Predicting the Distribution of West Nile Fever

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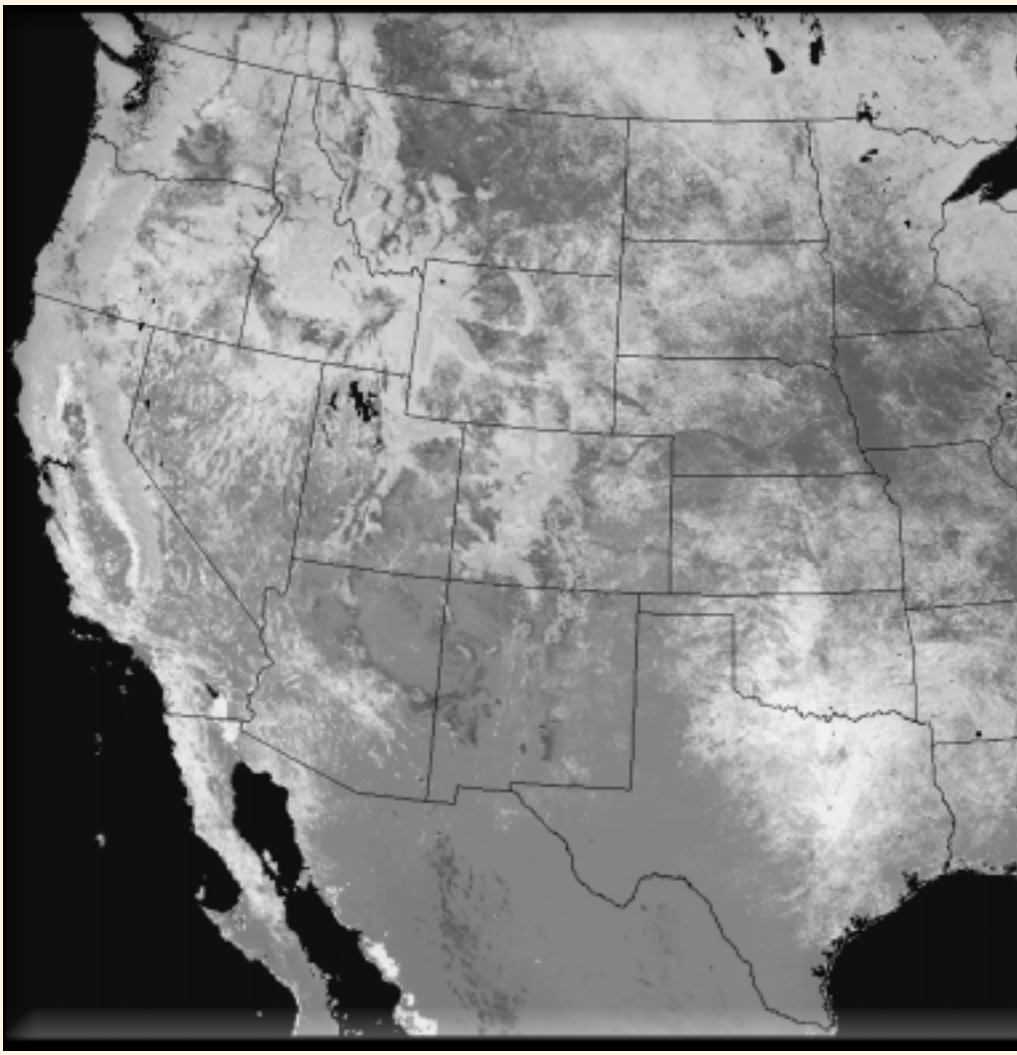

The front cover image is derived from the conterminous U.S. AVHRR 1km data set produced by the United States Geological Survey (USGS) for 1997-2000 (Eidenshink, 1992). The original 14-day maximum value composites were used to produce land surface temperature (LST) imagery (Price 1984) which has here been temporal Fourier processed to derive measures of the mean, amplitudes and phases of the annual, bi-annual, and tri-annual cycles that best describe the thermal seasonality of habitats across the U.S. (Rogers, 2000). In this real color image the mean of the LST is shown in red, the amplitude of the annual cycle in blue, and the phase or timing of this annual cycle in green. The major North-South temperature difference (dull red in the upper part of the image to bright red in the lower part) is considerably affected by the Rockies in the West and, to a much lesser extent, the Appalachians in the East. The brighter blue in the upper part of the image indicates the greater annual amplitude of the LST cycle at higher latitudes. Finally there is less variation in the timing of the annual peak of LST, which is earlier in the South than in the North.

The black dots on the image represent the centers of all counties reporting one or more birds positive for West Nile Virus (WNV) from January 2001 to 20th October 2001 (http://cindi.usgs.gov/hazard/event/west_nile/west_nile.html). West Nile Virus causes flu-like symptoms that in particularly vulnerable people, such as the elderly, may lead to occasionally fatal encephalitis. WNV had an exclusively Old World distribution until 1999 when it was first reported in New York (Nash et al., 2001). From the two or three states affected in the first year, the number grew to 12 states in 2000, and more than 20 in 2001 (Marfin et al., 2001). WNV is naturally transmitted by mosquitoes between bird hosts, and it is thought (though not yet proven) that migrating birds are responsible for the rapid spread of this disease in the U.S. (Rappole et al., 2000). The southern states of Florida, Georgia, and Alabama, all first affected in 2001, are on major bird migration routes along the eastern seaboard.

The International Research Partnership for Infectious Diseases (INTREPID) program is using remotely sensed satellite data to monitor and predict the spread of this new disease in the U.S. The project's efforts are funded by NASA through its Earth Observing System Data and Information System (EOSDIS) Synergy Project managed by Raytheon Corporation in Landover, Maryland (http://earth-outlook.east.hitc.com:1500/); an initiative designed to develop remote sensing applications for state and local use. The INTREPID group is working together with the New York State Department of Health, the agency with the longest experience of West Nile surveillance and control in the U.S., to develop ways of combining field and satellite data with the aim of producing WNV risk maps, updated in real time during the mosquito seasons, to guide survey and control services to areas of greatest risk. Once developed, similar approaches will

in North America using Satellite Sensor Data

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be applied to other regions of the country. Images of the sort shown here, that capture habitat seasonality in biologically meaningful ways, may be used to identify different ecozones (Brooker et al., 2001) within which different suites of mosquito vectors or hosts are likely to be involved in WNV transmission, and therefore where separate analyses should be carried out. Risk maps will be made available on the web, with secure access to participating states only, so that data confidentiality is maintained.

As with all similar "emerging diseases" the questions often asked are "Why here?" and "Why now?" Satellite data go some way towards answering such questions. We now have an almost 20-year archive of global AVHRR data at 8km spatial resolution (James & Kalluri 1996) which may be used to look for telltale signs of global change, perhaps associated with emerging diseases. As an example, Figure 1 shows (A), the 1982-2000 mean LST (in false color composite, where blue indicates low temperature and red high temperature), and also the mean LST for the three single years (B) 1998, (C) 1999, and (D) 2000. It is clear from these images that 1998 was warmer than average, 1999 was about average and 2000 was slightly cooler than average. We suggest that the mild winter of 1998/99 provided conditions favorable for WNV transmission in 1999, perhaps by allowing greater over-winter survival of hibernating mosquitoes, leading to higher numbers of vectors in 1999.

INTREPID's work on WNV is one part of an ambitious scheme to produce early warning systems for a variety of diseases which, like WNV, are transmitted by insects or ticks (malaria, dengue, Lyme Disease, Tick-borne Encephalitis) together with other infectious and non-infectious diseases with environmental correlates (influenza, asthma). Clearly, satellite data provide the only means available to us for extensive monitoring in space and time of these dynamic disease situations.

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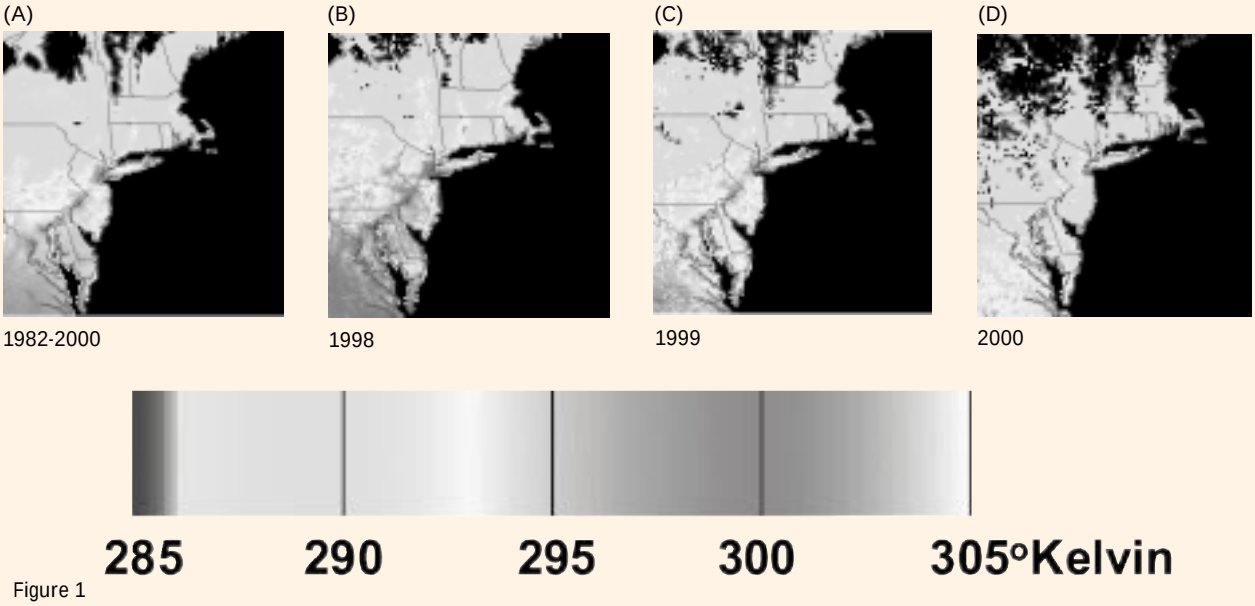

Figure 1

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