news and views

Sea surface temperature and climate

from P. B. Wright

Sea surface temperature (SST) is an important factor in climate. The physical reasons are readily apparent; if relatively cold and unsaturated air blows over the sea, heat and moisture are transferred from the sea into the air, and the rates of transfer depend on the temperature difference. Thus subsequent behaviour of the airstream depends on the temperature of the ocean surface over which it has passed; for example, the latent heat from the additional moisture evaporated into the air may be released into the upper troposphere at some distance downstream, modifying the circulation there. This may in turn influence the circulation even farther afield.

Moreover, SST has high thermal inertia. The sea surface takes a long time to cool down (or warm up) because any change of temperature has to be distributed through the top 100-m layer which is well stirred. Some of the effects of these properties are familiar—maritime climates are more equable and more humid than continental ones, and their seasons are delayed a month or two. It is not surprising therefore to find that SST variations play an important part in causing the climate to differ from year to year. A number of correlations have been discovered over the past few years—between SST near Newfoundland and atmospheric circulation over Europe, SST over the North Pacific and weather over both North America and Europe, and between SST in the Equatorial Pacific and the 'Southern Oscillation', which involves rainfall in Australia and many other regions.

Markham and McLain (see this issue of *Nature*, page 320) have now found a new example, a close relationship between SST in the equatorial Atlantic and rainfall in north-east Brazil. Correlation coefficients reach the remarkably high value of 0.8 in four separate months. It is particularly noteworthy that correlations of 0.7 occur in a predictive formula—between December SST and the following January-to-March rainfall. Moreover they are highly significant, indicating a real physical relationship. The details of the chain of interactions are still far from clear. Warm SST probably favours a modified trade wind pattern, which affects the rainfall. But the physical basis is sufficiently firm, and the relationship sufficiently close (even after allowing for sampling variations), for useful forecasting of the rainfall in this drought-prone region of the globe to be possible. When the physical details become better understood, and the most relevant sea area is pinpointed accurately, improved forecasts should be possible.

The forecasting potential depends essentially on the fact that SSTs in the equatorial Atlantic not only influence the rainfall, but also persist for several months. This is similar to the behaviour of equatorial Pacific SSTs. This raises the following questions. Are there other influences of the Atlantic SST similar to those of the Pacific? Are the two regions in any way coupled? Why do anomalies persist so long, and why do they eventually change? It will be some time before these questions are answered. But another question comes to mind. Are there any other regions where SST anomalies tend to persist for several months or longer? If so, then whatever their cause, we ought to know of their existence, because they would imply a forecasting potential for regions whose climates they influence. This should be simpler to answer; it merely requires a routine statistical analysis of SST data series.

However there are serious problems with data, some of which are mentioned in the paper. It is a tedious and intricate job to transform millions of observations from ships' logs into series of monthly means, checked for errors, for 5° squares over the globe. But the need for reliable homogeneous series cannot be overemphasised. Work is now in progress in the Meteorological Office at Bracknell to devise an objective procedure for identifying errors, which will be a valuable contribution to the task. Nevertheless, as this paper shows, even the data available at present "form a picture that is coherent and of predictive value".

The paper also looks at correlations between equatorial and higher-latitude climates, and suggests a plausible mechanism by which warm South Atlantic sea temperatures could favour a deeper upper-air trough near Newfoundland. This sequence of interactions is the reverse of one put forward by Namias some years ago. The problem of cause and effect is a thorny one. It will not be answered from simple correlation studies like that of Markham and McLain, but these are valuable in providing pointers. Numerical models will have a crucial role; one could impose a persistent SST anomaly and look at the effects in different latitudes. Some such experiments have been made on both the Pacific and the Atlantic, which clearly indicate that equatorial SSTs can greatly influence higher-latitude circulation patterns.

So there is a great deal of further work needed along several parallel lines. The SST data base needs to be improved and made available. The homogeneous series so obtained should be analysed to discover areas where persistence is strongest. These areas should be used in correlation analyses to discover regions for which forecasts are possible, and also in numerical experiments to investigate the physical relationships which underlie the correlations. □