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An alternate approach to the relationship between the southern oscillation and rainfall in Malaysia

STEPHAN R. L. MEIJER*

Univ. of Agric., Wageningen, the Netherlands

and

PRAKASH SANKARAN

Malaysian Met. Service, Petaling Jaya, Malaysia

सार — मलेशिया में समरूपी वर्षा विशेषताओं के साथ विभिन्न क्षेत्रों के वर्षा घातांकों के साथ, जलवायु विश्लेषण केन्द्र (संयुक्त राज्य अमरीका) के विवरण पर आधारित दक्षिण दोलन सूची (द. दो. सू.) का सहसंबंध स्थापित किया गया। यह देखा गया कि प्रायद्वीपीय मलेशिया (पूर्वी तट, पश्चिमी तट) में दो घातांकों के मध्य किसी प्रकार का सहसंबंध स्थापित नहीं था। किन्तु सबाह और सारावाक के राज्यों के लिए कुछ महत्वपूर्ण सहसंबंध विद्यमान थे। इन से प्राप्त उपलब्धियों के लिए कुछ भौतिक व्याख्या देने का प्रयास किया गया है।

ABSTRACT. The Southern Oscillation Index (SOI) based on the version of the Climate Analysis Center (USA), was correlated with rainfall indices of various regions with similar rainfall characteristics in Malaysia. It was found that no correlation exists between the two indices in Peninsular Malaysia (East Coast, West Coast) but some significant correlation exist for the States of Sabah and Sarawak. An attempt has been made to offer some physical explanation to the findings.

1. Introduction

Interest in planetary-scale phenomena such as the the southern oscillation, henceforth referred to as SO, has been generated in recent years particularly since the record breaking *El Nino* episode of 1982-1983. Knowledge of inherent relationships that may exist between the SO and particular regions, in our case Malaysia, would be a boon to medium and long range forecasting techniques. The aim of this study is to determine whether any contemporareous correlation exists between Malaysian rainfall and the SO. Important meteorological variables which are indicative of the SO fluctuation are sea level pressure, sea surface and air temperatures, wind, geopotential height, rainfall and cloudiness.

Preliminary studies done by Cheang (1987) show that the linear correlation coefficient between the total November to March rainfall in Malaysia and the SOI for the same months is about 0.6. This study based on his work attempts to examine the correlation of the SOI with all months of different rainfall regions of Malaysia.

2. Data source

This investigation uses monthly rainfall records of 36 years (1951-1986) for 9 stations in Peninsular Malaysia. Furthermore the monthly rainfall records of 21 years (1966-1986) were used for 6 stations in Sabah and Sarawak.

The SOI data were taken from the monthly bulletin of *Climate System Monitoring* (WMO 1986).

3. Method and analysis

Fluctuations in the SO have been monitored in terms of several indices. Among these, the so-called southern oscillation index (henceforth referred to as SOI), is regarded as a prime indicator for the strength and variation of this large-scale atmosphere circulation. In this study the index used is based on the Climate Analysis Center's (USA) version. To compute the SOI, the Tahiti and Darwin anomalies are first normalized by the standard deviation of the respective anomaly time series. Then the difference (Tahiti—Darwin) of the standardized anomalies is computed. This difference is further anomalized by the standard deviation of the difference (Tahiti—Darwin) time series. This additional normalization results in a time series having a mean of zero and unit variance.

Rainfall data from principal meteorological stations of the Malaysian Meteorological Service were used in this study as they provide reliable and reasonably long

*Attached to the Malaysian Meteorological Service from January to April 1988 records. Nine of these stations were selected because of their record length and homogeneous locations (being coastal). The record length of Peninsular Malaysia stations chosen was 36 years (1951-1986) which gives a maximum sample size of 36 × 12 = 432 months. For Sabah and Sarawak the record length was less being 21 years (1966-1986), providing a maximum sample size of 252. The stations chosen were Bayan Lepas, Ipoh, Sitiawan, Subang, Malacca, Kota Bharu, Kuala Trengganu, Kuantan and Mersing in Peninsular Malaysia and Kuching, Sibu, Bintulu, Miri, Kota Kinabalu and Sandakan in the States of Sabah and Sarawak.

An important aspect of correlation studies is to divide the stations into, in this case, regions of similar annual mean rainfall pattern. For the purposes of this study regionalization was done according to standard practices at the Malaysian Meteorological Service. The stations (for Peninsular Malaysia) were divided into the East Coast and the West Coast. The underlying reason for this is that East Coast stations experience heaviest rainfall during the winter months of November to March whilst the West Coast stations during the inter-monsoon months of April and October. An examination of the low order moments lends further support to this division.

There are only six stations in Sarawak and Sabah and this small number poses a problem in regionalization. All the Sarawak stations show a maximum of rainfall during the northeast monsoon and it seems logical to group them together. However, Sabah has only two selected stations which depict two dissimilar annual mean rainfall regions. For completeness they were grouped together but caution must be emphasized in making assessments of the results.

One way to remove the seasonal and annual cycle is by recourse to the standardized anomaly index (henceforth these rainfall anomaly indices will be referred to as SAI). The SAI is defined according to each region as :

$$I_t = \frac{1}{N} \sum \frac{(X_{it} - \bar{X}_i)}{\sigma_i}$$

where, $i = 1, 2, \ldots, N$

$\bar{X}_i$ = Sample mean

σ_i = Sample standard deviation for each station.

The SAI possesses many useful statistical properties. Firstly, it has a mean of zero and when all pairs of stations have unit correlation coefficients, a variance of 1. This makes it identical to the optimal weighted average under the criteria of variance, explained by Katz & Glantz (1986). Sample A.F.s of the SAI for the various regions, namely East Coast, West Coast, Sabah and Sarawak were small ranging between +0.15 and −0.15. This shows that the seasonal and annual cycles have been removed to a large extent. The reduction to insignificant autocorrelation has effectively provided us with a large sample of realizations of a single independent random variable with zero mean and near unit variance.

TABLE 1

East Coast SAI-West Coast SAI

Month	R_s	T	R	T
Jan	0.77	6.92	0.61	4.49
Feb	0.67	5.29	0.65	4.99
Mar	0.38	2.37	0.43	2.78
Apr	0.24	1.43	0.29	1.77
May	−0.01	−0.08	0.03	0.18
Jun	0.06	0.38	0.26	1.57
Jul	0.21	1.26	0.19	1.13
Aug	0.23	1.37	0.25	1.51
Sep	0.13	0.77	0.04	0.23
Oct	0.35	2.17	0.25	1.51
Nov	−0.14	−0.84	−0.10	−0.59
Dec	0.47	3.07	0.48	3.19

TABLE 2

East Coast SAI-SOI

Month	R_s	T	R	T
Jan	−0.03	−0.15	0.11	0.65
Feb	0.15	0.86	0.18	1.07
Mar	0.26	1.60	0.23	1.38
Apr	0.05	0.26	0.04	0.23
May	−0.18	−1.08	−0.15	−0.88
Jun	0.07	0.40	0.04	0.23
Jul	−0.27	−1.64	−0.25	−1.51
Aug	−0.07	−0.43	−0.05	−0.29
Sep	−0.20	−1.21	−0.16	−0.95
Oct	0.33	2.05	0.35	2.18
Nov	0.23	1.37	0.28	1.70
Dec	0.34	2.08	0.30	1.83

TABLE 3

West Coast SAI-SOI

Month	R_s	T	R	T
Jan	0.02	0.10	0.06	0.35
Feb	0.13	0.73	0.16	0.95
Mar	−0.08	−0.48	−0.09	−0.53
Apr	−0.17	−1.01	−0.21	−1.25
May	−0.30	−1.86	−0.17	−1.01
Jun	0.07	0.40	0.12	−0.70
Jul	−0.04	0.20	0.06	0.35
Aug	0.01	0.03	0.02	0.12
Sep	0.12	0.69	0.16	0.95
Oct	0.01	0.06	−0.03	0.18
Nov	−0.41	−2.59	−0.26	−1.57
Dec	0.28	1.72	0.24	1.44

TABLE 4

Sarawak SAI-SOI

Month	R_s	T	R	T
Jan	0.44	2.10	0.27	1.22
Feb	0.43	2.05	0.48	2.38
Mar	—0.19	—0.84	—0.08	—0.35
Apr	—0.31	—1.42	—0.28	—1.27
May	0.25	1.12	0.24	1.08
Jun	0.40	1.92	0.47	2.32
Jul	0.44	2.11	0.44	2.14
Aug	0.12	0.88	0.21	0.94
Sep	0.58	3.10	0.55	2.87
Oct	0.02	0.08	—0.06	—0.26
Nov	—0.05	—0.24	—0.06	—0.26
Dec	0.45	2.18	0.47	2.32

TABLE 5

Sabah SAI-SOI

Month	R_s	T	R	T
Jan	0.71	4.38	0.66	3.83
Feb	0.61	3.34	0.54	2.80
Mar	0.28	1.29	0.32	1.47
Apr	0.22	0.99	0.20	0.89
May	—0.15	—0.65	—0.09	—0.39
Jun	0.12	0.51	0.21	0.94
Jul	0.11	0.50	0.08	0.35
Aug	—0.23	—1.04	—0.05	—0.22
Sep	0.33	1.52	0.30	1.37
Oct	0.23	1.01	0.21	0.94
Nov	0.09	0.38	0.35	1.63
Dec	0.47	2.31	0.44	2.14

The above facts make it impossible to compare the SOI with the SAI on a consecutive monthly basis.

In order to compare two time series it is necessary to convert them into white noise processes, prior to any cross correlation being calculated. Discrete white noise may be generated from non-white processes very simply by sampling the process at intervals equal to the lag at and after which the autocorrelations are sufficiently small.

4. Results

In Tables 1-5 three values are represented. R_s refers to the Spearman's rank correlation, R is the linear correlation coefficient and T, the t-statistic corresponding to the R_s and R. The t value significant at 5% is 2.04 and at 1% is 2.72 (two tailed), when N=36 (Peninsular Malaysia stations), whilst for N=21 t=2.08 and t=2.80, respectively (for Sabah and Sarawak stations).

Table 1 shows the correlation between the East Coast SAI and the West Coast SAI. The correlations are significant from December to March with the highest correlation in January (0.77). It appears that the SAIs are uncorrelated during the non-northeast monsoon months.

Tables 2 and 3 show the corrrelation coefficients of the SOI with the East Coast SAI and the West Coast SAI respectively. For the East Coast only the months of October and December are weakly correlated (0.33-0.35) at a significance level of 5% though not at 1%. For December, however, the linear correlation coefficient for the East Coast is much weaker (0.30) and not significant at 5%.

For the West Coast there is no significant correlation with the SOI. Only the month of November has a R_s = —0.41. However, R = —0.26 and is not significant at 5%. A closer examination shows a number of tied ranks in the evaluation for R_s and this explains its higher value.

Tables 4 and 5 show the results for Sarawak and Sabah respectively. For Sarawak the highest value for the correlation coefficients, both R and R_s are in September (0.55-0.58) and significant at 1% June, July, December, Jannuary and February are weakly correlated at 5% level of significance. It is interesting to note that R_s is about 0.40 for all these months.

In Sabah the correlation coefficient is significant at 1 % for January and February and at 5 % for December with a maximum R_s = 0.71 for January.

5. Discussion and concluding remarks

When studies of teleconnections between rainfall in a region and atmospheric variables far removed from this location are made, great care must be taken to evaluate the statistical properties of the underlying time series in order to avoid spurious or a untentable conclusions. Thus the technique presented here has attempted to maintain rigor in the statistcal method.

Firstly, there appears to be no significant correlation between the SOI and the rainfall in regions of Peninsular Malaysia, namely, the East Coast and West Coast divisions. This result may differ from those of preliminary studies, possibly due to different time scales and indices used. The East Coast SAI is, however, correlated with the West Coast SAI during the northeast monsoon months (December-March). This correlation may be attributed to a large-scale forcing mechanism such as the cold surge episodes. In the early winter cold surges emanating from central China tend to enhance precipitation in the northern equatorial trough which is located in Malaysian latitudes. This causes intense rainfall in the East Coast and slight increases in the West. Thus, if more cold surge episodes are in early winter it is likely that there will be more rainfall in both the East and West Coasts and conversely.

During the winter months the SAIs of Sabah and Sarawak appear to be correlated with the SOI. During this period, cold surges that enhance precipitation in this region are of the cross-equatorial type implying that there is lower tropospheric mass transport from central China to the Indonesian and

Australian regions. The concommitant mass adjustments may be responsible for pressure changes in Darwin. So, if the number and intensity of episodes are significantly large it will affect the SOI. As pointed out by Katz and Glantz (1986) other factors such as the 40-50 day oscillation and/or tropical cyclones may play a role in these apparent relationships. It seems possible that the apparent relationships that are evident in precipitation fields and the SOI may be due to the presence of a common broad-scale phenomenon, in this case, the cold surges.

However, it is admitted that there are a number of limitations in the analyses. Firstly the record length for Sabah and Sarawak is much smaller, $N=21$ years. Secondly the number of selected stations in Sabah is only two and they are by no means 'regionally consistent', in the sense of being strongly correlated. In fact, they have different annual mean rainfall regimes. Also correlations for summer months in Sarawak and especially for September need to be explained. Further, the coefficients of variation for a number of stations are about 1 (Kota Bharu, Kuala Trengganu). These suggest that the distribution during these months are highly skewed and may affect the assumption of normality in diagnostic tests or validity of results.

The results do not show that the complex east-west circulation is not linked to Peninsular Malaysian rainfall. It merely shows that the simple SOI may not be a useful indicator of rainfall anomalies in the specified regions of Peninsular Malaysia. More representative indices need to be formulated.

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