introduction

From Remote Sensing to Relevant Sensing in Human Health

Guest Editors, Simon I. Hay, Monica F. Myers, Nancy Maynard, and David J. Rogers

The continued importance of a range of infectious diseases is a major concern for global public health. The annual human toll of morbidity and mortality exacted by malaria is a telling example. The disease is caused principally by infection with the *Plasmodium falciparum* parasite and transmitted between people by blood-feeding females of the *Anopheles* genus of mosquitoes. Current estimates of the global malaria burden are crude, but it is on the order of 200 million clinical events per annum, from which approximately 1 million people die (WHO 1999). Three-quarters of these deaths (*i.e.* about 2,000 per day) will be in the under-five age group of sub-Saharan Africa's population. An increasing body of evidence suggests this risk has increased in the last decade, primarily because of the evolution of drug resistance (Snow *et al.*, 2001), rather than the widely cited alternative of climate change (Rogers and Randolph, 2000; Hay *et al.* 2000a; Hay *et al.*, 2002). Malaria is one infectious disease among many where remote sensing can have a significant future role (Rogers *et al.*, 2002).

The introduction of pathogens into new areas suggests that this bleak picture will get worse and mosquito-borne diseases are again appropriate to illustrate the point. Dengue fever is caused by infection with the dengue flavivirus and is transmitted between people by city tolerant *Aedes* mosquitoes. The best estimates, although again crude, are of 50-100 million clinical events per annum, from which a small percentage will die from haemorrhagic manifestations (Gubler, 1998). It is the leading cause of pediatric morbidity and mortality in many Southeast Asian countries. Dengue is predominantly a disease of built-up areas. It is therefore increasing its abundance globally, as populations in the tropics become increasingly urban. Furthermore, in common with other flaviviruses (the recent introduction of West Nile virus into the United States is another example; see Highlight article, p. 112), dengue is spreading its range in a world where geographical barriers have been shrunk by international air travel. The combination of an ever expanding human host population and more rapid spread of virus serotypes also suggests that more rapid evolution of these viruses is probable (Worobey *et al.* 1999).

Epidemiologists live in busy times. The above examples are selected from a large body of evidence that suggests that these times will get busier. Against this gloomy background, however, novel and cost-effective control techniques are continually being developed and the government and private sector are becoming increasingly motivated towards disease control (WHO 1999). These factors have lead to an increased impetus for those of us developing our ability to map spatial and temporal risk of disease, so that those interventions that are available may be most rationally and economically deployed (Brooker *et al.* 2001). In concert with these changes, our ability to acquire relevant information about the Earth's surface through remote sensing is rapidly improving. Environmental data derived from satellite sensors have never been more plentiful. In contrast, information on disease distribution in space and time, particularly in the tropics, has rarely been scarcer. The primary goal of this meeting of disciplines is to turn the data avalanche of remote sensing into useful information for public health. It is against this background, and with this challenge, that this special issue was conceived.

We considered only submissions detailing primary research into remote sensing applications in human health, as an extensive review exercise had been recently completed (Hay *et al.* 2000b). Six research papers and one Highlight article were ultimately selected for inclusion. They were chosen to show examples from the full range of human pathogens (viruses, bacteria, protozoa and multi-cellular organisms) and to demonstrate work from Africa, North American, and Asian regions. The studies were also selected to illustrate the application of both high and low spatial resolution satellite sensors and some of the diversity of techniques currently being used.

Summary of Contents

Highlight Article: Predicting the Distribution of West Nile Fever in North America Using Satellite Sensor Data — this article accompanying the front cover details the preliminary results of a nascent research program to investigate the introduction and ultimate spread of West Nile virus into North America.

Mapping Potential Risk of Rift Valley Fever Outbreaks in African Savannas Using Vegetation Index Time-Series Data — this article evaluates evidence for an association between Rift Valley fever outbreaks, rainfall (as inferred from vegetation growth responses), and the El Niño Southern Oscillation (ENSO) in Africa. The rudiments of an early warning system for RVF are discussed.

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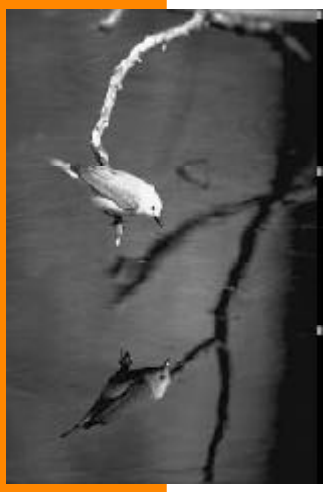

Climatic and Ecological Context of Ebola Outbreaks — looks at the ecological similarity in regions that have experienced Ebola outbreaks to help generate some hypotheses about the environmental conditions favorable to the elusive vectors or reservoirs for this disease.

Application of Remote Sensing to Enhance the Control of Wildlife-Associated *Mycobacterium bovis* Infection — presents a description of models to predict possum related bovine tuberculosis risk, plus an evaluation of their impact on vector control programs and their incorporation in a decision support system for the management of the disease.

Updating Historical Maps of Malaria Transmission Intensity in East Africa Using Remote Sensing — presents the results of a study that attempts to update the current knowledge on the spatio-temporal distribution of *Plasmodium falciparum* malaria in East Africa using historical map data and more recently available multi-temporal meteorological satellite data.

The Use of Remote Sensing for Predictive Modelling of Schistosomiasis in China — details important differences in schistosomiasis transmission and associated snail ecology between the upper and lower regions of the Yangtze River in China, and describes the results of a remote sensing classification of snail habitat in the upper region and modifications for its use in the lower region.

Using NOAA-AVHRR to Model Human Helminth Distributions in Planning Disease Control in Cameroon, West Africa — shows how remote sensing can be used to develop predictive maps of helminth infection prevalence and discusses how such maps can be used for planning control activities.

In one issue it is hard to convey the breadth of remote sensing applications in human health. We hope, however, that this selection may go some way to demonstrating the real and present potential of this research area. If we find any resonance in the remote sensing community, particularly among those who are open to broadening their research activities and constituency, this special issue will have been worthwhile.

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Authors

Simon I. Hay, Trypanosomiasis and Land-use in Africa (TALA) Research Group, Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, UK and Kenya Medical Research Institute/Wellcome Trust Collaborative Programme, P.O. Box 43640, Nairobi, Kenya

Monica F. Myers, Decision Systems Technologies, Inc. (DSTI), 1700 Research Boulevard, Suite 200, Rockville, MD 200850, USA

Nancy Maynard, NASA Environment and Health Program, Goddard Space Flight Center, Code 900, Building 33/Room E228, Greenbelt, MD 20771, USA

David J. Rogers, Trypanosomiasis and Land-use in Africa (TALA) Research Group, Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, UK

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