Chapter 5

Conclusions and discussions

This chapter summarizes the main results and analysis of temperature change in Southeast Asia (chapter 3) and solar radiation absorption by clouds and other components in Australia (Chapter 4). Section 5.1 summarizes the overall findings and statistical methods used in the studies, and section 5.2 provides more detailed discussion of these findings. Limitations and recommendations are given in section 5.3 and 5.4 respectively.

5.1 Overall findings

Temperature Changes in Southeast Asia:

We reported on the application of statistical techniques to analyse the trends and patterns of temperatures in South-East Asia from 1973 to 2008 (36 years). As discussed, monthly seasonally-adjusted surface temperature in Southeast Asia over this period comprised the data, and the area comprised 40 regions (grid-boxes) which are in the tropical zone, between latitudes 25°N to 25°S and longitudes 75°E to 160°E. As noted, serial time correlations were adjusted using an AR(2) process, and factor analysis reduced spatial grids to just 6 regions. To identify the relationship between the study region and the neighborhood region, we then extended the area of study latitudes from 25°N - 25°S to 25°N - 35°N and longitudes from 75°E - 160°E to 65°E - 160°E. The same two methods were repeated. The factor analysis classified the extended area into six regions and multivariate linear regression analysis used to find variance-covariance matrices of estimated parameters. In each region, a linear regression model was used to predict temperature in the future.

In section 3.2, we focused on all 3 time periods;1909-1944, 1941-1976, 1973-2008. It was noted that period 1 showed gradual increases with an average of 0.066°C per decade, period 2 showed essentially no increases, but for period 3 demonstrated marked increase in temperature with an average of 0.169°C per decade. In the 1973-2008 time period, the result showed an average temperature increase about 1°C in 60 years.

Solar radiation absorption in Australia:

The last study analyzed the solar radiation absorption by clouds and other components in the atmosphere using the surface solar radiation energy data from 144 stations in Australia. The solar absorption by clouds and other components is the function of the amount of solar energy reaching to the Earth. Statistical analysis is then performed to analyze the spatial and temporal patterns of solar radiation absorption. The linear model was used to fit into the five-day averages of radiation absorption in all the stations. Owing to the fact that the errors of the fitted linear model must be independent and normally distributed, Rc was transformed and auto-correlations were removed using a first-order autoregressive process to achieve this requirement. Factor analysis identified the stations into 7 geographical groups. Models from this method established seven patterns of cloud cover. The percentage of solar radiation absorption was affected by year and time period. The results also showed the estimated percentage cloud cover with 68% confidence interval in each month of a year and annual average percentage cloud cover over 23 years from 1990 to 2012.

The estimated cloud cover decreased from 2004 to the minimum in 2009. This phenomenon is influenced from many factors such as climate variability, vapour, natural gas and aerosols.

5.2 Discussions

In the study of temperature changes, classification by factor analysis in the extended area showed that some adjacent grid- boxes changed to combine with other factors. This showed that in case we study a different area, the combination of some grid-boxes will be different because there are different spatial correlations of the area which are classified by the factor analysis method.

The highest temperature change was in the western Pacific Ocean. The trade winds normally cause the equatorial surface waters to move water in the western Pacific. Interactions between the atmosphere and the ocean occur at the surface and result in the transfer of heat and moisture. Western coasts in the subtropics and middle latitudes are bordered by warm-water currents, and eastern coasts in polar region are bordered by cool water (Ackerman *et al.*, 2003). The results of the increased temperature in Southeast Asia in the third period is similar to the increase of the global surface temperature over 1975-2005 by about 0.2°C per decade (Hansen *et al.*, 2006). In addition, Lean and Rind (2009) projected global surface temperature increased 0.15 $\pm$0.2°C per decade in five years from 2009 to 2014. This was close to the results in the third period in our study. Our climate change assessment is based on observations in Southeast Asia. The temperature increased extremely during 1973-2008 period. The results reflected the marked increase since the 1970s which was reported by the Intergovernmental Panel on Climate Change (IPCC's Fifth assessment report)

Our study on spatial and temporal patterns of solar irradiance in Australia could demonstrate our methodology in explaining the pattern of climatology of solar radiation. In particular, the spatial patterns that identified regions are very useful for planning the solar energy resources in various regions within Australia. Moreover, long-term planning of the applications of solar energy needs forecasts of solar irradiance up to the intraseasonal and seasonal time scale. For this purpose, both statistical models and dynamical numerical weather prediction models are often applied. The regional pattern of solar radiation and the associated temporal variability within each region obtained by exploratory factor analysis in this study can be the basis for evaluating such statistical and numerical weather prediction models. The points of evaluating statistical models include whether the models consider the spatial variability of cloud cover well enough so that surface solar energy can be accurately estimated.

Knowledge of both temperature changes in Southeast Asia and spatial and temporal patterns of solar irradiance in Australia helps us to understand how to fit models to these data in a large area. It is especially important to know how to account for both time and spatial correlation. Factor analysis could be applied to identify spatial correlations giving adjoining grid-boxes combined into regional groups.

5.3 Limitations and suggestions

The estimated temperature data for missing observations over the period study are needed to evaluate. In this study, the 4 grid-boxes of 5^o by 5^o latitude-longitude grid-boxes were combined and averaged. Another method for doing this is interpolation for missing data, before using statistical analysis

For the solar radiation study, the solar absorption by clouds and other components (Rc) data were fitted by linear models and then checking assumption that the errors must be independent and normally distributed is needed. In this study, Rc need to transform for the stations located in latitude less than 30 degrees, then the linear models fit well into the solar radiation absorption data.

5.4 Recommendations

At the Earth's surface, temperature change relates to the amount of solar energy. Energy transfer from the surface to the atmosphere is one reason why the average temperature in the troposphere decreases with increasing distance from the surface (Ackerman, 2003). In this study, temperature change and solar radiation data are from difference sources and areas. Therefore, further research would be useful to evaluate the temperature and solar radiation trends in the same area and time period.

It is interesting to investigate rainfall patterns in the same 144 stations from 1990 to 2012. The study would reveal many relationships involving temperature, solar radiation and rainfall patterns in Australia.