Reply

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16 May 1979

In his comment, Sciremammano makes the valid point that the autoregressive nature of the data was not taken into account by Greenhut (1978) when the significance level of the correlations were computed. However, in the following we show that when this is done, the correlations obtained for one of the GATE phases and for all the phases combined remain significant.

Davis (1976) gives a method for determining the effective number of degree of freedom N_{eff}, in an autocorrelated data set containing N values. The result is

$$N_{\text{eff}} = \frac{N\Delta t}{\tau}, \tag{1}$$

[1] The National Center for Atmospheric Research is sponsored by the National Science Foundation.

0022-3670/79/061298-02$04.50

where Δt is the time-interval spacing of the data. The parameter τ is the time period necessary to gain a new degree of freedom in the data set and is given by

$$\tau = \sum_{k=-(N-1)}^{N-1} \left(1 - \frac{|k|}{N}\right) C_0(k\Delta t) C_1(k\Delta t) \Delta t, \quad (2)$$

where $C_0(t)$ and $C_1(t)$ are normalized correlation functions

$$\left.\begin{aligned} C_0(t') &= \frac{\langle p(t)p(t+t')\rangle}{\langle (p(t))^2\rangle} \\ C_1(t') &= \frac{\langle d(t)d(t+t')\rangle}{\langle (d(t))^2\rangle} \end{aligned}\right\}. \quad (3)$$

The angle brackets denote the mean value. The functions $p(t)$ and $d(t)$ represent data set pairs with values obtained in a time interval Δt.

We have let $p(t)$ and $d(t)$ correspond to the data on rainfall (RR) and sea surface temperature (SST), respectively, in Greenhut (1978). Using Eqs. (1), (2) and (3), we have calculated τ and N_{eff} for the three phases of GATE separately and for all phases combined. The results are shown in Table 1. Except for Phase III, there is, indeed, a reduction from the total number N of data pairs to N_{eff}. Using N_{eff}, the correlations necessary for 95% significance are now 0.81, 0.88 and 0.43 for the three phases of GATE, respectively, and 0.41 for all phases combined. The correlations for Phases I and II given in Fig. 3b of Greenhut (1978) are now too small to be included in the 95% significance band. Since $N_{\text{eff}} \approx N$ for Phase III, the conclusions for this phase in Greenhut (1978) remain valid, i.e., that there is significant (95%) positive correlation when SST leads RR by one day and some indication of significance (80%) of negative correlation when SST lags RR by one day. For all phases combined (Fig. 3a in Greenhut, 1978), there is significant (95%) negative correlation when SST lags RR by one day and some indication of significance (80%) of positive correlation when SST leads RR by one day. Thus, when these results are taken together, along with the general shape of the correlation curves as a function of SST lead and lag (Fig. 3 in Greenhut, 1978), evidence remains for the feedback mechanism between SST and RR as discussed by Greenhut (1978) even when the autoregressive nature of the data is taken into account.

TABLE 1. Time period in order to gain a new degree of freedom τ and effective number of degrees of freedom N_{eff} for each phase of GATE and for all phases combined. The data are sea surface temperatures and rainfall from Greenhut (1978).

	N	τ (days)	N_{eff}
Phase I	18	3.1	6
Phase II	18	4.0	5
Phase III	21	0.8	21
All Phases	57	2.5	23

REFERENCES

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