Appendix 1

**Figure of Seasonally Adjusted temperature
for whole 25 regions**

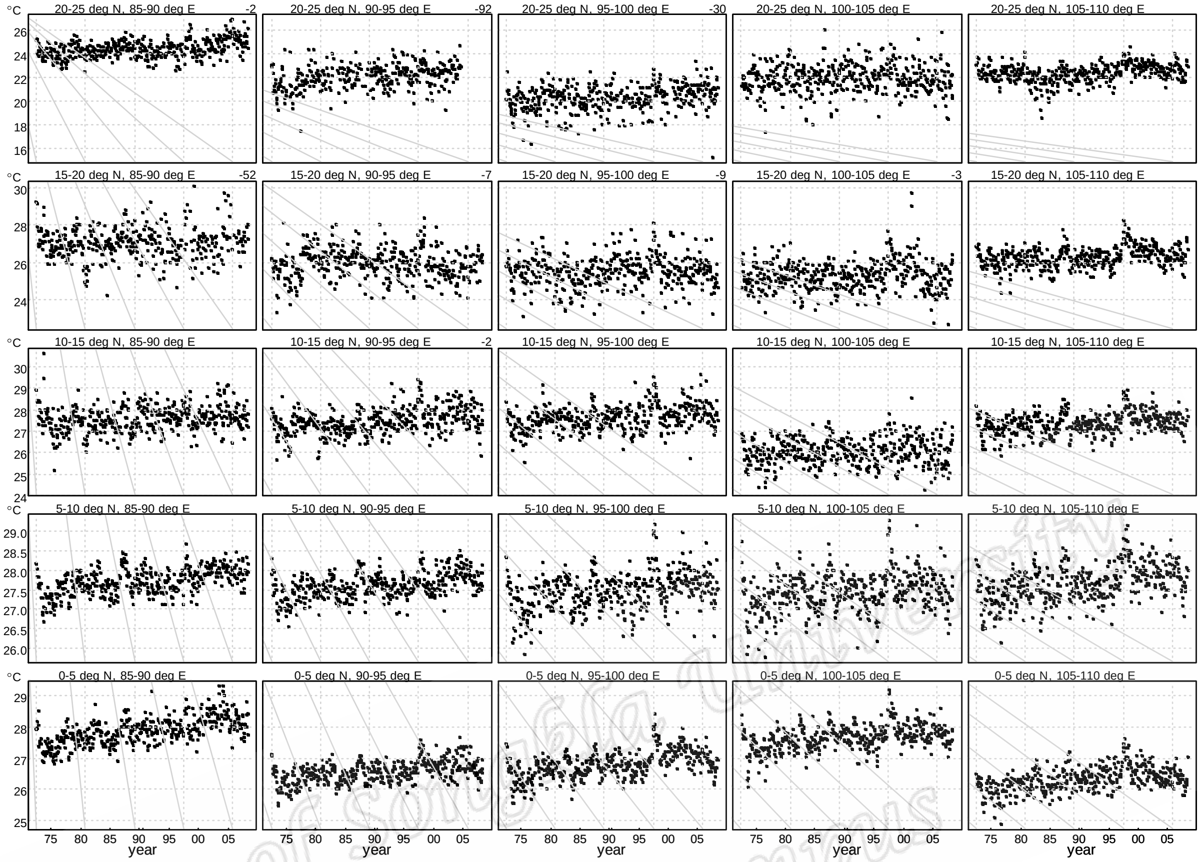

Figure 1. The seasonally temperature data for whole 25 regions.

Appendix 2

Proceedings: Open Network for Gaia Research Using Appropriate Methodologies (ONGRUAM)

Temperature Trend in South East Asia From 1973-2008

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Abstract

The objective of this study was to investigate the trend of monthly surface temperature from 1973-2008 in a region of South East Asia comprising $5^{o}x5^{o}$ latitude-longitude grid box regions, using linear splines to model and graph the data. The variation of the raw temperature by month in each region is affected by seasonal variation. Seasonally adjusting the data more clearly reveals the temperature trend, showing how the data varied with time over the period, as well as differences between regions. It is desirable to use models that closely fit the data and some models may produce better results for predicted values than others, depending on the data. Analyses using splines has not been extensively used for modeling temperature data but spline models may provide a better fit and linear spline proud straight forward forecasting.

Keywords: trend, linear splines, seasonal adjusted, forecasting trend.

1. Introduction

There is a growing concern about global warming and the impact which will have on people, animals and the environment. Global warming is the increase in the average temperature of Earth's near surface-air and oceans. The Earth's temperature is influenced by many factors. Scientists classify these factors as either climate forcing or climate feedbacks depending on how they operate (National Academies Report, 2008). A forcing is something that is imposed externally on the climate system such as excess greenhouse gases, and aerosols produced by industrial processes. A feedback is an energy change that is produced within the climate system itself such as water vapour and cloud. Temperature varies all around the world, very low at the North and South Poles but quite high at the Equator.

In the past three decades (from 1975-2005) the average global surface temperature has increased by about 0.2°C per decade (Hansen et al., 2006), whereas global surface temperature has increased about 0.75 °C when compared to the mean temperature from 1860-1900. Land surface temperature has increased twice as fast as sea surface temperature – 0.25 °C and 0.13 °C per decade respectively (Intergovernmental Panel On Climate Change, 2007)

Different regions have different temperature variation. In the south eastern Mediterranean Sea from 1948-1985 the trend of temperature decreased about 0.3 °C, then increased after 1985 (Maiya and Kemel, 2009). In the Pacific Ocean the temperature increased sharply from 1951-1975 and then increased with indistinct causes – the increase was about 3.1 °C when compared to average temperature from 1951-1975 (Hartmann and Wendler, 2005).

In Australia, temperature has increased about 0.32 °C from 1981-2005 (Collins et al., 2000). In Asia the magnitude of surface warming has been largest in Japan, (Tokyo, 2.8 °C), followed by Korea, (Seoul, 2.5 °C) and Thailand in Bangkok 1.8 °C (Taniguchi et al., 2007).

The intensity of the effect is different in each region. Models are used to forecast based on data. There are many methods for forecasting, in this study we used linear spline functions to fit models that could be used for forecasting.

2. Methods

Linear regression is an analytic approach commonly used to examine the relationship between dependent (temperature) and independent (time) variables. Predictor variables may be separated into logical categories or we may add additional terms that are functions of existing predictors such as spline modeling, may provide a better fit. Splines are continuous lines or curves. The join points that mark one transition to the next are referred to knots. Knots give the curve freedom to change direction and more closely follow the data, then fit model to the data.

Linear spline model are given by

$$s(t) = c_0 + c_1 t + \sum_{j=1}^{m} c_{j+1}\left(t - T_j\right)_+$$

C_0 is a constant.

C_1 is parameter for the first of time t

C_{j+1} are parameters for time t when knots are defined.

T_j are knots

j is number of knots, $j=1,2,3,\ldots,m$.

t_+ is t if $t > 0$

A linear spline defined on an interval $(0, T)$ takes the form where t_+ is t if $t > 0$, otherwise. The constants T_j are called **knots**. A linear spline is a piecewise continuous linear function with discontinuities in its derivative at each knot. Suppose that (y_i, t_i) are data comprising measurements of average temperatures y_i, say, at successive months t_i. To fit a linear spline by linear regression, we simply take y as the outcome variable and the components t, $(t - T_1)_+$, $(t - T_2)_+$ … as predictors. For the global temperature data, there are 36 x 12 = 432 months in a 36-year period, and we will assume that the fitted splines have knots after 12 and 24 years (after 144 and 288 months), so the model contains 4 parameters, c_0, c_1, c_2 and c_3. These constants are the value at the first month, the slope over the first 12 years, the increase in slope from the first to the second 12-year period, and the further increase in slope from the second to the third 12-year period, respectively.

3. Result

(Figure 1)

The range of monthly temperatures in each regions were differences such as on the first right panel of histogram reveal that the average Earth surface temperatures for each month from Jan 1973 to Dec 2008, in the area between longitudes 100-105° East and latitudes 15-20° North, during years 1973-2008 ranged from 18 to 31 degrees Celsius, and have a left-skewed distribution, with peak between 26 and 27 degrees. There is also some evidence of a second peak between 21 and 24 degrees.

(Figure 2)

Figure 2 shows the observe a time series plot of average monthly temperatures. Each dot denotes the average temperature for a month, and the dots are joined to show the pattern of change over the period. The most noticeable pattern is the seasonal periodicity. To seasonally adjust the data, we subtract the monthly averages and then add back the overall mean. This removes most of the variation in the average monthly temperatures, so we can now more easily detect a trend in the data. The seasonally-adjusted temperatures for all six 5^{o} x 5^{o} grid boxes in the region. It gives a picture of the global warming trends in recent decades for Thailand. With linear trends superimposed. The largest increase (0.23^{o}C per decade) was in the region west of Bangkok.

4. Conclusion and Discussion

The trend of global temperature in South East Asia from 1973-2008 were increase in the past decades and exhibit differences in each region. There are many methods to use, however, it is desirable to use models that closely fit the data and some modeling methods may produce better results for predicted values than other methods, depending on the data. Analyses using splines is often cumbersome and interpretation are often complex, anyway, spline modeling may provide a better fit taking into consideration the variation in the relationship between the predictor variable and the response variable. Spline with few knots are generally smoother than splines with many knots, however, increasing the number of knots usually increases the fit of the spline function to the data. It is necessary to compare the tradeoff between model complexity and model fit in order to assess whether a much more complex model provides a significantly better fit.

Acknowledgements

We are grateful to Professor Don McNeil for his helpful guidance.

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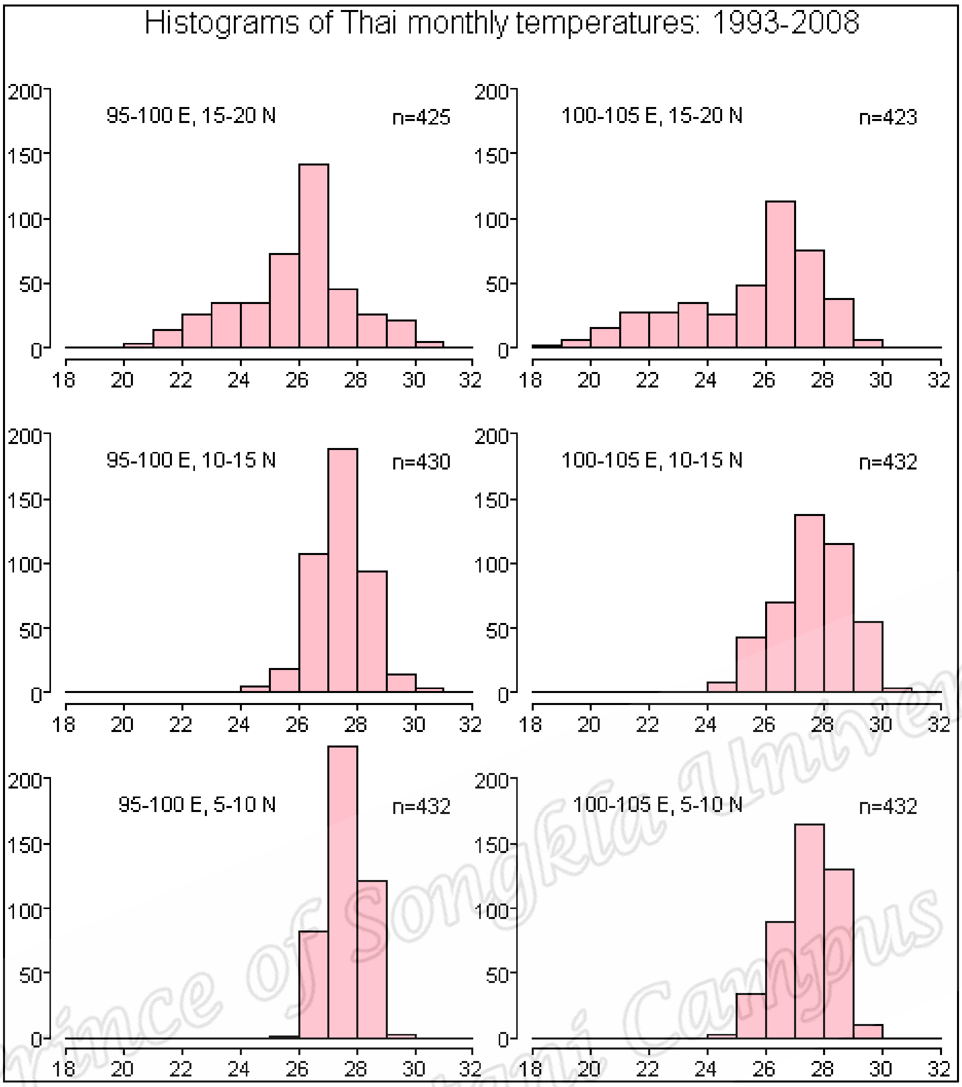

Figures 1: The histograms of the average monthly temperatures for the same period recorded from a further five 5^{o} x 5^{o} grid boxes including most of Thailand.

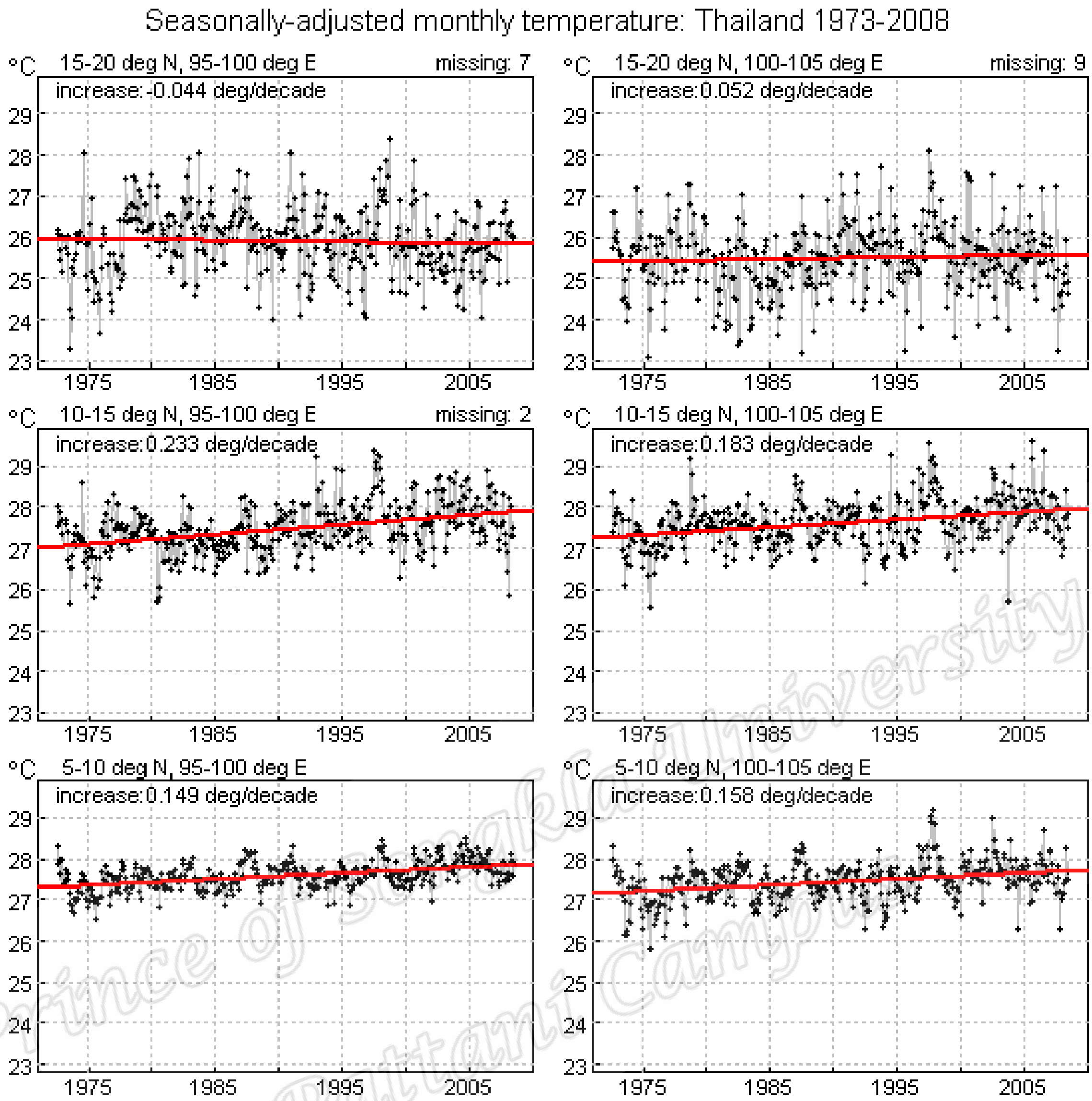

Figure 2: Seasonally-adjusted temperatures for all six 5° x 5° grid boxes in the region.

It gives a picture of the global warming trends in recent decades for Thailand.