
Concluding Remarks

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Concluding remarks

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In opening this Discussion Meeting, Professor Houghton said that it was the aim of the organizers to put most emphasis on the consideration of problems of the interpretation of data from remote sensing. That aim does indeed seem to have been achieved and we have had some very useful studies of the significance of data and of the principles and methods used in interpretation. Two points have in particular occurred to me. In the first place, as with other types of satellite observation, the techniques of observation and the capacity for obtaining very large amounts of data are outrunning the understanding of the results and the ability to extract significant conclusions; it should, however, be noted that whereas in research it is the new, ill-understood observation that leads to further progress, the many, well-understood, routine observations are the ones that are needed in applications. The second point, and it is related to the first, is the great complexity of some processes that produce detectable signals, so that the interpretation of the response of a remote sensor may only be possible in some limited, well-defined circumstances. A clear instance was given by Dr Curran in his discussion of the determination of leaf area index, while Dr Tucker showed how incompletely the imaging of sea waves is understood.

Today has been devoted to oceanography and glaciology, where the questions being addressed by remote sensing have been with us for a long time. Dr Cartwright showed us some records of tides in the English Channel – the first systematic survey of those tides was made by Edmond Halley in 1701. I suspect that many in the meeting may not fully realize the great importance of the polar ice fields in determining global flows in the oceans and atmospheres, whether in cooling the air or water, or establishing flows around or out of the polar regions, or damping waves and tides and perhaps slowing down the spin of the Earth. The ability of remote sensors to determine the thickness of an ice cap, the extent of sea ice and the proportion of open water will surely lead to important developments in our understanding of the polar ice fields and of this global effect.

Professor Woods reminded us of the dominant influence of the oceans on climatic change, both because the ocean absorbs two thirds of all heat absorbed from the Sun, and because it stores in just the uppermost 5 m or so as much heat as the atmosphere stores. Thus climate cannot be understood without a good knowledge of the general circulation of the oceans, but hitherto that has depended on sampling at isolated points and the results have been grossly distorted by incompleteness and aliasing. For this reason, remote sensing is especially attractive in oceanography, but its use is beset by many problems. The measurement of the height of the sea surface, potentially a most powerful technique, depends upon the very accurate determination of satellite orbits, and thus upon a detailed knowledge of the gravity field, required also in estimating the hydrostatic surface of the sea, and on sufficiently frequent tracking to reduce the uncertainties due to the drag of the air upon a satellite to an acceptable level. Again, waves and wind stress can be estimated from satellite observations, but the mechanism by which wave signals in particular are produced seems still to be obscure. Lastly, as Sir John Mason mentioned,

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the temperature of the surface of the sea can be measured, but what is it that is measured: the temperature of the bulk liquid, or that of spray or foam? Thus there are major problems to be analysed, and I hope that this meeting will bring them to the attention of physicists, applied mathematicians and engineers who might work upon them. At the same time, as Dr Robinson pointed out, some of the data that are being received are of novel sorts, and instead of trying to interpret them in preconceived ways, they should be looked at on their own terms to see what they tell us about the natural world. One of the uses of remote sensing will be to alert us to changes in the environment and to predict natural catastrophes. It was made clear that, as has been said elsewhere, the effects of an increase in carbon dioxide in the atmosphere and oceans of the amounts foreseen in the next half century or so are less than the uncertainty of, for example, measurements of sea temperature. Satellite surveillance should help to follow the effects of pollution, but its capacity should not be overestimated. As for catastrophes, satellite observations can already detect incipient hurricanes; whether it will ever be possible to recognize areas in which earthquakes might be about to occur must at the moment remain speculative.

There are indeed great prizes to be looked for in studying the world about us by remote sensing but many of them are still far off, and will only be attained by deep, thorough and subtle analysis.

It remains for me to offer to all our contributors the thanks of the organisers for their participation and ready cooperation; our thanks go likewise to those who have contributed extempore. We all of us, organizers, contributors and participants, are indebted to the officers and staff of the Royal Society for enabling this meeting to take place and for providing the facilities of the Society with their usual efficiency.