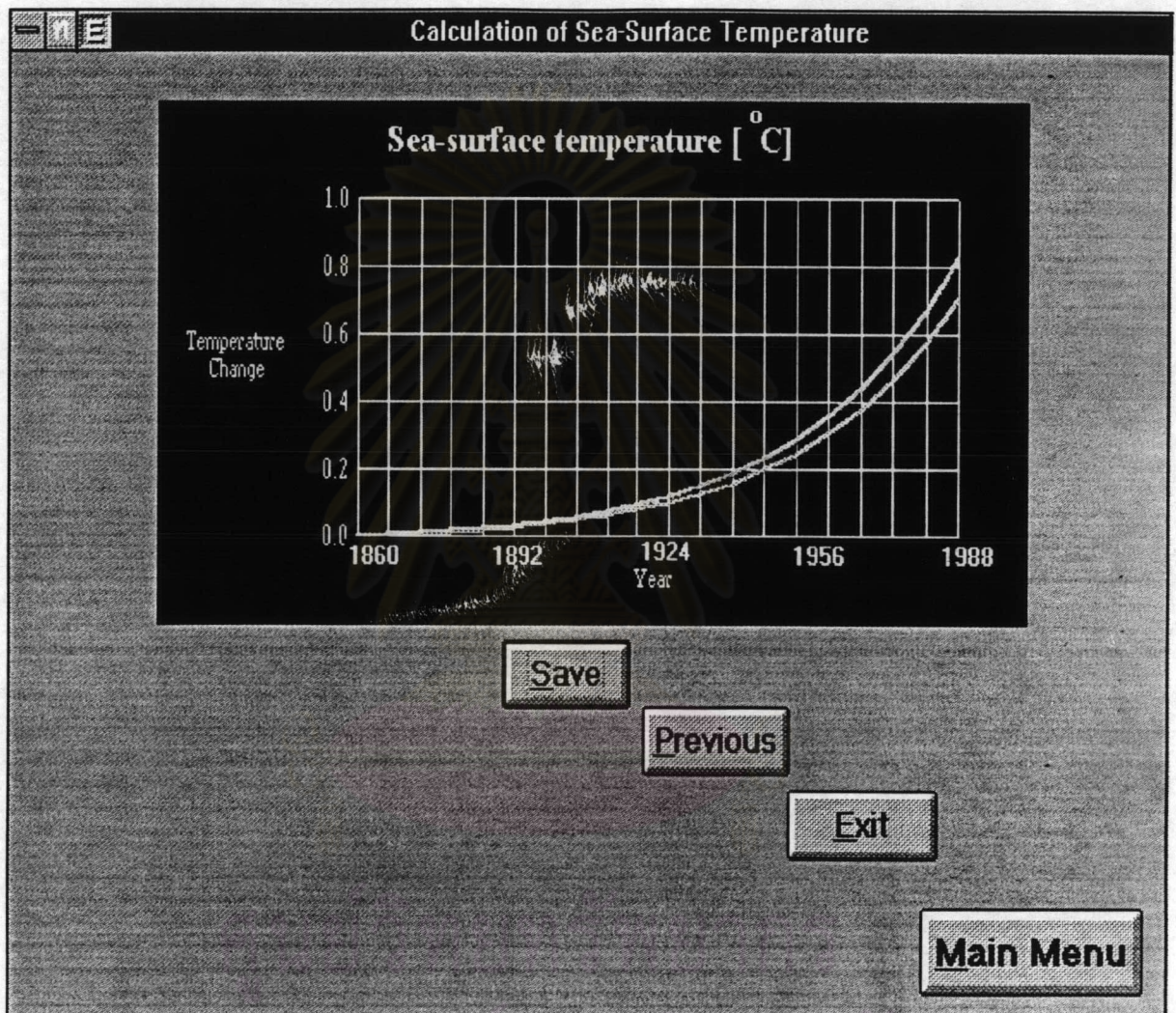4.6.3   Using time factor, display only graphical simulation result

Figure 4.13   Climatic Temperature Change Graphical Results Menu
(using Time Factor)

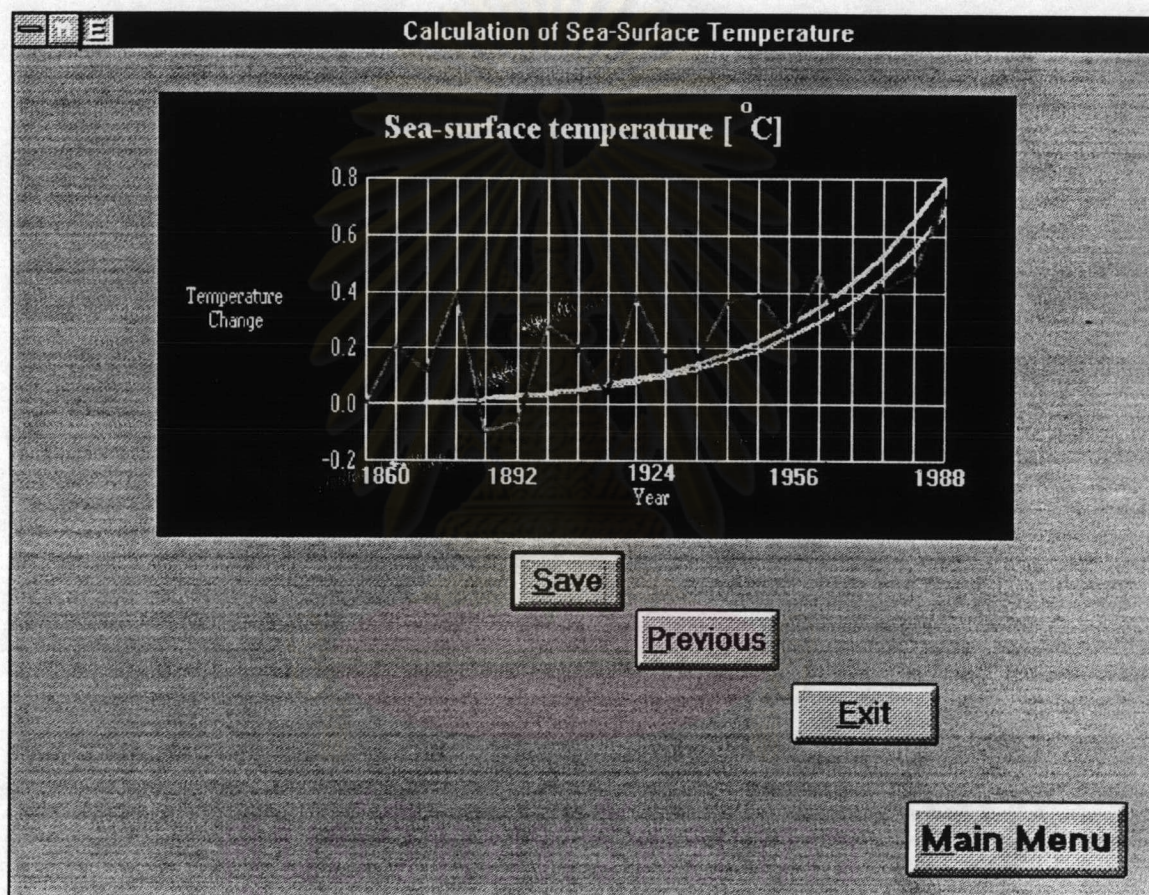4.6.4 Using time factor, display graphical simulation result compared with reference

Figure 4.14 Climatic Temperature Change Graphical Results Menu compared with Reference (using Time Factor)

4.6.5   Using GHG factor, display only numerical simulation result

Figure 4.15   Climatic Temperature Change Numerical Results Menu
(using GHG Factor)

4.6.6   Using GHG factor, display numerical simulation result compared
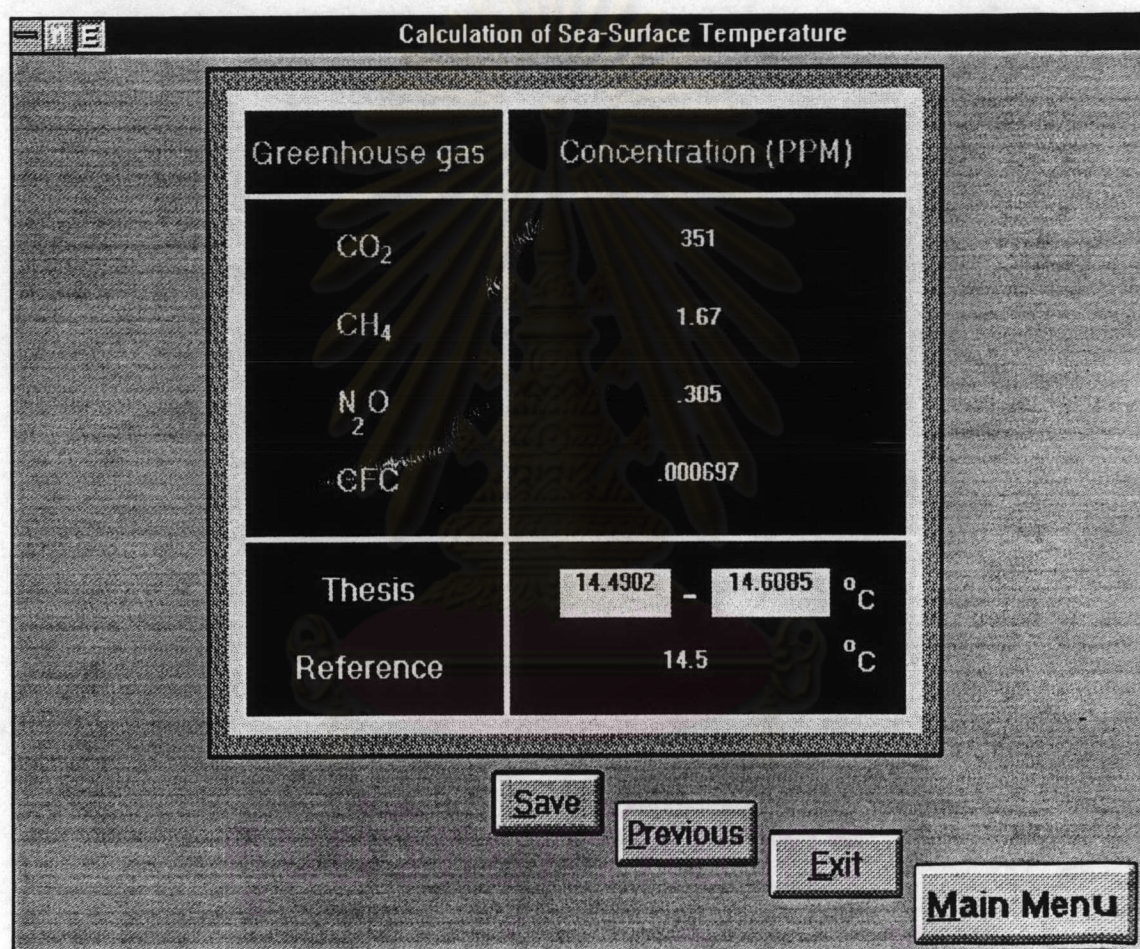with reference

Figure 4.16   Climatic Temperature Change Numerical Results Menu
compared with Reference (using GHG Factor)

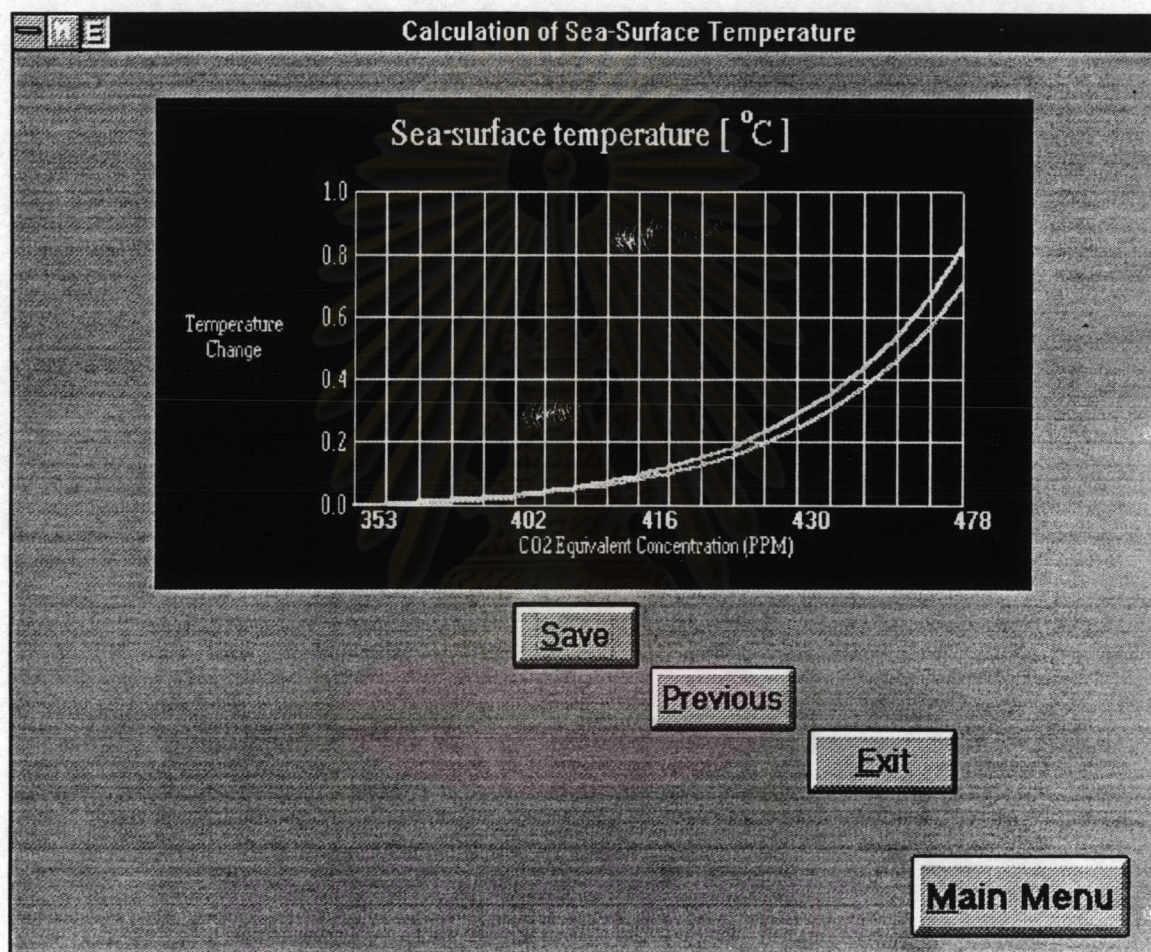4.6.7 Using GHG factor, display only graphical simulation result

Figure 4.17 Climatic Temperature Change Graphical Results Menu
(using GHG Factor)

4.6.8 Using GHG factor, display graphical simulation result compared with reference
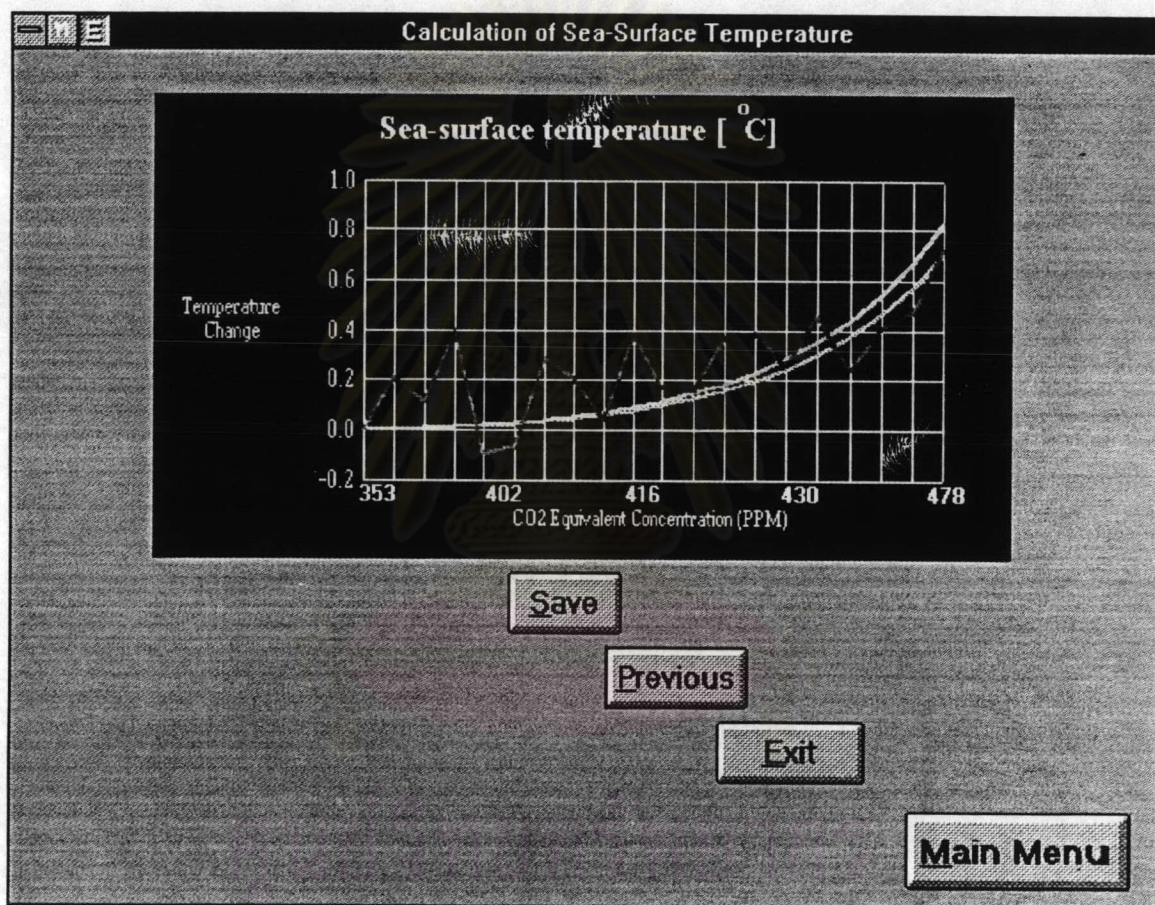

Figure 4.18   Climatic Temperature Change Graphical Results Menu
compared with Reference (using GHG Factor)

4.7 Theory Presentation

The user can access theory section by select "Help" menu item. The content of subjects will appear as shown in Figure 4.19. Each topic has hypertext which is linked together. Users are able to obtain the detail of subjects wanted by clicking a mouse on the selected topic.
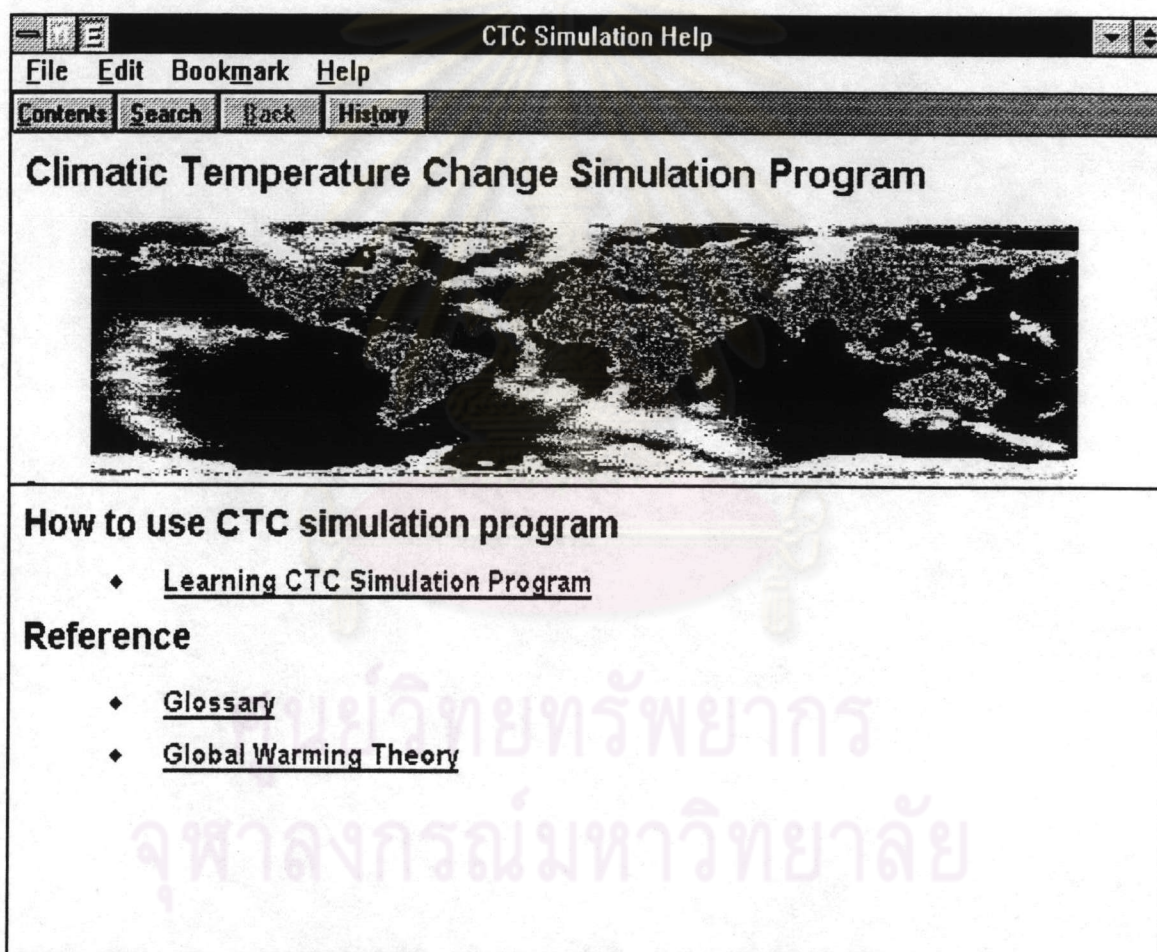

Figure 4.19 Content of the Climatic Temperature Change Simulation Program Help

Furthermore, the user can also access the required topics by calling the search dialog box and input keyword to search as shown in Figure 4.20.
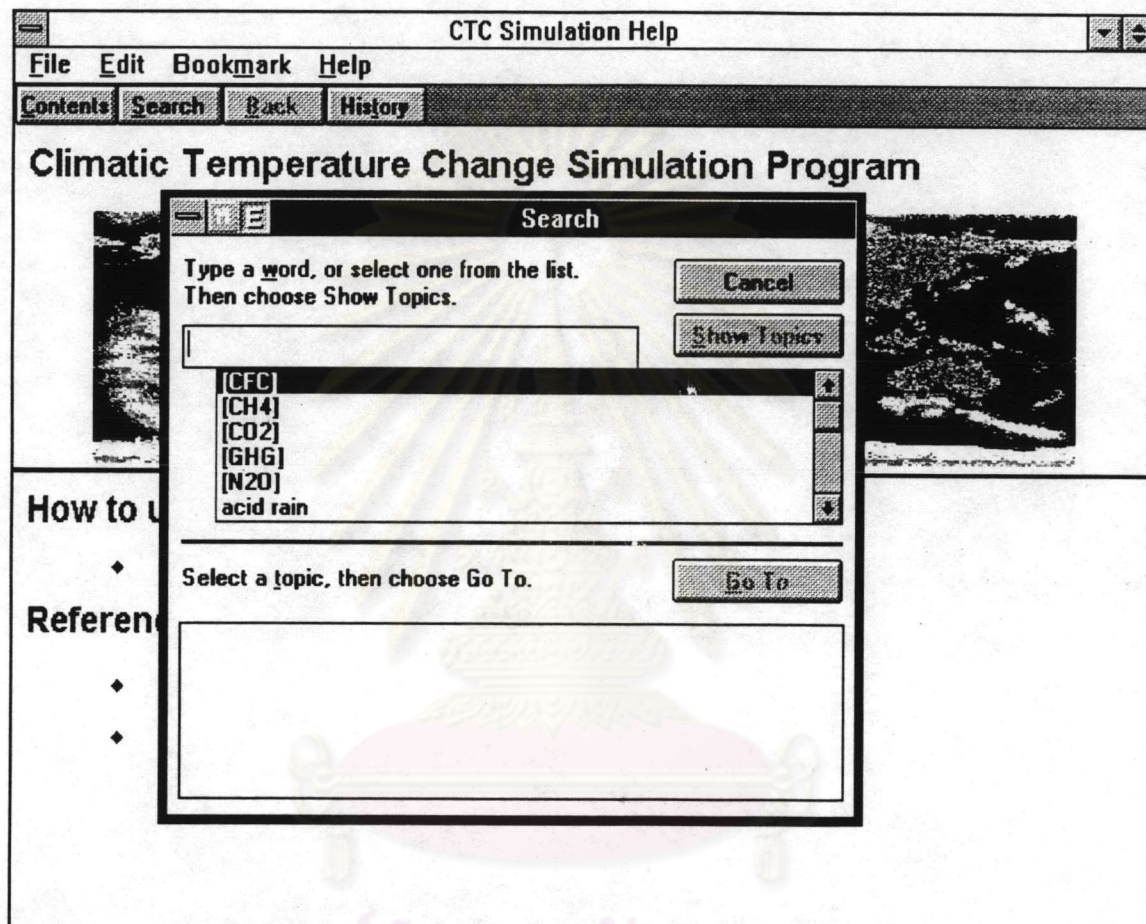

Figure 4.20   Search Dialog Box in Theory Section

There are many equations which is described in chapter III. The theoretical section of this climatic temperature change simulation program supports those equations with hot spots. The user can click on the symbol to see nomenclature in pop-up window as illustrated in Figure 4.21.
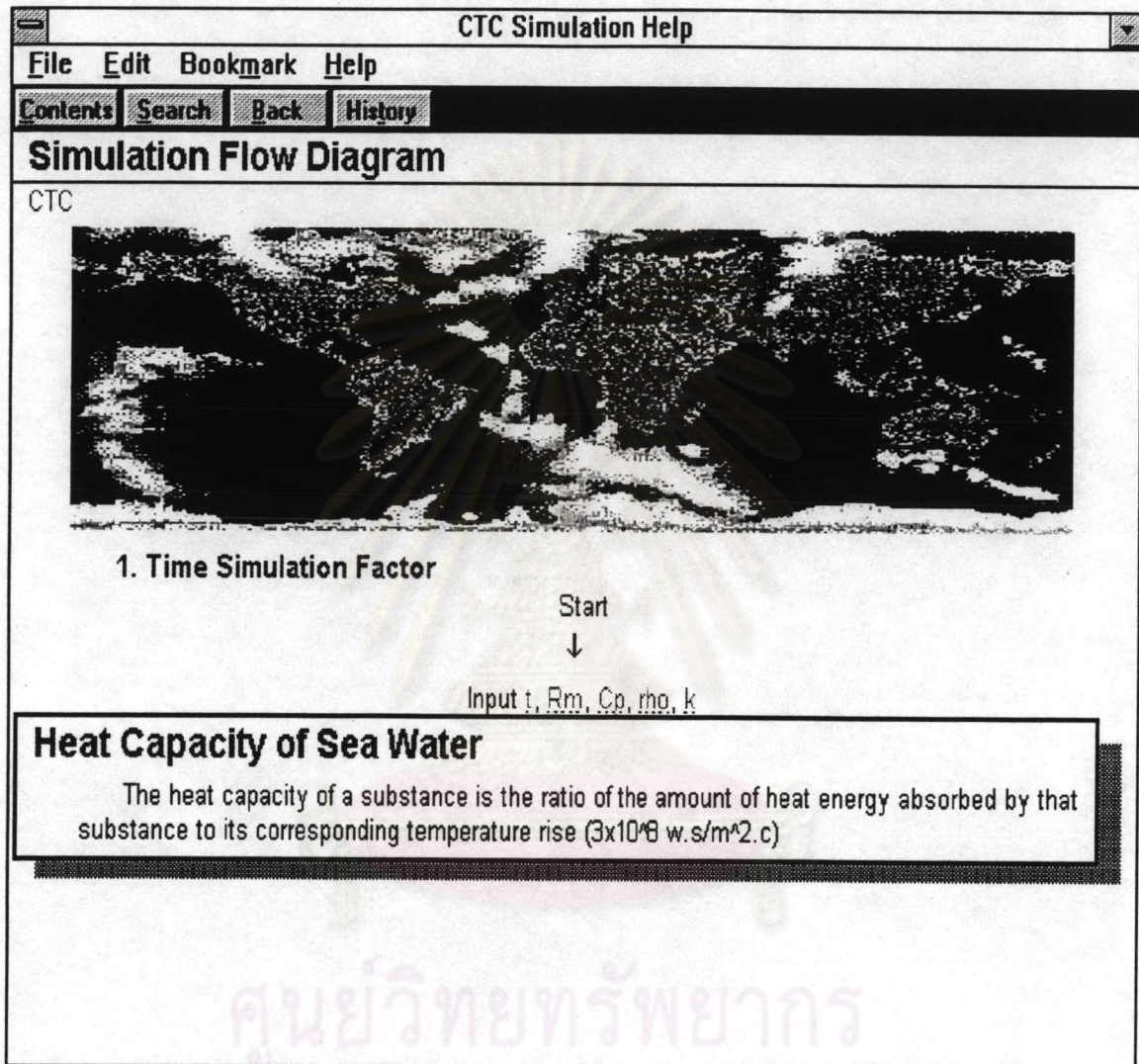
Figure 4.21 Popup Window shown after click on Hot Spot