cells can permit a clear answer; but there are already examples where the leftward shift will have to be very large to accommodate the observed findings. For instance, di Virgilio, Lew and Pozzan[1] report that phorbol esters can promote secretion from neutrophils at an ionized Ca concentration of 10 nM. This would require a bigger shift in sensitivity than has so far been observed in 'leaky' cells; only determination of the properties of C-kinase in neutrophils can substantiate or refute the authors claim for a completely Ca-independent mechanism.

Although this particular case must be considered non-proven, secretion — like contraction — seems likely to involve multiple controls. Apart from the release of stored products, membrane fusion plays a central role in the control of membrane turnover and the nature of the signals involved in directing membrane traffic are obscure. Even within the limited area of exocytotic secretion there are tissues that appear to secrete in response to a fall in ionized calcium. In one of these, the parathyroid, such changes have been very clearly documented by Quin 2 (ref. 15) and there is strong circumstantial evidence pointing to something similar in the control of renin release[16]. Whether such findings necessitate something quite different in the way of secretory control or can be accommodated within more conventional systems — perhaps by inclusion of a Ca-dependent inhibitory control — are matters for future experiments to resolve. □

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Climatology

Clues from sea-surface records

from Joseph O. Fletcher

THE paper by Folland, Parker and Kates in this issue of *Nature* (page 670) gives important new insights into the behaviour of the global climate system. Their records show that globally averaged sea-surface temperature not only underwent a large fluctuation over the last century but that the large changes — cooling about 1900 and warming in the 1930s — were sudden rather than gradual.

The rapid change found in historic sea-surface records is good news for investigators of climate variability because the existence of large and abrupt 'climate signals' simplifies the strategy for investigation. Instead of groping in statistics to extract signal from noise, reseachers can focus on the large signals and ask questions aimed at revealing the dynamics of climate variability on that time scale. Where does the signal appear first? How does it spread? What is the sequence of its evolution? Is the signal apparent in other geophysical fields such as surface wind and surface pressure? If so, do the changes in the various fields relate to one another in physically consistant ways? What do the trends tell us about possible causes and influential mechanisms?

The sea-surface record offers the best opportunity for delineating the dynamical behaviour of the global system over the last century — and it is a remarkably good record. Thanks to international agreements and standardized procedures adopted in 1853 (Whipple, A. *Smithsonian*, 171; March 1984), about 100 million observations have been taken by ships over the last 130 years. The quantities recorded include sea-surface temperature, wind direction and speed, atmospheric pressure and temperature, sea state and cloudiness. Comparisons between the fields offer additional dimensions for judging the validity of signals reflected in individual fields.

The data are unevenly distributed in time and space with large gaps in the early years. About half of the total observations were made in the Atlantic, which is the most fully surveyed ocean area. The Pacific is the least covered, with especially large gaps in the data for early decades. By contrast, the record is excellent in the belt of westerlies in the Indian Ocean and South Atlantic. Because the sailing route, during the last century, from Europe to the Indies and the Orient was typically south from Europe to the Southern Hemisphere westerly belt near Argentina and then east, coverage in this region was as good in the 1850s to 1870s as a century later. As a result, changes in sea-surface temperature and global surface wind field are well delineated since 1854.

The most striking feature of the global ocean-surface temperature record is the sharp cooling shortly after 1900. Folland *et al.* point out many possible sources of unreliability of the data, however, and some investigators believe that these problems may be so serious that only the secular changes recorded on a few heavily travelled ship routes may be genuine (Ramage, C.S. *J. Climate appl. Meteor.* 23; Feb 1984, and Barnett, T.P. *Mon. Weath. Rev.* **112** (2); Feb 1984). If real, the change near 1900 suggests that a sharp adjustment of the global system occurred, one which should be reflected in other independently observed geophysical fields such as surface wind and surface pressure. The combined record of all the surface fields can be viewed with greater confidence than one field alone. The pressure field must relate to the wind field, and in regions of strong sea-surface temperature gradients the wind field relates to sea-surface temperature anomalies.

Indeed, the record of the surface wind field does reveal adjustments of the global ocean – atmosphere system around 1900 and in the 1930s. Changes in the wind field during the 1900 adjustment of the global circulation have been partially described (Fletcher, J.O. & Fu, C. *Proc. 7th Climate Diagnostics Workshop*, US Dept of Commerce, NOAA; Oct 1983). They include a decrease in the vigour of the surface wind field over most of the ocean domain, with the most abrupt change in the Asian sector of the Southern Hemisphere westerlies, and an abrupt adjustment of the seasonal position of the tropical convergence in the far western tropical Pacific. Indirect evidence for an adjustment of the large-scale atmospheric circulation in the Indian Ocean around 1900 is also found in the African record, as a sharp decrease in rainfall feeding the Nile River (Riehl, H. & Meiten, J. *Science* **206**, 1178; 1979), and on the Antarctic side, as a sudden warming at Mizuho station, signalled by oxygen isotope ratios in ice cores (Kato, K. in *Ice Caring Project at Mizuho Station*, ed. Kusunaki, K., 165, National Institute of Polar Research, Tokyo; 1978). The implications of the sea-surface temperature record should not, therefore, be dismissed.

The global marine surface data set contains the most detailed record we will ever have of the dynamics of the global climate system over the last century and more. During this period several sharp adjustments seem to have occurred. What remains to be done now is to delineate more fully the spatial and temporal characteristics of these adjustments and to glean from them clues to the nature and causes of global climate change. With the aid of recent work on sea-surface fields, radiosonde coverage since about 1950, satellite observations since about 1970 and, more recently, three-dimensional modelling of the behaviour of the atmosphere, the implications of the long historical record should come clear. □

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