

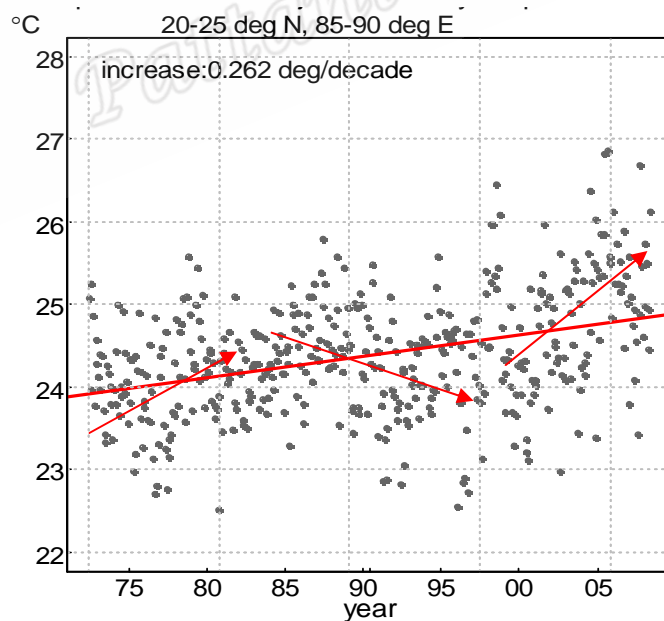
## Chapter 4

### Linear Spline Model

This chapter covers the statistical modeling used in this study. Spline linear regression models were fitted to the data.

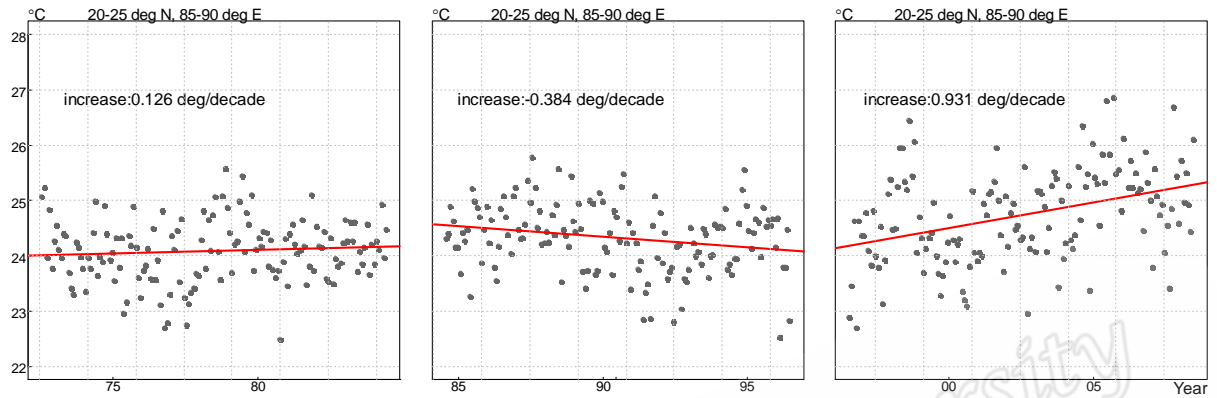
#### 4.1 Linear regression model

The results in Chapter 3 showed a linear increasing trend for all regions. However, the temperature data showed that the pattern was not linear over time, exhibiting some up and down variation. In region 1, Figure 4.1 shows that the temperature trend increased by  $0.26^{\circ}\text{C}/\text{decade}$ . However, the time series show that the temperatures increase in the first 12 year period, then decrease during the second 12 year period and finally increase again in the last 12 year period.



**Figure 4.1** Scatterplot of seasonally adjusted temperature after filtering for region 1 (20-25 deg N, 85-90 deg E)

Based on this observation, a simple linear regression model was fit to these temperature data at three different time periods as shown in Figure 4.2.



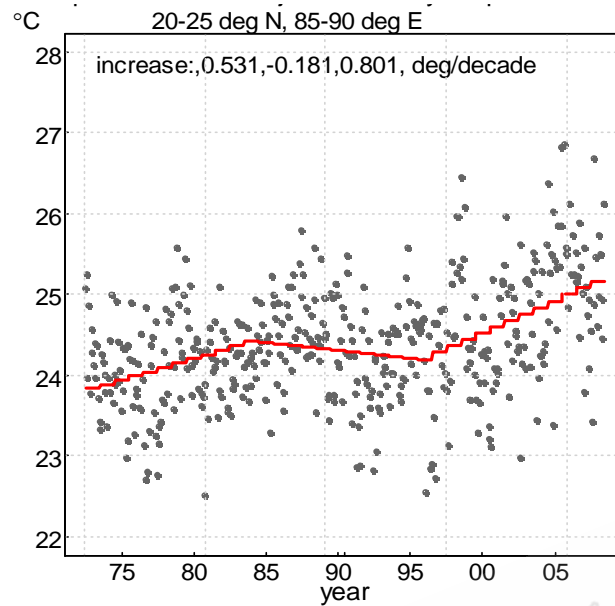
**Figure 4.2** Simple linear curves for each 12 years period

Figure 4.2 shows that the temperatures increased by  $0.12^{\circ}\text{C}/\text{decade}$  in the first period.

In the second period the temperatures decreased by  $-0.38^{\circ}\text{C}/\text{decade}$ . In the last period the temperatures increased by  $0.93^{\circ}\text{C}/\text{decade}$ .

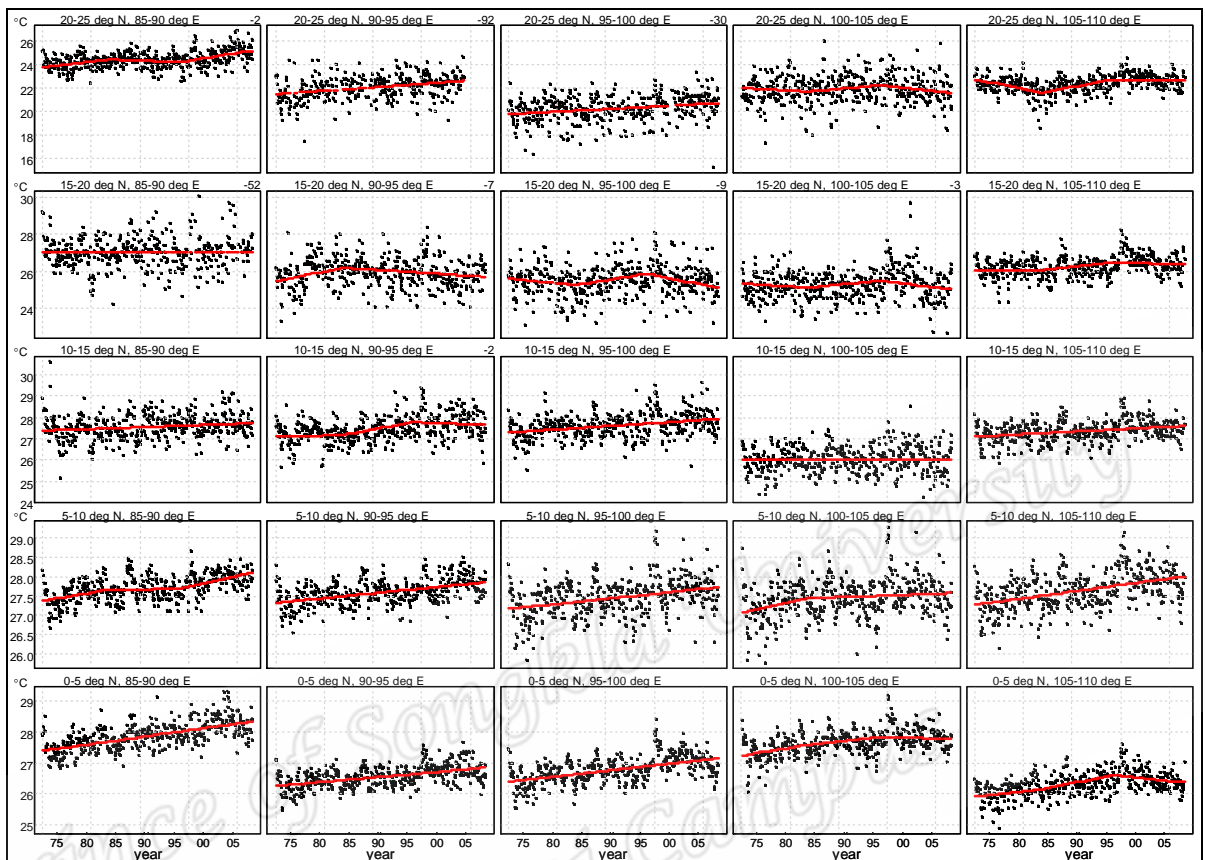
#### 4.2 Linear spline model

Since the simple linear regression model clearly showed that the temperatures trends were different for the three different periods, a spline linear regression model was fit to these temperature data.



**Figure 4.3** Linear spline curve for region 1

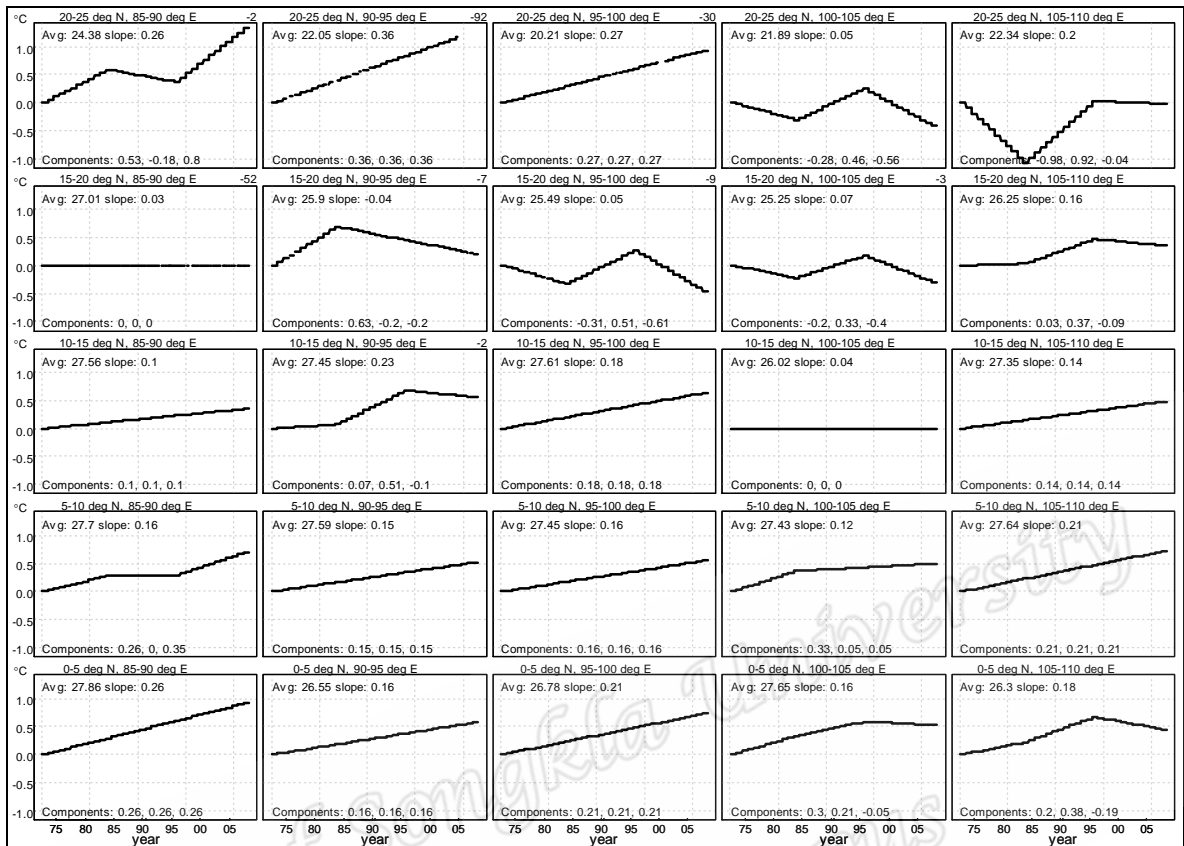
The spline linear regression model was fit to the temperatures in all 25 regions. To see the monthly temperature trend more clearly, we fixed knots for linear splines fitted (3 periods each of the same duration in years) then plot fitted line in each region. The first period is from 1973 to 1984. The second period is from 1985 to 1996. The last period is from 1997 to 2008.



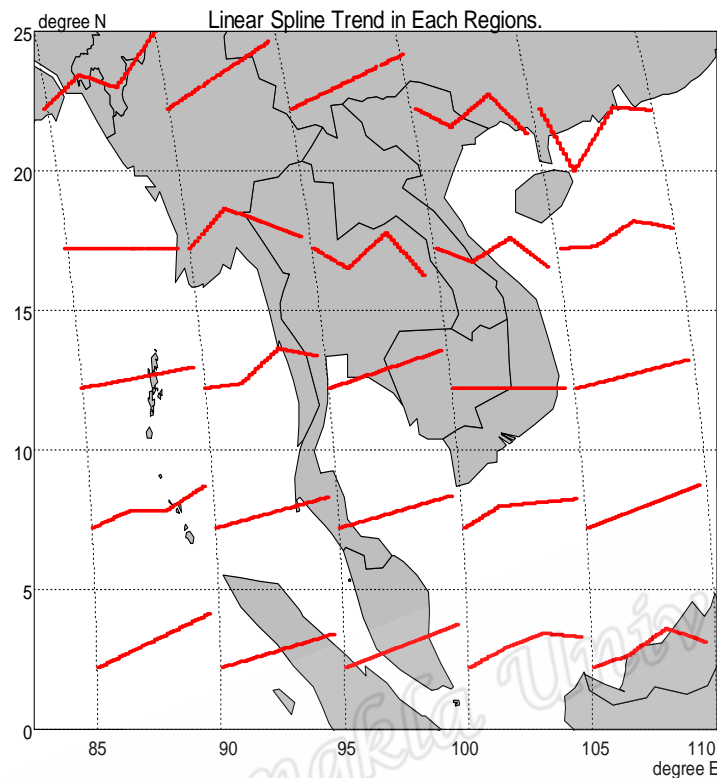
**Figure 4.4** Seasonally adjusted temperature data in South East Asia from 1973 to 2008 with linear splines superimposed

Figure 4.4 shows the seasonally adjusted temperature data in each region in South East Asia from 1973 to 2008 with linear spline trend superimposed. In general, the temperatures have increased in the past three decades but with notably different trends for each region. The linear splines fitted in each region in South East Asia from 1973 to 2008 without data plotted is shown in Figure 4.5.

The range of the average temperature for all regions is  $20.21^{\circ}\text{C} - 27.70^{\circ}\text{C}$ . Apart from a few regions, the slopes of the spline curves in Figure 4.5 increase over time .



**Figure 4.5** Spline curve of the monthly temperature data in South East Asia without data plot from 1973 to 2008.



**Figure 4.6** Map of the study area with spline curves showing temperature trends over time

Figure 4.6 Shows map of South East Asia with spline curves in each regions. The graph shows the trend of temperature per decade exhibit different variation in each period and regions. The area lies between 20-25 degree North reveals that the temperatures from fitted spline curves increase in the first 12 years period, then decrease and increase again after 1996. In the Northeast of Thailand (15-20 °N, 95-100 °E), the trend shows the temperatures decrease in the first 12 years and increase after 1984. The temperature trend decrease again after 1996.