National Aeronautics and
Space Administration
Office of Earth Science

Report of Findings
CDC NCID and NASA Technical Meeting
May 21-22, 2003

Prepared by
Timi S. Vann
Deputy Program Manager, Public Health Applications
John C. Stennis Space Center, MS

June 3, 2003

EXECUTIVE SUMMARY

This report documents findings from the first formal meeting between NASA and the Centers for Disease Control and Prevention (CDC) dedicated to discussions on the uses of Earth science and remote sensing for the surveillance of West Nile virus and other vector-borne infectious diseases. The meeting focused on West Nile virus because of heightened public awareness, media interest, and heritage efforts by NASA to map the risk of this virus. However, both parties agreed that the potential contributions of Earth science and remote sensing for infectious disease surveillance extended beyond West Nile virus. As a result of this meeting, the CDC and NASA concluded that there is significant basic research required to better understand the complex ecology of West Nile virus. The state of the science limits the usefulness of NASA data to understand and respond to this disease. However, further discussions centered on areas of opportunity where NASA could make focused investments that lead to measurable improvements in vector-borne infectious disease surveillance through the development of innovative methodologies and tools. This report includes recommendations for collaborations between NASA and the CDC that were identified as mutually beneficial and that clearly led to enhanced decision support. These collaborations include the following:

1. verification and validation of Earth science data for regional modeling of plague within the context of the CDC's Plague Surveillance System;
2. data standardization, handling, linkage, modeling, and display of CDC's ArboNET surveillance information; and
3. development of methodologies and decision support tools for responding to malaria that have potential transferability to other vector-borne infectious disease.

BACKGROUND

West Nile (WN) virus is a mosquito-borne human, equine, and avian neuropathogen indigenous to Africa, Asia, Europe, and Australia[1]. WN virus is transmitted to humans primarily though the bite of an infected mosquito. This virus can cause a range of illness from uncomplicated fever to fatal meningoencephalitis[2]. In 1999, WN virus was discovered in the Northeastern United States and has since spread throughout much of the continental United States. Although the rate and magnitude of WN virus cannot be known with certainty, it is anticipated to be soon endemic to the United States.

From a public health perspective, it is important to understand the significance of WN virus. Although the incidence of severe neuroinvasive disease and death from WN virus increases with age, the mortality rate for this virus is low in the general population[3]. The significance of WN virus is not the virus itself, but rather what this particular virus represents as an epidemic agent. The discovery and rapid spread of WN virus underscores the risks associated with the introduction of more virulent pathogens. WN

---

[1] Campbell, G.L., Marfin, A.A, Lanciotti, R.S. and Gubler, D.J. (2002). "West Nile Virus" *The Lancet Infectious Diseases* Vol 2 pp 519-529.
[2] Ibid.
[3] Ibid.

virus demonstrated how unprepared this country's public health system is to respond rapidly and effectively to episodic diseases.

Since its discovery in the Northeastern United States, a number of NASA and NASA-sponsored investigators have used remotely sensed data to map WN virus risk. These risk maps are based on presumed correlations between remotely sensed measurements of temperature, precipitation, and vegetation and the incidence, prevalence, and anticipated spread of this disease.

In 2001, NASA's newly formed Earth Science Enterprise Public Health Applications Program initiated a concerted effort to bring NASA's multiple efforts to track WN virus into focus. This focus was shaped by the new NASA Applications strategy that is built on a foundation of federal partnerships and partner priorities.

On March 25, 2003, three members of NASA's Public Health Applications Team met with representatives from the Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector Borne Infectious Diseases (CDC NCID DVBID). The CDC NCID is the lead federal agency for preventing illness, disability, and death caused by infectious diseases in the United States. The purpose of this trip was to initiate a dialogue between NASA and the CDC to discuss explicitly NASA's heritage efforts to utilize remotely sensed data for WN virus risk mapping and more broadly to discuss CDC interest in potential partnerships for other vector-borne infectious diseases. Dr. Robert Venezia, Dr. Stan Morain, and Timi Vann were the NASA representatives. Dr. William Sprigg, Institute for the Study of Planet Earth at the University of Arizona, provided additional support. The NASA presentation given at this meeting is provided in Appendix A.

This initial dialogue resulted in important feedback and information from the CDC. The CDC is familiar with efforts to use remotely sensed data for WN virus risk mapping. The CDC communicated that tracking and predicting occurrences of WN virus using satellite data and attributing the rate and magnitude of WN virus spread to a few parameters or to a warm winter pattern is simplistic and is not scientifically validated. That stated, the CDC recognized the value in evaluating how new science and technology may help the CDC to understand better the complex ecology and transmission dynamics of WN virus and of other infectious diseases. The significant interest was not on WN virus per se but on methodologies and tools that could be used not only to understand and respond to WN virus but to a whole host of vector-borne infectious diseases. To this end, the CDC was interested in better understanding the full range of NASA capabilities from data collection and handling to model and other product development. As a result of this initial dialogue, NASA and the CDC agreed to a two-day meeting to understand better the issues facing the CDC and the capabilities present within NASA. Both agencies agreed that the goal was to determine if a mutually beneficial collaboration were feasible and, if so, to define a focus for such a collaboration.

TECHNICAL MEETING

On May 21 and 22, 2003, the technical meeting between the CDC and NASA was held on the campus of the University of Mississippi Medical Center. NASA representation was diverse and individuals were selected based on their ability to speak to a suite of NASA Earth science and technology capabilities. The CDC attendees represented arbovirus diseases, plague, and data collection and handling interests. Members from the University of Mississippi provided a clinical perspective, and members from academia and the State of California served to bridge the interests of the two agencies. A list of attendees is provided in Appendix B.

Goals & Objectives

The goal of the meeting was to determine if NASA's Earth system science and supporting technologies could make a meaningful contribution to vector-borne disease study and ultimately to disease surveillance (decision support). The objective was to come away from the meeting with enough information to explain how NASA capabilities could help the CDC or to define specifically why they could not. Participants agreed that there could be no negative findings. The meeting agenda is provided in Appendix C.

To achieve this goal and to meet the objectives, the meeting was structured to first afford the CDC an opportunity to provide an overview of surveillance for vector-borne infectious disease and to discuss some of the unique challenges to understanding WN virus in particular. NASA presented an overview of Earth science remote sensing and provided examples of heritage efforts and current projects focused on health research and public health applications. NASA provided examples of complementary capabilities in data processing, product development, and archiving as well as information technology systems. Copies of the CDC and NASA presentations are provided in Appendix D.

Summary of CDC Presentation on Vector-Borne Disease Surveillance and WN Virus

Effective vector-borne infectious disease surveillance is international in scope, includes both passive and active reporting, and is verified and validated through lab-based testing. Information is exchanged through secure database networks. Passive surveillance entails standardized reporting systems and relies on physician input of clinical presentations of disease. This surveillance method is effective for monitoring long-term disease trends. Active surveillance relies on a standardized data collection methodology and rapid lab-based verification and validation of data. The objective of active surveillance is to detect disease with minimal delay. Both surveillance methods are limited in their ability to contribute to disease prediction.

All arborviral viruses have complex transmission cycles centered around a primary host (e.g, bird) and a primary vector (e.g., mosquito). There are intrinsic and extrinsic factors that influence transmission dynamics. Satellite remote sensing is not effective for measuring intrinsic factors. These factors are vector-, host-, and pathogen-specific characteristics, such as population density, behavior, immune status, virulence, and genetics. Extrinsic factors, such as rainfall, temperature, humidity, and wind, are parameters that can be measured with remote sensing instrumentation. Many extrinsic factors are linked to intrinsic factors and result in forcing effects that are complex and not easily understood.

The implementation of an effective disease surveillance and response strategy must also consider the infrastructure and organization of public health. Surveillance does not equal prevention. It is important to understand that Public Health practice is conducted at state and local levels. The CDC does not have regulatory authority over state and local public health practice, and local response is dictated by community-based organizations (e.g., state and local health departments). The CDC provides state and local entities with critical guidance and resources for infrastructure development and maintains data systems that facilitate the exchange of information across jurisdictions. This structure mandates that the CDC work closely with state and local public health departments to develop integrated, community-based prevention and response strategies.

As part of the surveillance overview, the CDC spoke to the complexity of the WN virus host-vector transmission and life cycle, which limits the use of remote sensing to predict risks and epidemics. In fact, the priority goal for the CDC is not to predict risk of incidence but to understand the complex ecology. Understanding the ecology is a first step to understanding the possibilities for an epidemic. The CDC concluded that many considerations must be taken into account, and environmental parameters, although important, are only one small aspect of understanding and responding to vector-borne disease.

Summary of CDC Presentation on Plague

The CDC provided NASA with an overview of plague and suggested that the state of scientific understanding of this disease is more mature than that of WN virus and may be more appropriate for evaluating uses of remote sensing and Earth science for vector-borne disease surveillance.

Plague is an infectious disease caused by the bacterium *Yersinia pestis*. Plague is transmitted to humans by fleas that are infected with the bacteria. The last urban plague epidemic in the United States occurred in 1924-25; however, it remains a persistent threat. Plague surveillance is a CDC priority. Plague is a Class A disease and, by law, all occurrence of cases or suspected cases must be reported. Plague is a major public health concern because of the severity of disease and the potential for epidemic spread. This disease is also monitored for its potential as a bio-terrorist pathogen. Plague prevention and response efforts are underway at regional, state, and local levels through the CDC-sponsored Plague Surveillance System.

Summary of CDC Presentation on ArboNET

The CDC provided NASA with an overview of the Nation’s Arboviral Surveillance System, titled ArboNET. ArboNET is a passive surveillance system managed by the

CDC. The purpose of this data information system is to collect and archive data to study and operationally monitor regional and national arboviral disease trends. The CDC, participating health departments, the Department of Defense (DoD), and the U.S. Geological Survey (USGS) are primary users of ArboNET.

The CDC has published guidelines, established case definitions, and developed surveillance categories for ArboNET. Data flow locally from each state to the ArboNET database. Each state collects two types of data: numerator (individual) data on human, equine, and avian disease cases derived from field collects and from clinical and lab reports; and denominator (aggregate) data on individuals tested per week and by county. These data are entered and uploaded weekly into ArboNET.

The data server is housed at CDC Headquarters in Atlanta, GA; ArboNET technical management (medical epidemiologists and programmers) is located at the CDC National Center for Infectious Disease in Fort Collins, CO.

Summary of NASA Presentations

NASA’s presentations attempted to provide the CDC with an overview of NASA Earth science capabilities and remote sensing. Presentations began with an introduction to remote sensing principles and highlights of example projects of potential public health interest. This introduction was followed by an overview of NASA’s Earth science data, examples of data products, and an explanation of NASA’s network of distributed Earth science data information and archiving centers. Current projects and heritage efforts were also presented and “lessons learned” were discussed. In addition to the NASA briefings, a project from the State of California was presented. This presentation effectively highlighted the considerable research required to understand better the complex ecology of WN virus.

Overall, the presentations appeared to be well received. The CDC seemed particularly interested in NASA’s partnership with the Department of Defense that is focused on malaria habitat, transmission, and predictive risk modeling. Malaria is associated with environmental parameters that are measured using NASA and other remote sensing instrumentation, and predictive models are being developed using neural network methodologies. These models are being used to support force protection and deployment decisions by the U.S. military. The CDC clearly indicated that this type of effort exemplifies what is needed to understand and respond to other vector-borne infectious diseases like WN virus.

Conclusions

The CDC NCID finds value in NASA data and technology capabilities. However, NASA’s data and technology must be validated in partnership with the CDC. This validation must be carefully planned and could take a significant amount of time. Additionally, CDC staff resources and funding are very limited.

Although WN virus was the impetus for this first technical meeting between the CDC and NASA, both parties agreed that the potential contributions of Earth science and remote sensing for infectious disease surveillance extended beyond WN virus. The CDC and NASA concluded that significant basic research is required to understand better the complex ecology of WN virus, and that the state of the science limits the usefulness of NASA data to understand and respond to this disease.

The Plague Surveillance System was offered as an ideal starting point to structure a CDC-NASA collaboration. The study of malaria was identified as valuable given the maturity of model development and connection to local decision makers. Plague and malaria are both vector-borne infectious diseases, but each represents different points along a continuum of research to decision support, and both hold great potential to contribute significant methods and tools that can be extended to the surveillance of other vector-borne infectious diseases. The ArboNET surveillance system exemplifies cross-cutting issues, such as metadata, data standards, data collection, data processing, and data display.

Members from academia suggested that the CDC and NASA spearhead the development of a committee dedicated to developing a strategic vision that would prioritize research, focus efforts, and manage and/or structure coordination for long-term collaborations between NASA and the CDC.

FINDINGS & RECOMMENDATIONS

Finding #1: WN virus

To be effective in prevention and control of WN virus, CDC epidemiologists believe that more research is needed to understand better its complex ecology. Consequently, the CDC concluded that NASA's efforts to track WN virus and to map risk are premature since significant gaps in scientific understanding currently limit their validity. In essence, the application readiness level for WN virus is nonexistent.

Recommendation:

1. Discontinue Earth Science Applications Division funding of WN virus risk mapping activities.

Finding #2: Plague Surveillance System

The CDC has used remotely sensed data to model plague in the Southwest United States. Ecology and transmission are understood better for plague than for WN virus, and links between climate and plague vector habitats are relatively well characterized. Predictive models (trophic cascade models) have been developed using precipitation and temperature parameters, and vegetation classes have been derived from Advanced Very High Resolution Radiometer (AVHRR) and ground station data. The AVHRR data coincide with incidence of disease. However, more verification and validation is required to refine models and to extend and link remote sensing data and information to local prevention strategies.

Recommendation:

1. Work with the CDC to define information and technology requirements for enhancing the Plague Surveillance System, and target investments to support solutions that meet partner-defined requirements.

Finding #3: ArboNET

Significant discussion focused on expanding uses of ArboNET surveillance data, data limitations, and data handling. The CDC identified a number of data limitations and handling challenges. These challenges included data compilation and analysis, metadata standards, delays in testing and reporting, and data reporting inconsistencies. The CDC is very interested in NASA's experiences and capability in data and information. This includes establishing data pipelines from the CDC to NASA DAACs, data standards, data collection, computational technologies, data display, and information system architectures. Developing new methodologies for enhancing the ArboNET disease surveillance system hold potential for significant improvements in standard approaches to data selection, collection, processing, and display.

Recommendation:

1. NASA data and information system experts should work with the CDC to evaluate ArboNET and to define system improvements and information and technology gaps. Investments should be targeted to support solutions that meet partner-driven requirements.

Finding #4: NASA's Malaria Investment

The CDC is interested in utilizing new technologies and in developing methodologies for monitoring and modeling infectious diseases. New tools and methodologies that are developed to model, prevent, and respond to plague may have significant transferability to other vector-borne infectious diseases.

Recommendations:

1. Continue applied research efforts to develop decision support tools for Malaria. Investments should continue to fund the partnership with DoD and should be used to expand the partnership to include peer review, coordination, and consultation with the CDC NCID.

2. Increase project funding to support model and other tool development that can be extended and/or applied to other CDC-defined vector-borne disease surveillance priorities.

Finding #5: CDC-NASA Strategic Working Group for Arboviral Diseases

WN virus demonstrated how unprepared this country's public health system is to respond rapidly and effectively to episodic diseases. Research and applications to enhance preparedness must be guided by a strategic plan that is focused not on a specific disease but on achieving a long-term vision for substantive improvements to disease control and prevention strategies and operations.

Recommendation:

1. Establish a joint-agency and academic advisory committee dedicated to developing a strategic vision that would identify and prioritize needs, focus efforts, and manage and/or structure coordination for long-term collaborations between NASA and the CDC. This committee is volunteer-based; no significant funding is required.

Finding #6: NASA Investment in Basic Research to Support Public Health and Clinical Medical Practice

The CDC stated that any partner investments in WN virus should be tied to basic field- and lab-based research. Therefore, partner collaborations should stimulate interesting biological and ecological investigations and findings. However, the CDC also emphasized that this activity currently does not exist on a continuum leading directly to measurable enhancements to public health decision support; it remains squarely in the domain of basic research.

NASA's Applications Division does not invest in basic science research. All research and development activities are expected to be clearly road-mapped to specific improvements in the decision support systems and tools of partner agencies. In the case of WN virus, these opportunities are not present. This presents NASA with a critical juncture early in its partnership with the public health practice and clinical medical communities. NASA should consider adding a basic research component to complement the Agency's applications focus.

Recommendation:

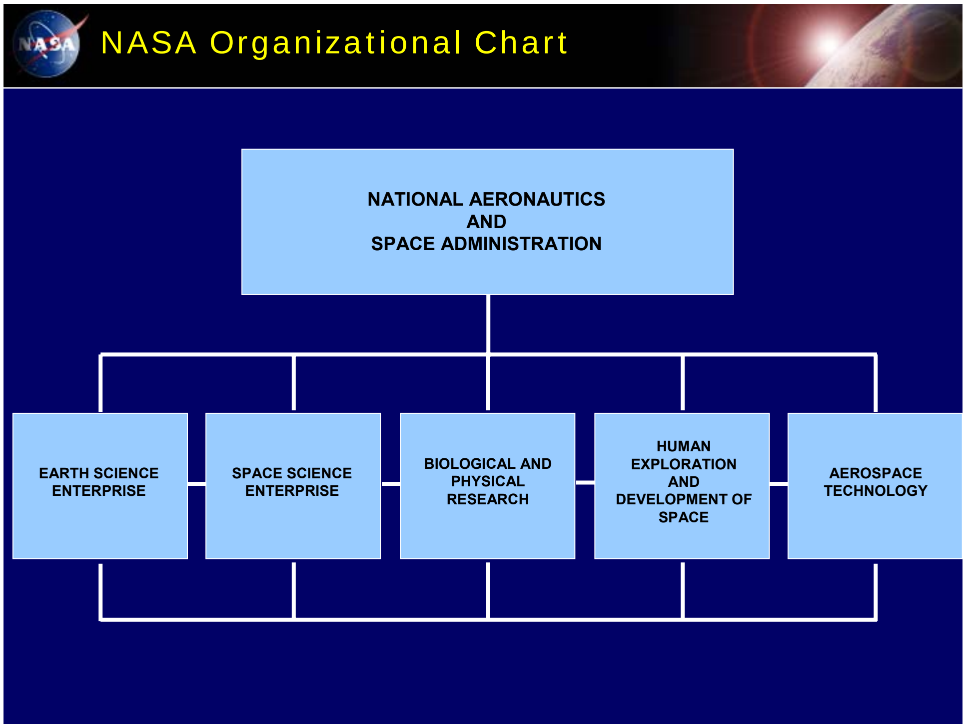
1. Distribute this Report of Findings to the Earth Science Enterprise Science Division and to the Biological and Physical Research Enterprise with the recommendation to support collaboratively a basic public health and clinical medical research focus. There is currently no such scientific focus within the Earth Science Enterprise. However, there are significant fundamental research opportunities to utilize NASA's unique capabilities to increase understanding of vector-borne disease ecology (as exemplified by WN virus) and to decrease uncertainties associated with disease transmission dynamics. This initiative would fit within the stated missions of both Enterprises. Moreover, CDC officials stated that they would support a partnership based on this concept.

APPENDIX A

MARCH 25, 2003, NASA PRESENTATION

NASA Earth Science Enterprise
Public Health Applications
Program

March 25, 2003

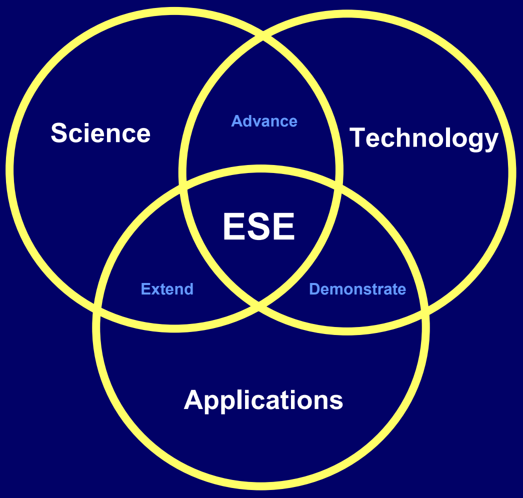


NASA Organizational Chart

NATIONAL AERONAUTICS
AND
SPACE ADMINISTRATION

- EARTH SCIENCE ENTERPRISE
- SPACE SCIENCE ENTERPRISE
- BIOLOGICAL AND PHYSICAL RESEARCH
- HUMAN EXPLORATION AND DEVELOPMENT OF SPACE
- AEROSPACE TECHNOLOGY

NASA Earth Science Enterprise



Science

Advance

Technology

ESE

Extend

Demonstrate

Applications

Science Questions

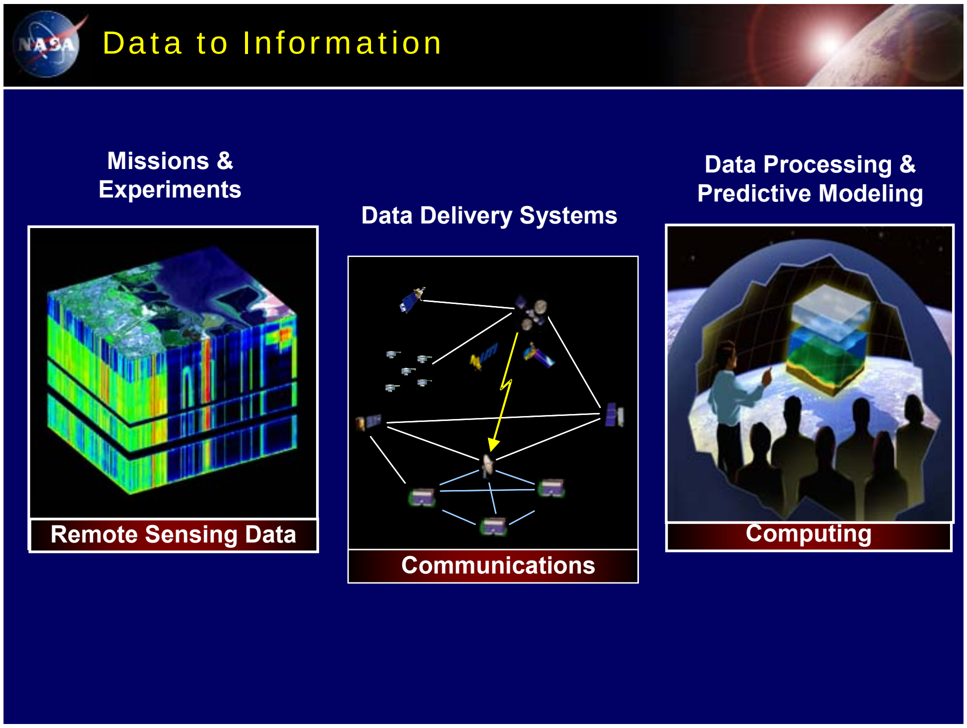
Variability: How is the global Earth system changing?

Forcing: What are the primary causes of change in the Earth system?

Response: How does the Earth system respond to natural and human-induced changes?

Consequences: What are the consequences of changes in the Earth system for human civilization?

Prediction: How well can we predict future changes to the Earth system?



Data to Information

Missions & Experiments

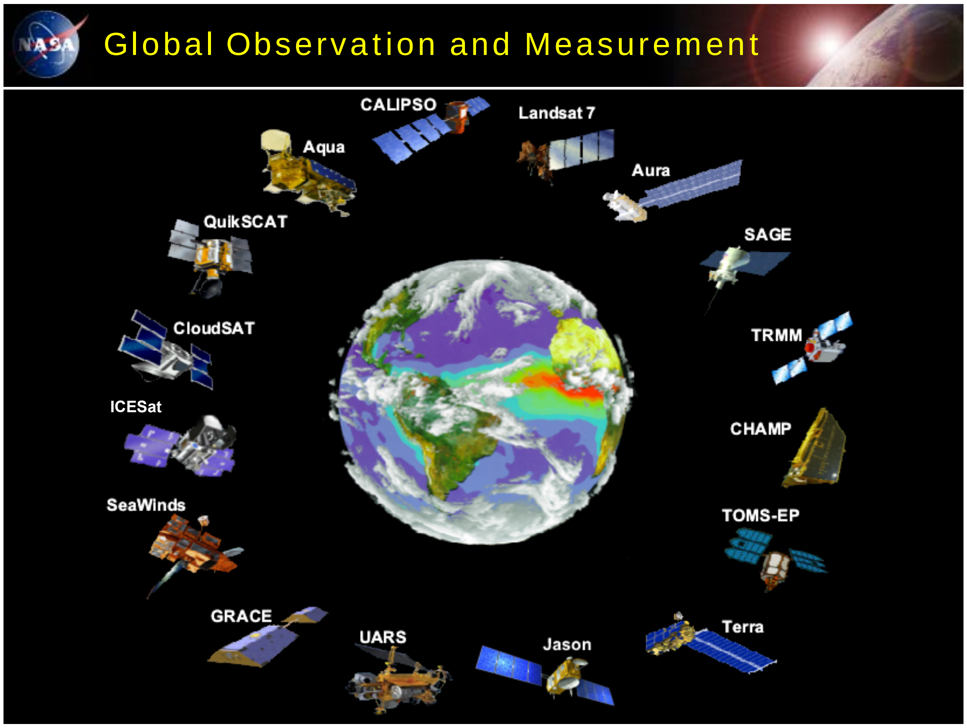
Data Delivery Systems

Data Processing & Predictive Modeling

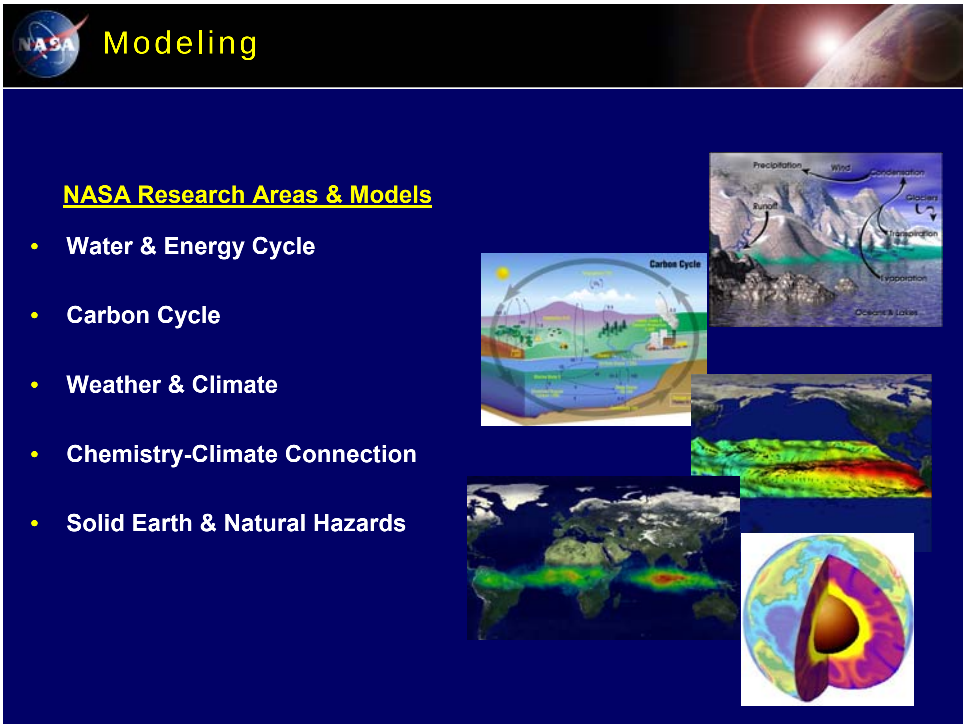
Remote Sensing Data

Communications

Computing



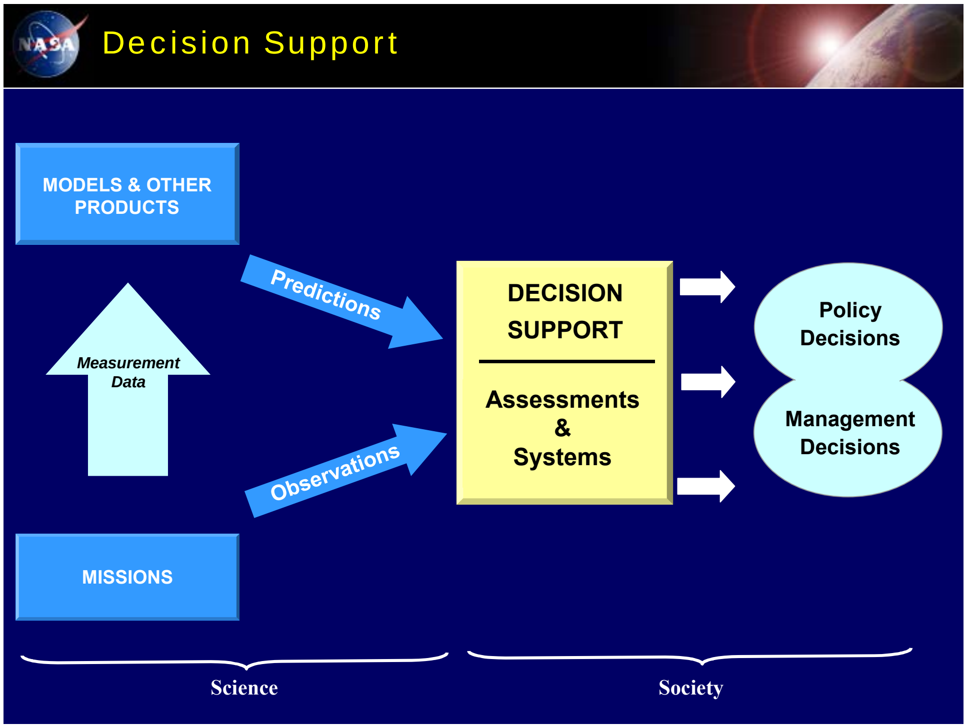
Global Observation and Measurement



Modeling

NASA Research Areas & Models

- Water & Energy Cycle
- Carbon Cycle
- Weather & Climate
- Chemistry-Climate Connection
- Solid Earth & Natural Hazards



Decision Support

MODELS & OTHER PRODUCTS

Measurement Data

MISSIONS

Predictions

Observations

DECISION SUPPORT

Assessments & Systems

Policy Decisions

Management Decisions

Science

Society

Applications

Carbon Management

Public Health

Energy Forecasting

Aviation Safety

Water Management

Homeland Security

Coastal Management

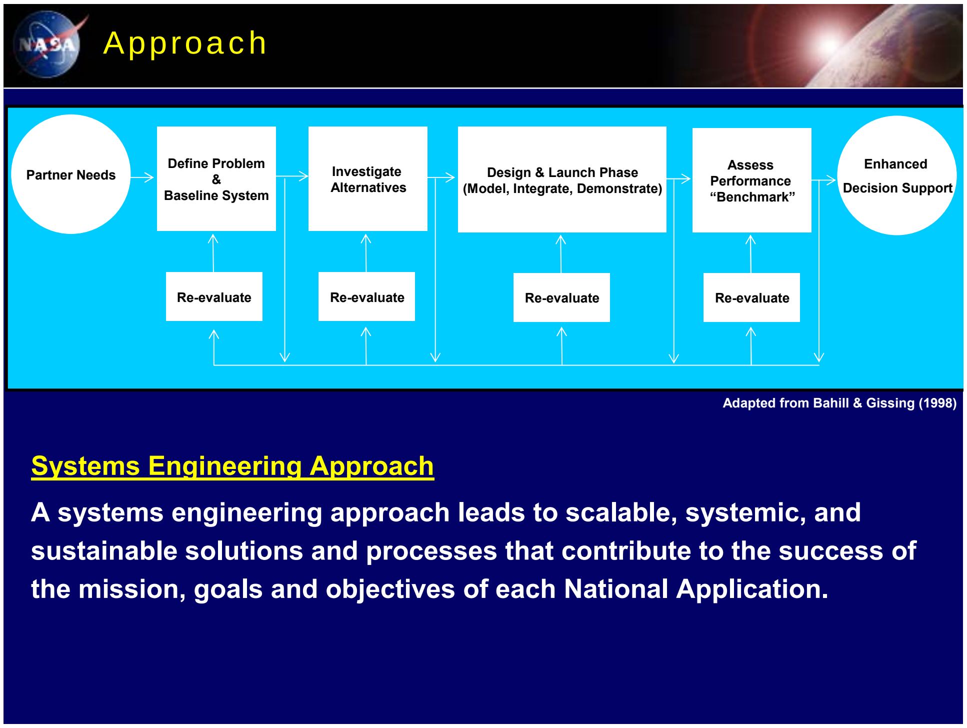
Disaster Preparedness

Agricultural Competitiveness

Invasive Species

Community Growth

Air Quality



Approach

Partner Needs → Define Problem & Baseline System → Investigate Alternatives → Design & Launch Phase (Model, Integrate, Demonstrate) → Assess Performance "Benchmark" → Enhanced Decision Support

Re-evaluate

Re-evaluate

Re-evaluate

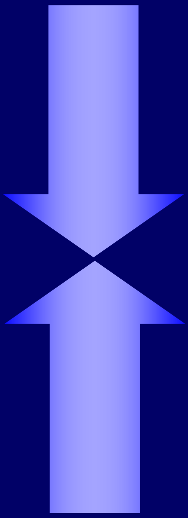
Re-evaluate

Adapted from Bahill & Gissing (1998)

Systems Engineering Approach

A systems engineering approach leads to scalable, systemic, and sustainable solutions and processes that contribute to the success of the mission, goals and objectives of each National Application.

Project Selection Criteria



Socioeconomic Value

Application (User) Feasibility

Mandated Program

Partnership Opportunity

Appropriate for NASA

Science & Technology Readiness

Program Balance

Cost / Budget Context

West Nile Virus

Thursday, October 17, 2002

Gazette Regional News

NASA focuses 'eyes' on West Nile

by Miesha Lowery
Capital News Service

ANNAPOLIS — The National Aeronautics and Space Administration is usually preoccupied with tracking space shuttles and satellites, but soon the lowly mosquito will be on its radar.

The mosquito, a carrier of the West Nile virus, has been spreading the microbe across the country at alarming rates, and NASA is trying to use its innovative technology and satellites to predict where the next outbreak will occur.

NASA's Web site outlines the program and satellite maps that will show land surface temperatures nationwide, vegetation, bird migration patterns and reported cases of birds infected with the virus.

Last year, NASA, Oxford University and New York state began using the virus tracking system to create climate maps based on data from satellites, according to the New York State Department of Health.

These maps revealed areas that are most likely to provide the ideal climate for the virus to flourish, and they tracked areas where the virus already has spread.

"The goal of the program is to extend the benefits of NASA's investments in Earth system science, technology and data toward public-health decision-making and practice," said Robert Venezia, program manager at NASA Headquarters in Washington, D.C., in a written statement.

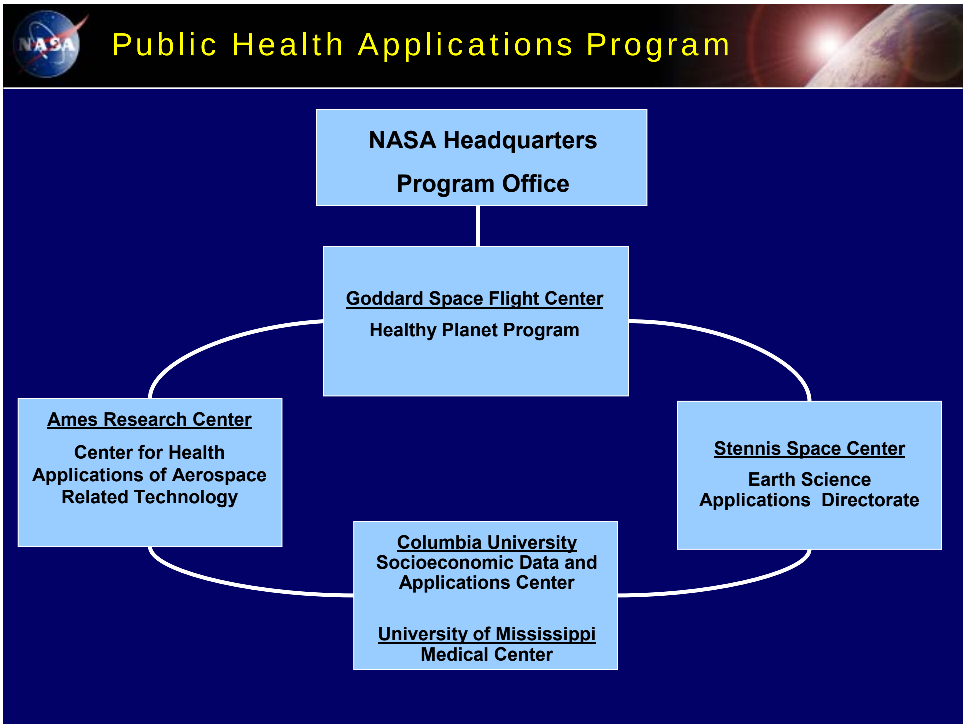
NASA centers, including the Goddard Space Flight Center in Greenbelt, will help collect the data.

West Nile travels with infected birds. Mosquitoes feed on the birds and pass the virus to their larvae, humans and animals, continuing the cycle.

The disease can cause flu-like symptoms and can lead to encephalitis, or sometimes-fatal brain swelling.

West Nile's rapid spread this year, NASA said, has been attributed to an abnormally warm winter in 1998 to 1999, which allowed mosquito larvae to survive and spread almost nationwide. In early 1999, only three states reported cases of West Nile virus, today 35 states have confirmed cases of the virus, with Illinois contributing the highest number of human cases, 654, according to the Centers for Disease Control and Prevention.

The last five winters have flip-flopped between cool and warm with last winter being the second warmest on record in Maryland, according to the National Climate Data Center



Public Health Applications Program

NASA Headquarters
Program Office

Goddard Space Flight Center
Healthy Planet Program

Ames Research Center
Center for Health Applications of Aerospace Related Technology

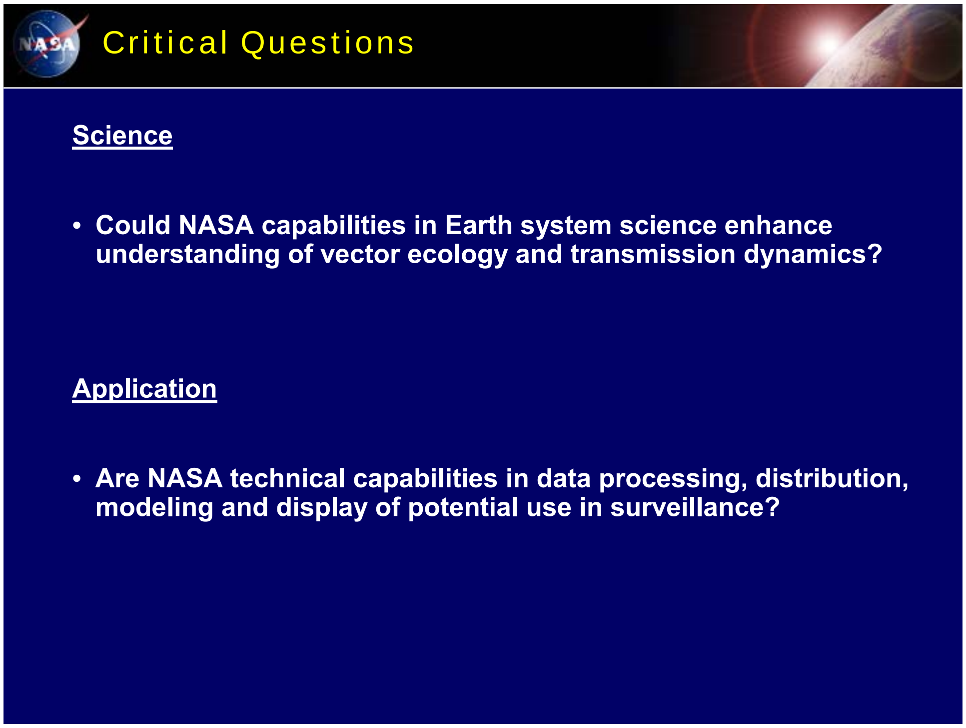
Stennis Space Center
Earth Science Applications Directorate

Columbia University
Socioeconomic Data and Applications Center

University of Mississippi
Medical Center

Summary

- Raw materials = $1.5 billion in Earth science, technology, data
- Unique NASA capabilities—no duplication, no competition
- Not mapping, not GIS
- Roadmap leads from science to decision support
- Partner determines priority foci
- Joint peer review, joint public affairs message
- Vector-borne disease, not just WNV
- Environmental health, not just vector-borne disease



Critical Questions

Science

- Could NASA capabilities in Earth system science enhance understanding of vector ecology and transmission dynamics?

Application

- Are NASA technical capabilities in data processing, distribution, modeling and display of potential use in surveillance?

NASA Commitment

1. Coordinate NASA scientists and engineers to address strategic issues defined by DVBID. Assemble “NASA Tiger Team”
2. Leverage NASA’s academic partners to focus on priority questions.
3. Fund high risk activities associated with the adaptation and adoption of new technologies and information.
4. Ensure a long-term relationship with the DVBID through formal agreement and by programming NASA funds today.
5. Provide public support for CDC’s efforts to use the best technologies and science available to respond to infectious disease threats.

NASA Contact Information

NASA Headquarters

Robert A. Venezia, Dr.P.H.
Program Manger for Public Health Applications
National Aeronautics and Space Administration
Headquarters, Office of Earth Science
300 E. Street, S.W., Code YO
Washington, D.C. 20546
TEL (202) 358-1324
FAX (202) 358-3098

NASA Stennis Space Center

Timi S. Vann, M.A.
Deputy Program Manger for Public Health Applications
National Aeronautics and Space Administration
Earth Science Applications Directorate
Building 1100 Code MA30
John C. Stennis Space Center, MS 39529
TEL (228) 688-1487
FAX (228) 688-7455

APPENDIX B

Participant List
CDC NCID VBID and NASA Meeting in Jackson, Mississippi
May 21-22 2003

NASA Headquarters

1. **Robert A. Venezia, Dr.P.H.**
   Program Manager for Public Health Applications
   Office of Earth Science
   NASA Headquarters
   300 E Street, S.W., Code YO
   Washington, DC 20546
   Tel 202-358-1324
   Fax 202-358-3098
   Robert.A.Venezia@nasa.gov

NASA Stennis Space Center

2. **Timi S. Vann**
   Deputy Program Manager for Public Health Applications
   Applications Research Division
   NASA Stennis Space Center
   MA10 Building 1100
   Stennis Space Center, MS 39529
   Tel 228-688-1487
   Fax 228-688-7455
   Timi.S.Vann@nasa.gov

3. **Lauren Underwood, PhD**
   Scientist, Lockheed Martin Space Operations
   Remote Sensing Directorate
   Building 1105
   Stennis Space Center, MS 39529
   Tel 228-688-2096
   Fax 228-688-2776
   lauren.underwood@ssc.nasa.gov

4. **Robert E. Ryan, PhD**
   Technology Validation Manager
   Lockheed Martin Space Operations
   Remote Sensing Directorate
   Building 1110

Stennis Space Center, MS 39529
Tel 228-6881868
Fax 228-688-7694
robert.ryan@ssc.nasa.gov

NASA Goddard Space Flight Center

5. **Nancy G. Maynard, PhD**
   Associate Director
   Healthy Planet Program
   NASA Goddard Space Flight Center
   Code 900, Building 3, Room E-228
   Greenbelt, MD 20771
   Tel 301-614-6572
   Fax 301-614-5620
   Nancy.G.Maynard@nasa.gov

6. **Gilberto A. Vicente, PhD**
   George Mason University - School of Computational Sciences
   NASA Goddard Space Flight Center, Code 900
   Building 33/Room F213
   Greenbelt, MD 20771
   Tel 301-614-5670
   Fax 301-614-5620
   gvicente@pop900.gsfc.nasa.gov

7. **Richard Kiang, PhD**
   Leader, Earth Science Operations Data Group
   NASA Goddard Space Flight Center, Code 902
   Building 32, Room S160D
   Greenbelt, MD 20771
   Tel 301-614-5375
   Richard.K.Kiang@nasa.gov

8. **Compton J. Tucker, PhD**
   Senior Earth Scientist, Laboratory for Terrestrial Physics
   NASA Goddard Space Flight Center, Code 923
   Greenbelt, MD 20771
   Tel 301 614-6644
   Compton.J.Tucker@nasa.gov

9. **Robert J. Lutz, PhD**
   Associate Head of Science Data Systems Branch
   NASA Goddard Space Flight Center
   Code 586, Building 23, Room W333
   Greenbelt, MD 20771

Tel 301-286-1006
robert.j.lutz@nasa.gov

10. Steven J. Kempler
NASA Goddard Space Flight Center
Earth Sciences Data and Information Services Center
Distributed Active Archive Center and Products and Services Cooperative
Code 902
Greenbelt, MD 20771
Tel 301-614-5765
steven.j.kempler@nasa.gov

11. Bill Teng
Science Systems and Applications, Inc (SSAI)
NASA Goddard Space Flight Center
Earth Sciences Data and Information Services Center
Distributed Active Archive Center and Products and Services Cooperative
Code 902
Greenbelt, MD 20771
teng@daac.gsfc.nasa.gov

NASA Ames Research Center

12. Louisa R. Beck
Remote Sensing Scientist
Center for Health Applications of Aerospace Related Technologies
Ecosystem Science & Technology Branch
NASA Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035
Tel 650/604-5896
Fax 650/604-4680
louisa.r.beck@nasa.gov

13. Cindy Schmidt
NASA Adjunct Investigator
California State University, Monterey Bay
NASA Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035
Tel 650-604-0021
Fax 650-604-4680
cschmidt@mail.arc.nasa.gov

14. Brad Lobitz
NASA Adjunct Investigator

California State University, Monterey Bay
NASA Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035
Tel 650-604-3223
Fax 650-604-4680
blobitz@mail.arc.nasa.gov

NASA Invitee

15. **William Sprigg, PhD**
Deputy Director, Institute for the Study of Planet Earth
AND
Research Professor, Department of Atmospheric Sciences
715 N. Park Ave., 2nd Floor
Tucson, AZ 85721
Tel 520-622-9062
wsprigg@u.arizona.edu

16. **William Reisen, PhD**
Arbovirus Field Station
4705 Allen Road
Bakersfield, CA 93312
Tel 661-589-0891
arbo123@pacbell.net

CDC Participant List

1. **Duane J. Gubler, ScD**
Director
Division of Vector-Borne Infectious Diseases
Tel 970.221.6428
E-mail: dgubler@cdc.gov

2. **John T. Roehrig, PhD**
Chief, Arbovirus Diseases Branch/DVBID
Tel 970.221.6442
E-mail: jroehrig@cdc.gov

3. **Daniel O'Leary, DVM**
Sr Veterinary Epidemiologist
Arbovirus Diseases Branch/DVBID
Tel 970.266.3525
E-mail: doleary@cdc.gov

4. **Aaron Kipp**
   Fellow
   Arbovirus Diseases Branch/DVBID
   Tele: 970.266.3596
   E-mail: akipp@cdc.gov

5. **Ken Gage, PhD**
   Chief, Plague Section
   Division of Vector-Borne Infectious Diseases

Work Address (for all):
PO Box 2087
Fort Collins CO 80522

UMMC Participant List

1. **David Dzielak, Ph.D.**
   Associate Vice Chancellor for Research, UMMC
   ddzielak@ovc.umsmed.edu

2. **Fazlay Faruque, Ph.D., PG**
   Director of GIS, UMMC
   ffaruque@son.umsmed.edu

3. **Stanley Chapman, MD**
   Professor of Medicine (Infectious Diseases)
   Director, Division of Infectious Diseases, UMMC
   schapman@medicine.umsmed.edu

4. **Richard Finley, MD**
   Associate Professor of Medicine, (Infectious Diseases)
   rfinley@medicine.umsmed.edu

5. **Worth Williams**
   Senior Programmer/Analyst, GIS/Office of Research
   wwilliams@dis.umsmed.edu

6. **Grace "Lorine" Oberhousen**
   Senior Secretary, Office of Research
   goberhousen@ovc.umsmed.edu

APPENDIX C

FINAL AGENDA
MAY 21-22, 2003 CDC NCID AND NASA MEETING

May 21
8:00 AM – Workshop Opening & Welcome - *Robert Venezia (NASA HQ) and David Dzielak (UMMC)*

- Purpose, goals & objectives
- Schedule, orientation & logistics
- Introductions

8:45 AM – State of the science for understanding WNV and other vector borne infectious diseases – *Duane Gubler, et al. (CDC)*

This session will include presentations on:

- overview of state of science for understanding WNV and other VBID
- history of WNV
- scientific methodology and technologies used for studying WNV
- any science/information gaps in understanding WNV
- discussion

9:30 AM – State of the technology for responding to VBID outbreaks – *Duane Gubler, et al. (CDC)*

This session will include presentations on:

- types of technologies used to respond to disease outbreaks (in the field, in the lab, in the office)
- what are the data sources, who "owns" the data, is the data accessible, data storage and format
- data processing: how much data, how soon, how often
- who needs information and how is it shared
- technology gaps – what technologies would the CDC like to have
- discussion

10:15 AM - BREAK

10:30 AM – NASA Earth science and remote sensing – *Cindy Schmidt, Louisa R. Beck (NASA ARC)*

- NASA "Big Picture" overview
- Remote sensing overview
    - how data is collected (passive & active)
    - wavelengths
    - resolutions – what that means for public health
    - what can be detected – examples of possible interest to public health

- “So What” – what can remote sensing do for public health?
- discussion

12:00 PM - LUNCH

1:00 PM– NASA technology – *Steven J. Kempler, Robert J. Lutz (NASA GSFC)*

- Remote sensing instruments
- data management and user services
- advanced information systems
- computational technologies and modeling

2:45 PM - BREAK

3:00 PM – NASA environment and health research

- health and environment research – *Compton J. Tucker, Richard Kiang, Gilberto Vincente (NASA GSFC); William Reisen (University of California); Louisa R. Beck (NASA ARC)*
- discussion

4:45 PM – Identify critical themes of Day 1 - *Robert Venezia (NASA HQ)*

What important themes emerge from today's Earth Science and Public Health presentations that are relevant to West Nile Virus specifically, and vector-borne disease in general?

	Earth Science	**Public Health**
Science		vector ecology, transmission dynamics**
Technology	sensor capabilities**	surveillance systems**
	computation**	
Data	modeling**	predicting epidemics**

** ***Note: These are proposed theme categories only.***

We will complete this table and rate the importance of each theme. The top two themes will be pursued during the Day 2 breakout sessions

5:00 PM – Adjourn

6:00 PM – Dinner reception at the Fairview Inn

May 22
8:00 AM – Top Two Critical Themes – *Breakout Sessions*

Discussion: What are the immediate and long term needs for finding solutions in each critical theme? Consider decision-maker demands, basic research gaps, and applied research needs.

9:45 AM – BREAK

10:00 AM – Plans & Timelines – *Open Discussion*

For each critical theme and the identified challenges to finding solutions, discuss:

- collaboration plan
  -- critical administrative steps
  -- critical scientific steps
  -- specific partners
- timelines
  -- short-term plan
  -- long-term plan
- investment needs
  -- expertise, workforce size
  -- funding
- anticipated benefits

11:30 AM – Working Lunch - Summary & Next Steps - *Robert Venezia (NASA HQ) & Open Group Discussion*

- meeting summary (Did we meet our objectives?)
- Where do we go from here?
- next steps

12:30 PM - ADJOURN

APPENDIX D
CDC NCID AND NASA MEETING PRESENTATIONS
MAY 21-22, 2003

01. Duane Gubler, ScD
"Types of Surveillance Used for Vector-Borne Disease"

02. Ken Gage, PhD
"Plague Foci and Epizootic Sites"

03. John Roehrig, PhD
"West Nile Virus – An Emerging Arbovirus in the United States"

04. Daniel O'Leary, DVM
"National Surveillance for West Nile Virus (WNV): Nuts and Bolts"

05. Louisa Beck, Brad Lobitz and Cindy Schmidt
"NASA Science Technologies and Human Health"

06. Compton Tucker, PhD
"NASA's Seasonal-to-Interannual Prediction Project (NSIPP)"

07. Steve Kempler, Bill Teng, and Bob Lutz, PhD
"Utilizing Earth Science Remote Sensing Data and Services to Support Human Health"

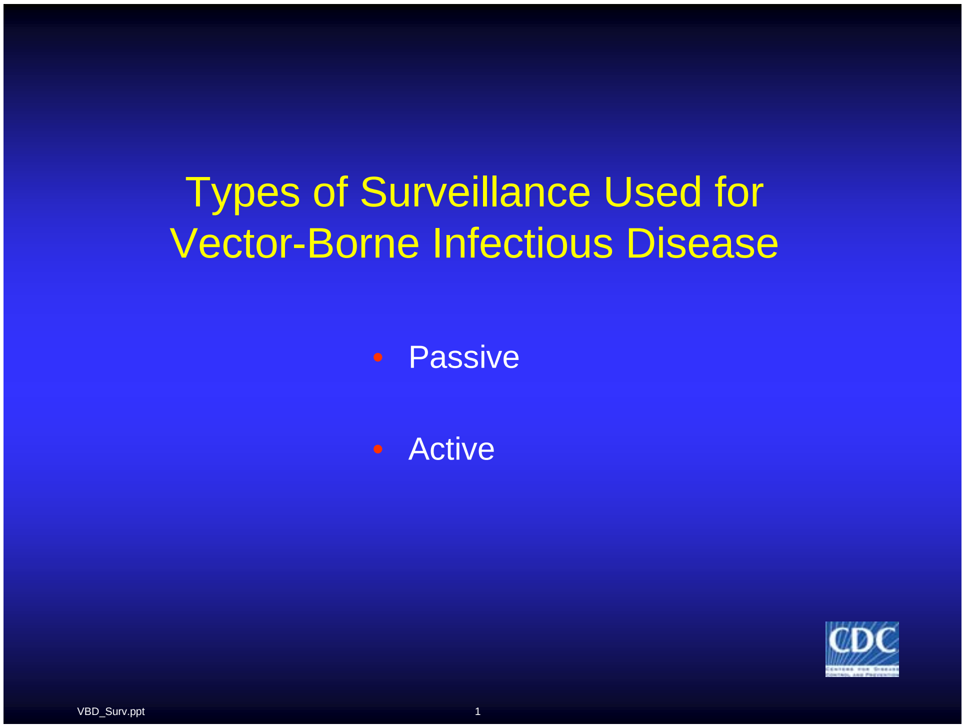
08. Compton Tucker, PhD
"Ebola River Hemorrhagic Fever"
"Yemen 2000 Rift Valley Fever Outbreak"

09. Richard Kiang, PhD
"Mekong Malaria and Filariasis"

10. Gilberto Vincente, PhD and Nancy Maynard, PhD
"MSIRS: A System for Locating Potential WNV Mosquito Breeding Sites"

11. William K. Reisen, PhD
"Use of Remote Sensing in Decision Support Systems for the Control of Mosquito-Borne Arboviruses"

Duane Gubler, ScD
“Types of Surveillance Used for Vector-Borne Infectious Disease”



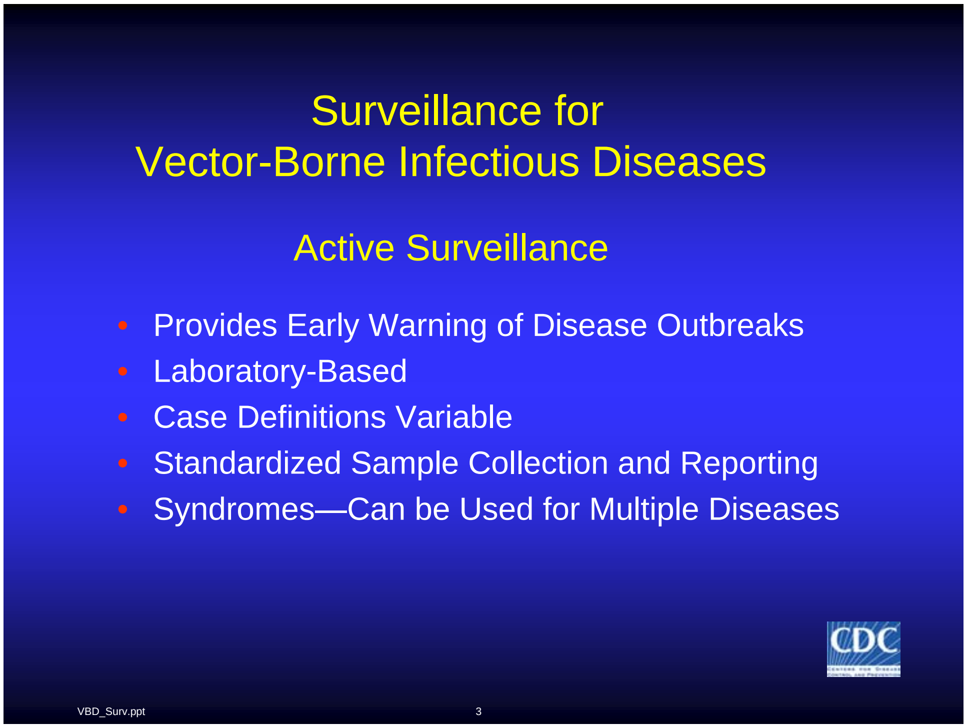
Types of Surveillance Used for Vector-Borne Infectious Disease

- Passive
- Active

Type of Surveillance Used for Vector-Borne Infectious Diseases

Passive Surveillance

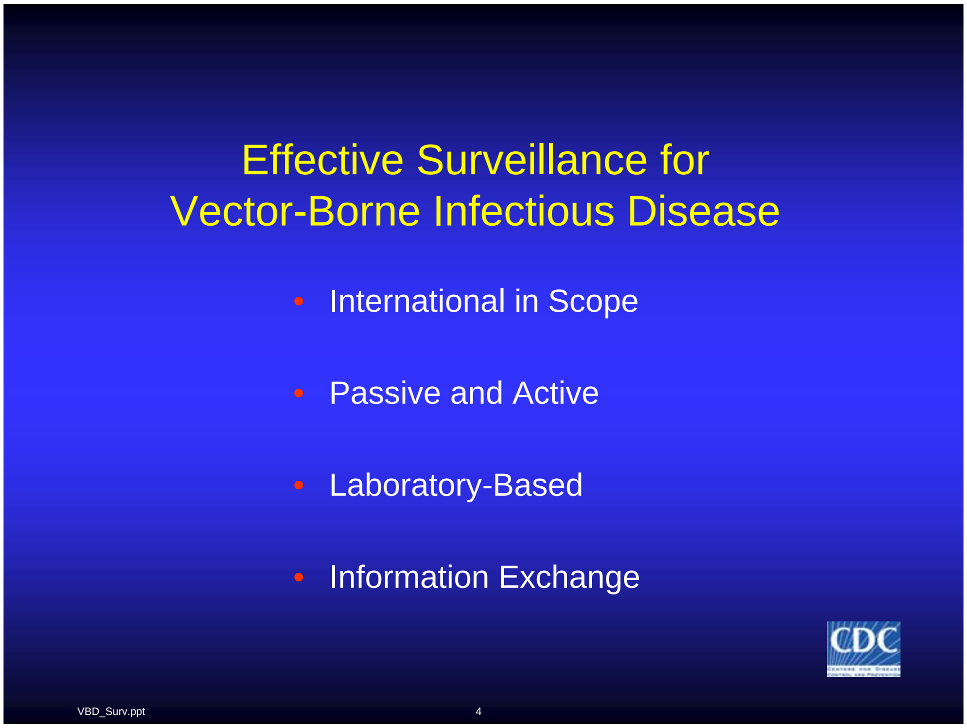
- Monitor Secular Trends
- Standardized Case Definitions
- Standardized Reporting Systems
- Relies on Physicians and Health Officials to Report
- Insensitive for Early Warning of Disease Outbreaks



Surveillance for
Vector-Borne Infectious Diseases

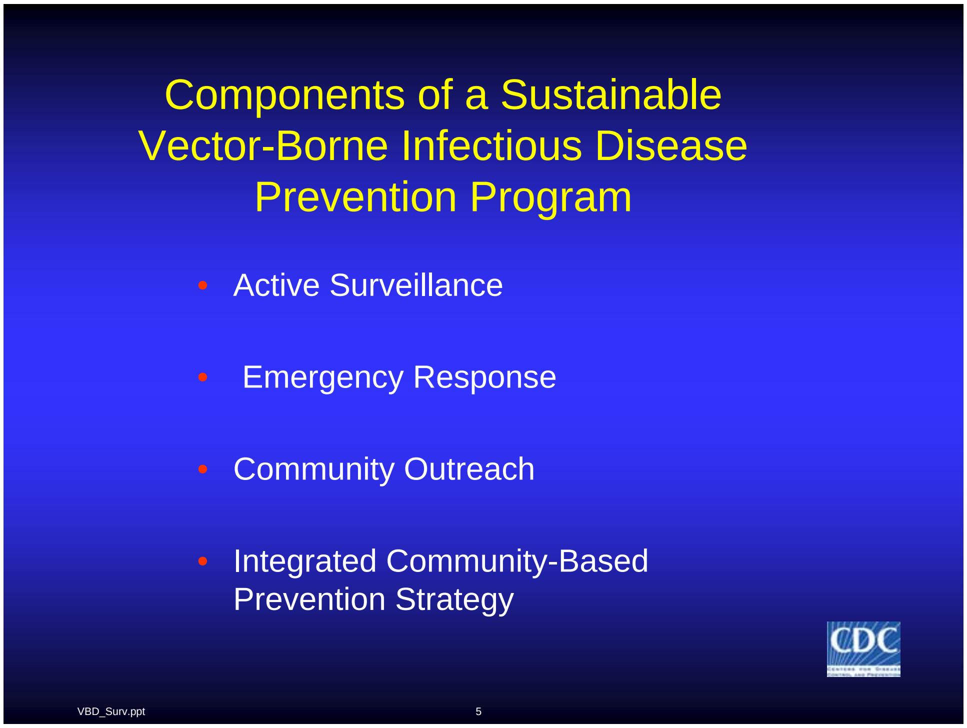
Active Surveillance

- Provides Early Warning of Disease Outbreaks
- Laboratory-Based
- Case Definitions Variable
- Standardized Sample Collection and Reporting
- Syndromes—Can be Used for Multiple Diseases



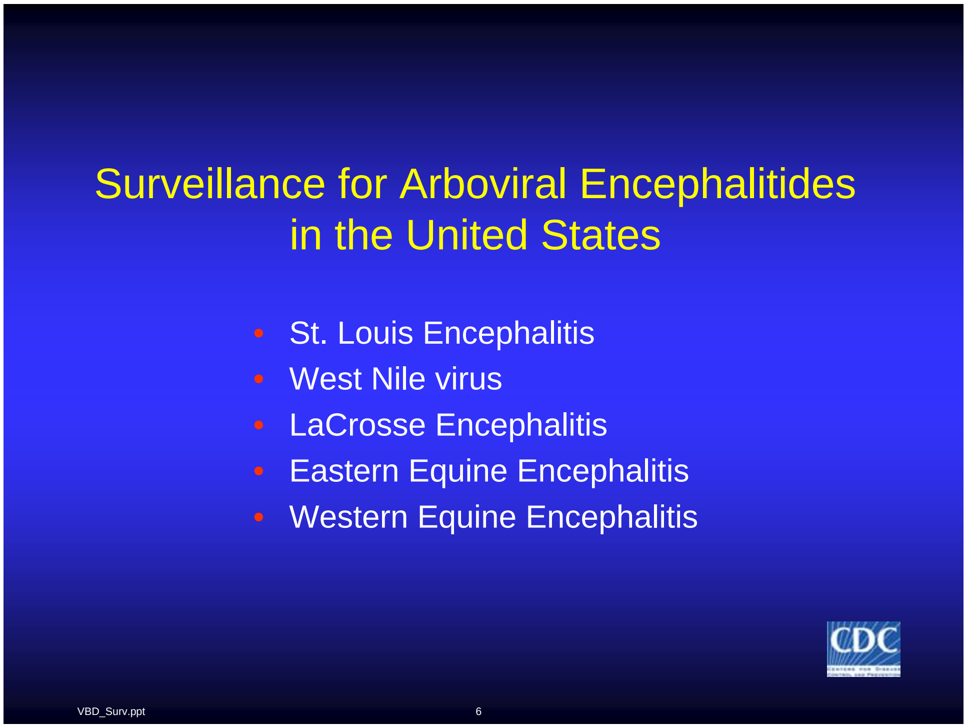
Effective Surveillance for
Vector-Borne Infectious Disease

- International in Scope
- Passive and Active
- Laboratory-Based
- Information Exchange



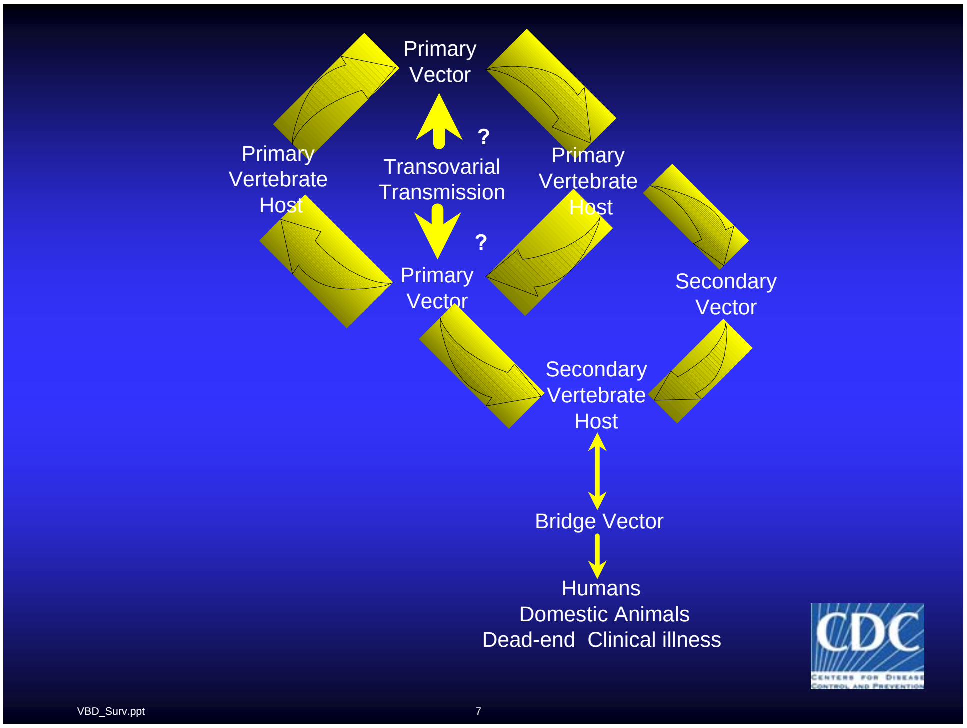
Components of a Sustainable Vector-Borne Infectious Disease Prevention Program

- Active Surveillance
- Emergency Response
- Community Outreach
- Integrated Community-Based Prevention Strategy



Surveillance for Arboviral Encephalitides in the United States

- St. Louis Encephalitis
- West Nile virus
- LaCrosse Encephalitis
- Eastern Equine Encephalitis
- Western Equine Encephalitis



Primary
Vector

?

Primary
Vertebrate
Host

Transovarial
Transmission

Primary
Vertebrate
Host

?

Primary
Vector

Secondary
Vector

Secondary
Vertebrate
Host

Bridge Vector

Humans
Domestic Animals
Dead-end Clinical illness

Factors that Influence Mosquito-Borne Disease Transmission Dynamics

- Extrinsic Factors
- Intrinsic Factors

Factors that Influence Mosquito-borne Disease Transmission Dynamics

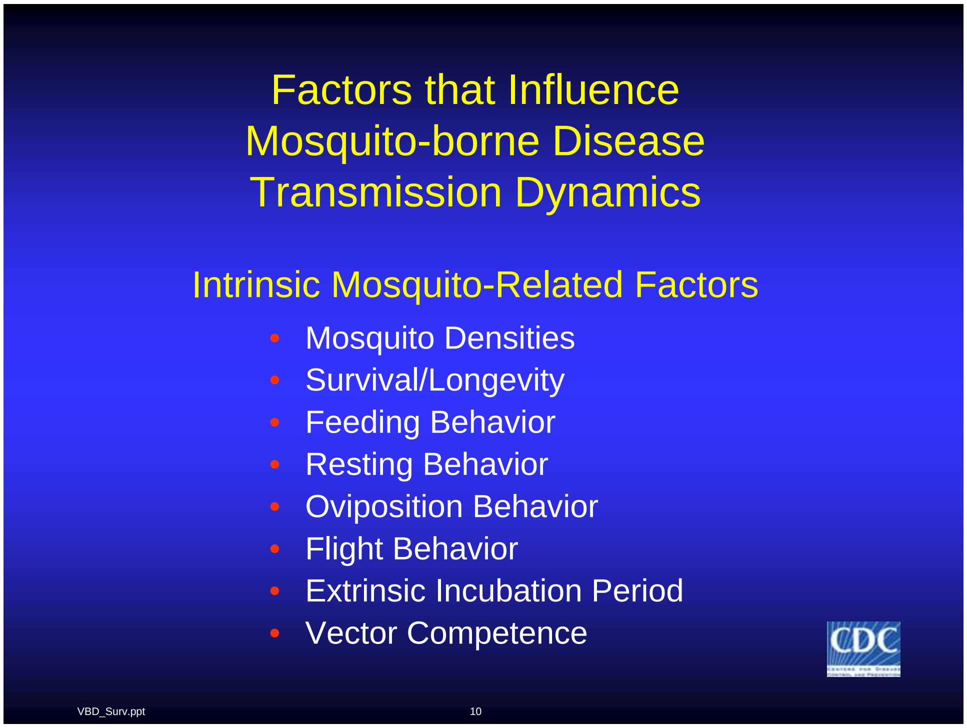
Intrinsic Factors

- Mosquito-Related
- Vertebrate Host-Related
- Pathogen-Related

Factors that Influence Mosquito-borne Disease Transmission Dynamics

Intrinsic Factors

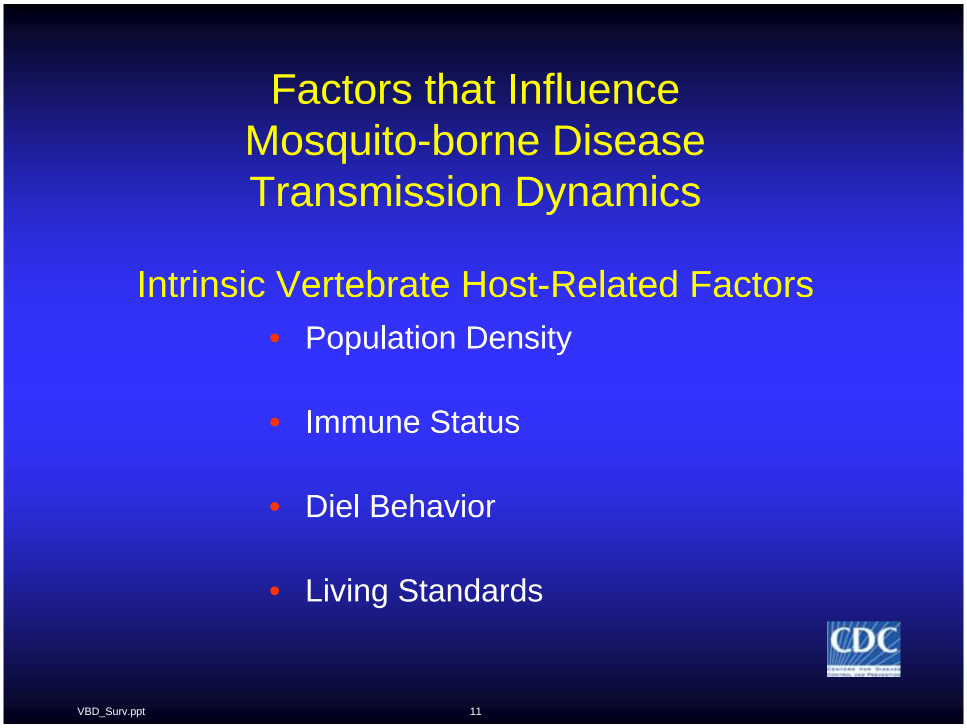
- Mosquito-Related
- Vertebrate Host-Related
- Pathogen-Related



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Intrinsic Mosquito-Related Factors

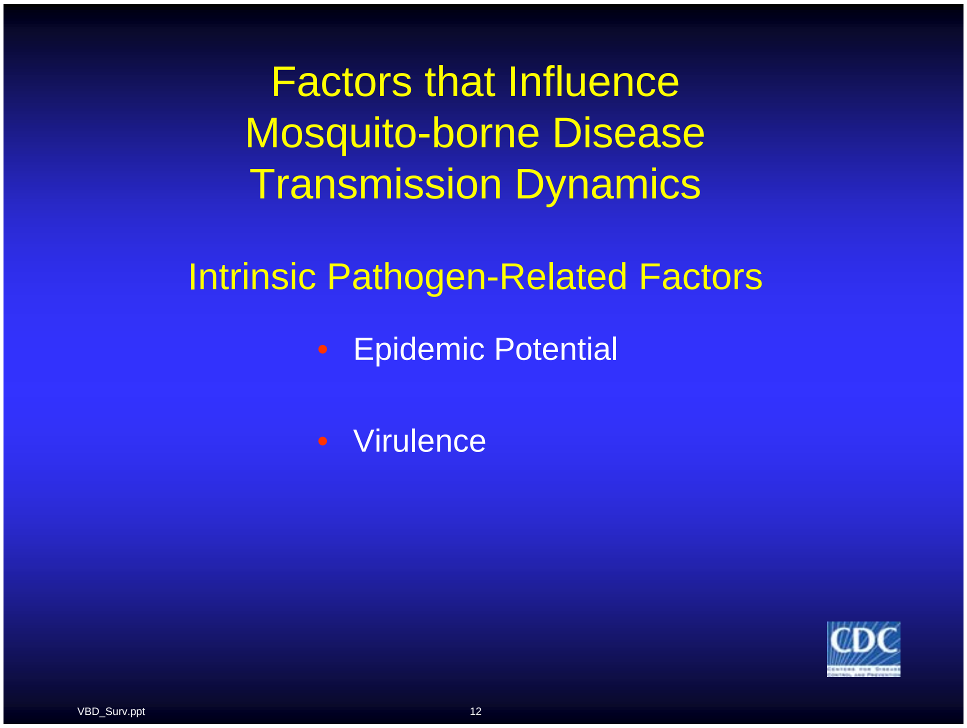
- Mosquito Densities
- Survival/Longevity
- Feeding Behavior
- Resting Behavior
- Oviposition Behavior
- Flight Behavior
- Extrinsic Incubation Period
- Vector Competence



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Intrinsic Vertebrate Host-Related Factors

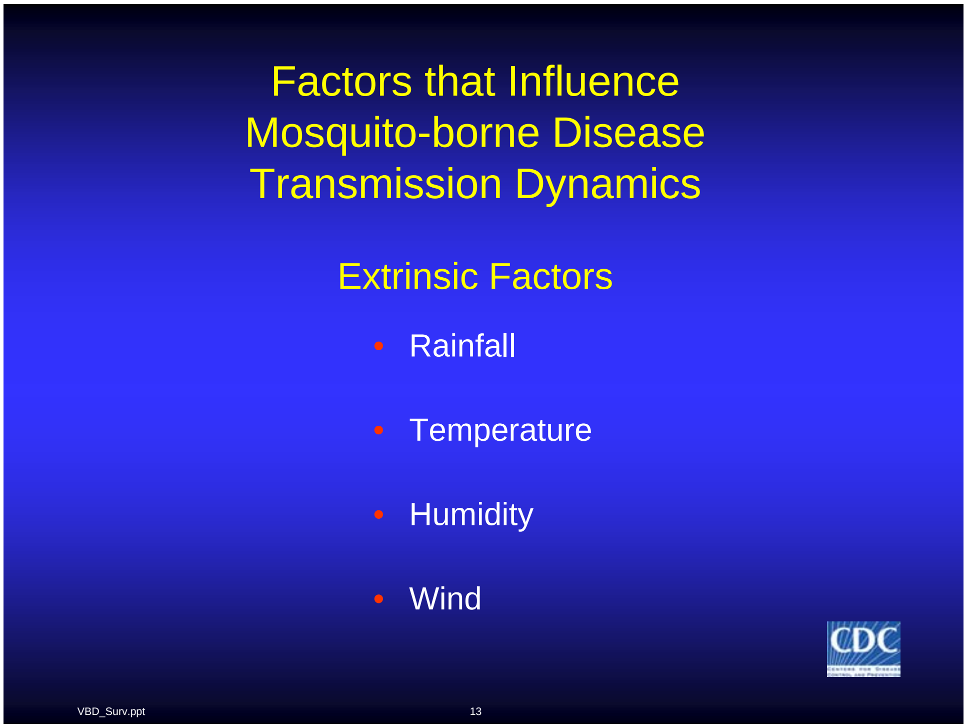
- Population Density
- Immune Status
- Diel Behavior
- Living Standards



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Intrinsic Pathogen-Related Factors

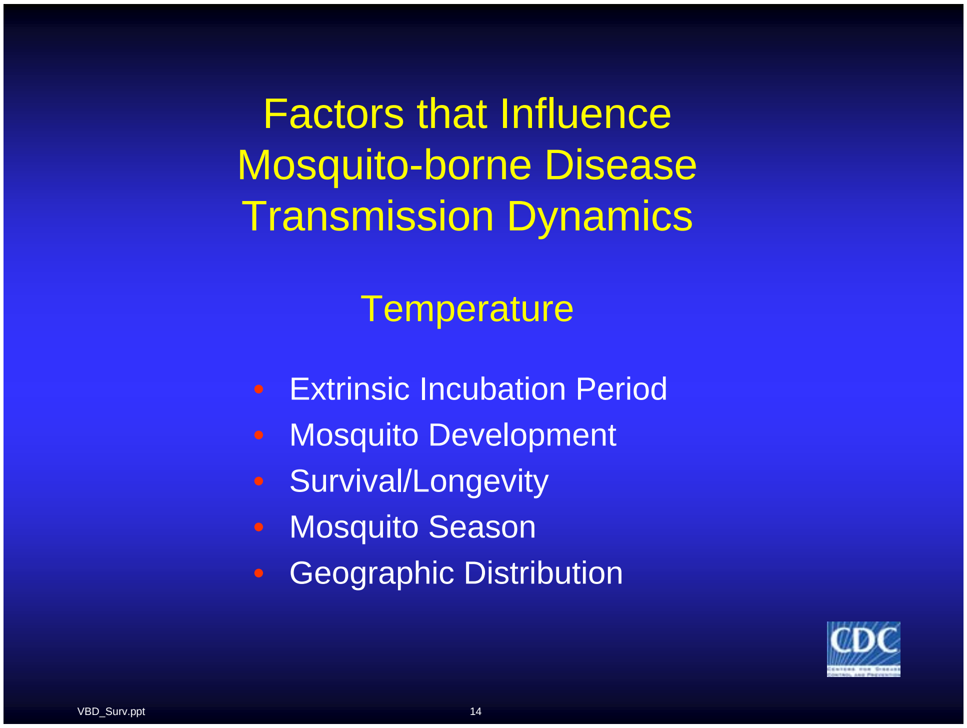
- Epidemic Potential
- Virulence



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Extrinsic Factors

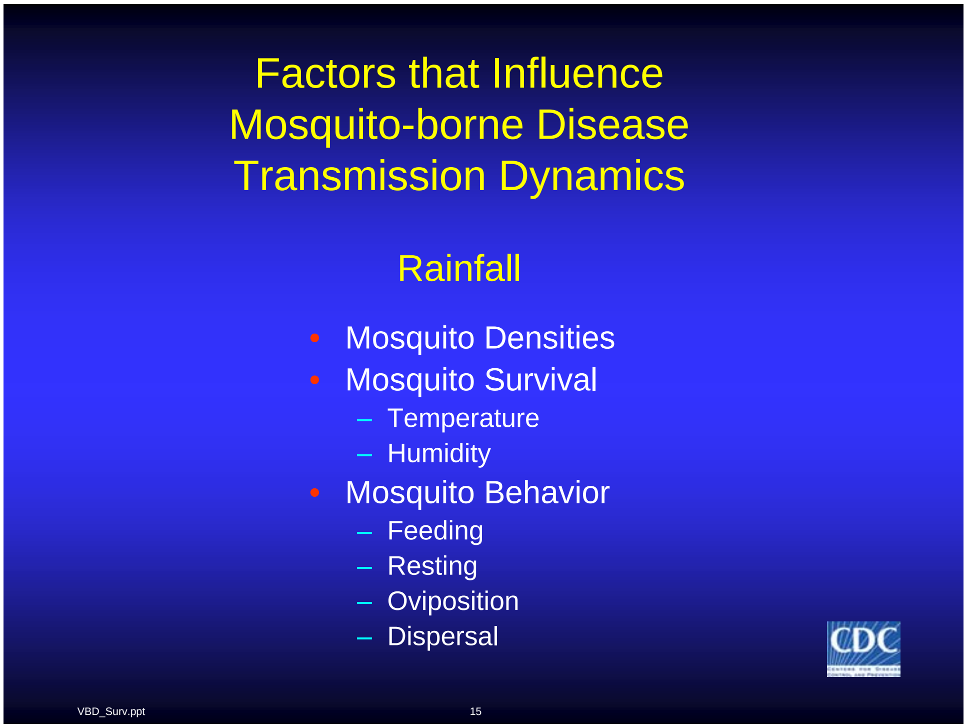
- Rainfall
- Temperature
- Humidity
- Wind



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Temperature

- Extrinsic Incubation Period
- Mosquito Development
- Survival/Longevity
- Mosquito Season
- Geographic Distribution



Factors that Influence Mosquito-borne Disease Transmission Dynamics

Rainfall

- Mosquito Densities
- Mosquito Survival
  - Temperature
  - Humidity
- Mosquito Behavior
  - Feeding
  - Resting
  - Oviposition
  - Dispersal

Requirements for Epidemic Transmission of Vector-Borne Diseases

Summary

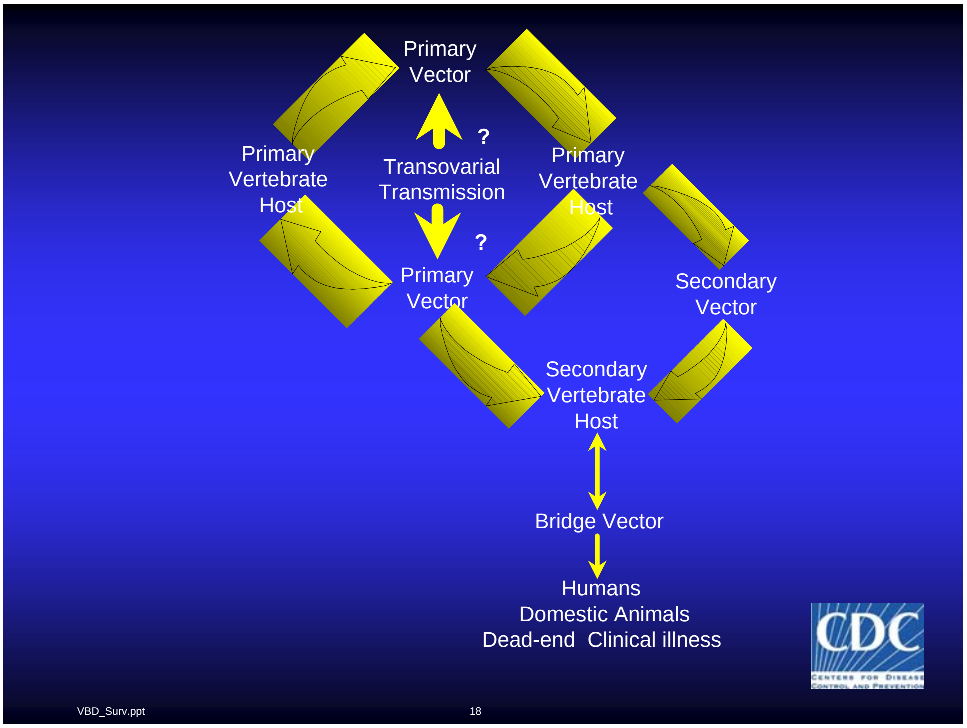
- Vertebrate Host Populations
  - Susceptibility
  - Population density
  - Distribution
  - Behavior
- Arthropod Vector
  - Vector competence
  - Population Density
  - Distribution
  - Behavior

Requirements for Epidemic Transmission of Vector-Borne Diseases

Summary

- The Pathogen
  - Strain

- Permissive Environmental Conditions
  - Temperature
  - Rainfall
  - Humidity
  - Geographic area



Primary Vector

Primary Vertebrate Host

?

Transovarial Transmission

?

Primary Vertebrate Host

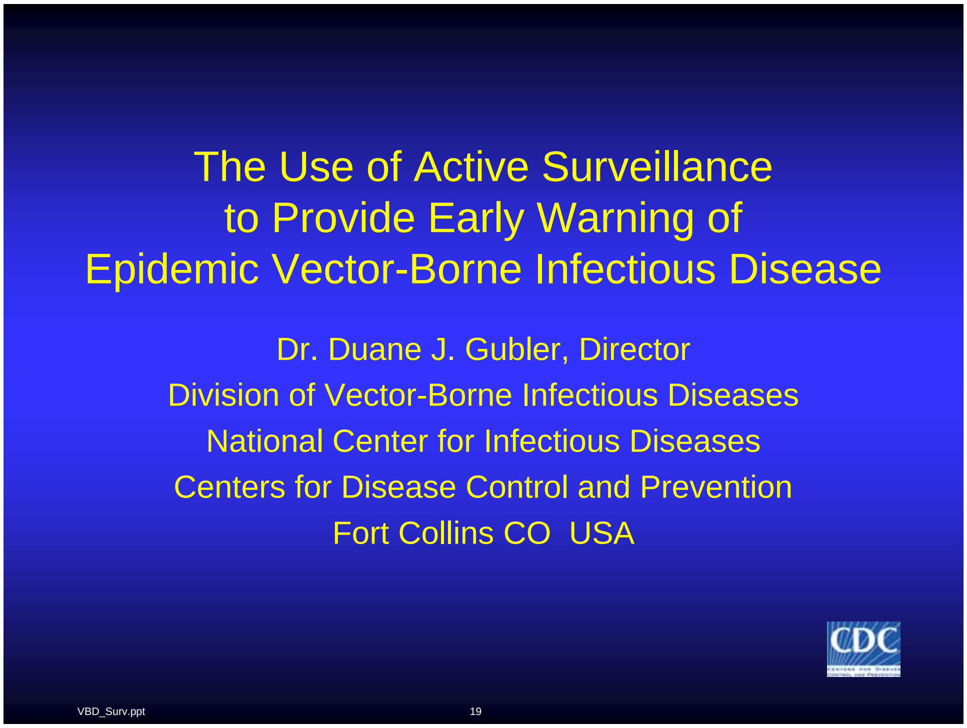
Primary Vector

Secondary Vector

Secondary Vertebrate Host

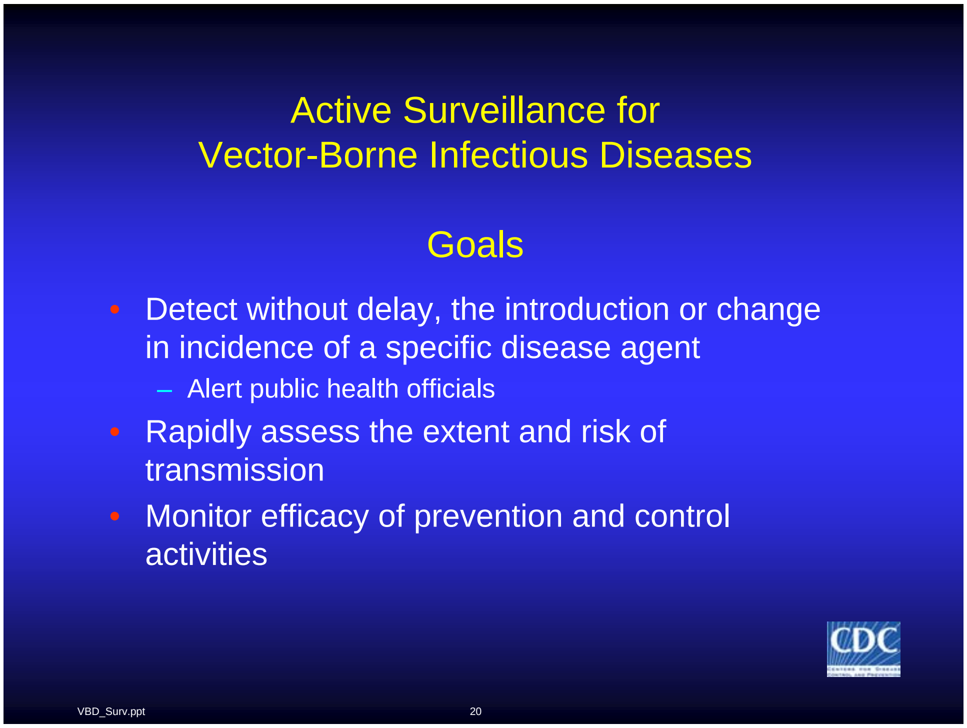
Bridge Vector

Humans
Domestic Animals
Dead-end Clinical illness



The Use of Active Surveillance to Provide Early Warning of Epidemic Vector-Borne Infectious Disease

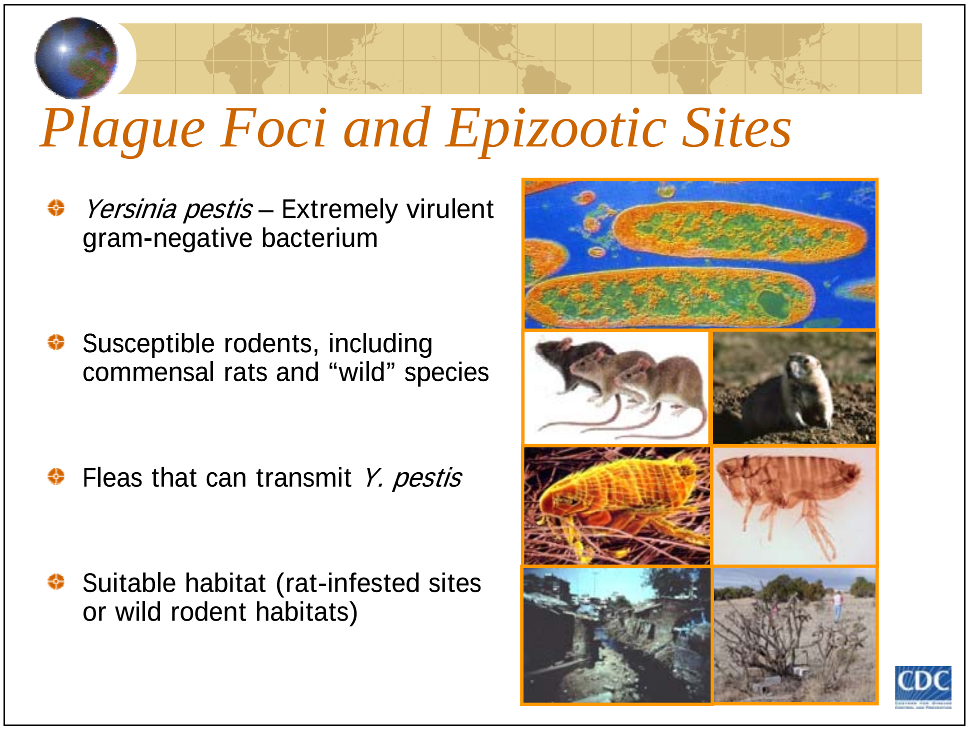
Dr. Duane J. Gubler, Director
Division of Vector-Borne Infectious Diseases
National Center for Infectious Diseases
Centers for Disease Control and Prevention
Fort Collins CO USA



Active Surveillance for Vector-Borne Infectious Diseases

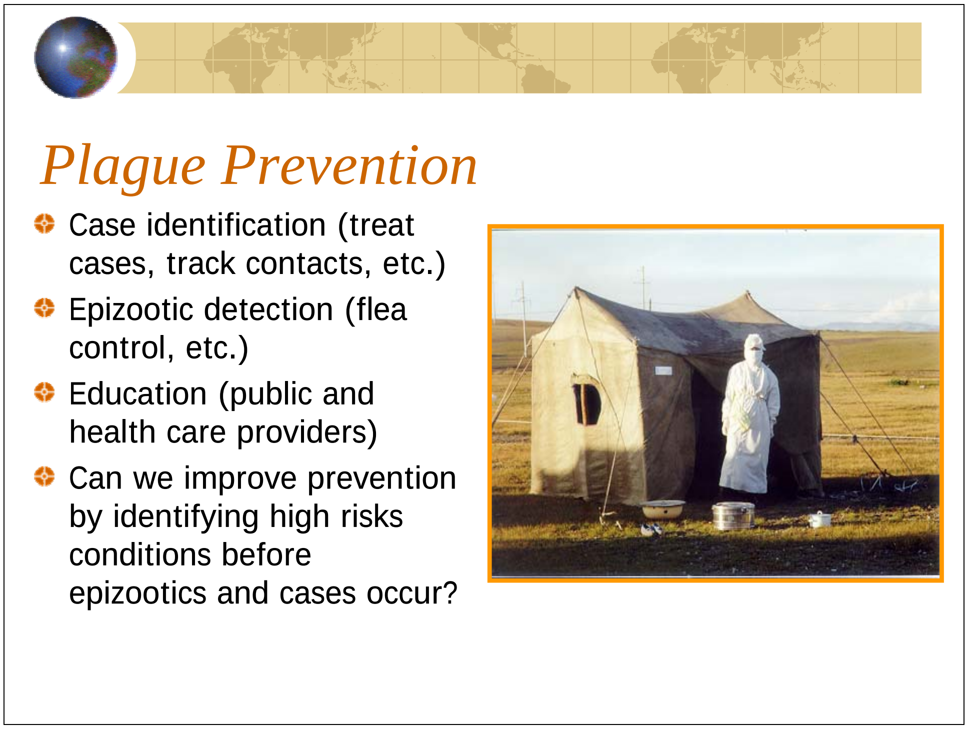
Goals

- Detect without delay, the introduction or change in incidence of a specific disease agent
  - Alert public health officials
- Rapidly assess the extent and risk of transmission
- Monitor efficacy of prevention and control activities



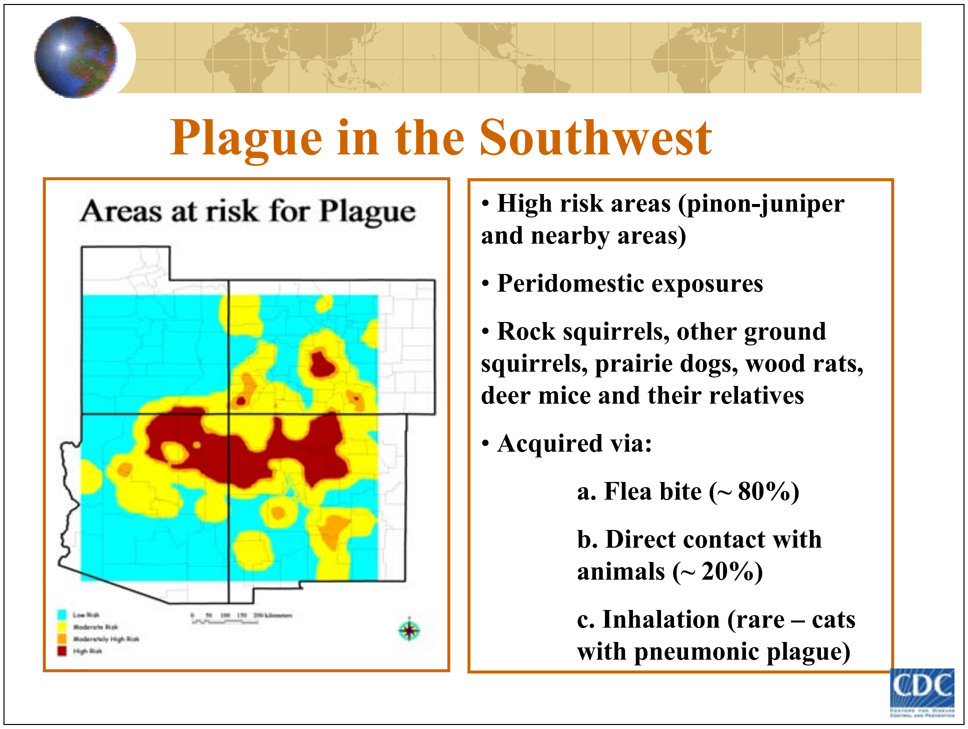
Plague Foci and Epizootic Sites

- *Yersinia pestis* – Extremely virulent gram-negative bacterium
- Susceptible rodents, including commensal rats and “wild” species
- Fleas that can transmit *Y. pestis*
- Suitable habitat (rat-infested sites or wild rodent habitats)



Plague Prevention

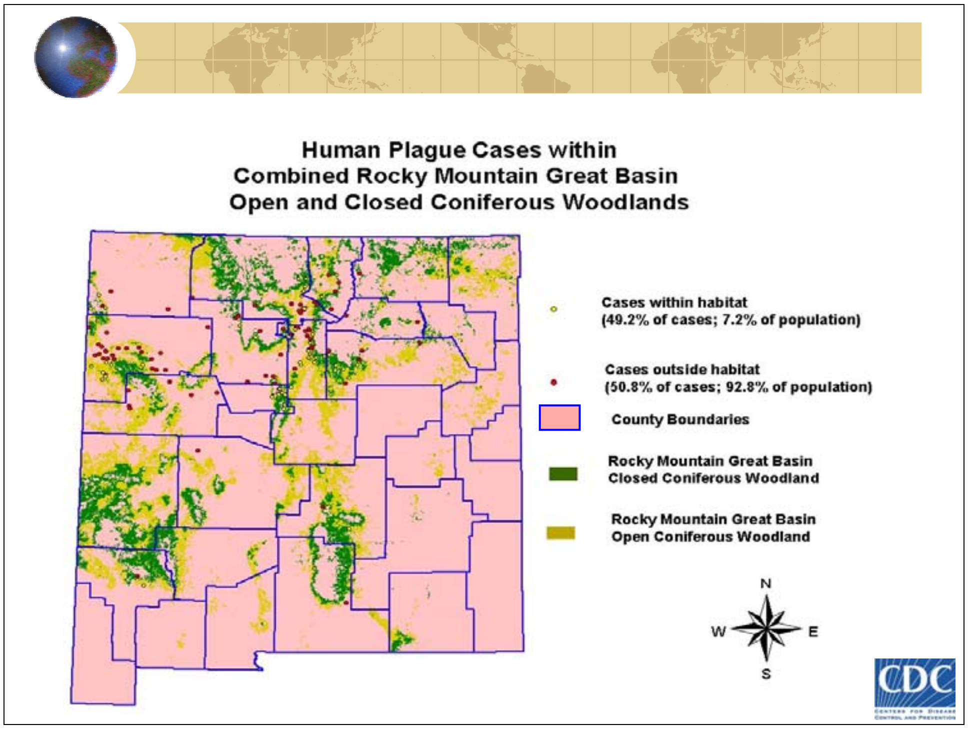
- Case identification (treat cases, track contacts, etc.)
- Epizootic detection (flea control, etc.)
- Education (public and health care providers)
- Can we improve prevention by identifying high risks conditions before epizootics and cases occur?



Plague in the Southwest

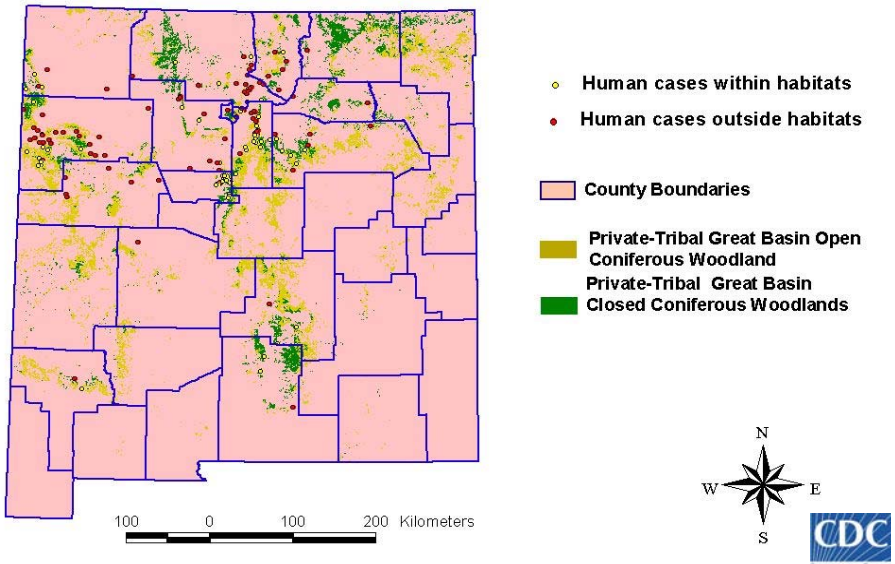
Areas at risk for Plague

- High risk areas (pinon-juniper and nearby areas)
- Peridomestic exposures
- Rock squirrels, other ground squirrels, prairie dogs, wood rats, deer mice and their relatives
- Acquired via:
  - a. Flea bite (~ 80%)
  - b. Direct contact with animals (~ 20%)
  - c. Inhalation (rare – cats with pneumonic plague)

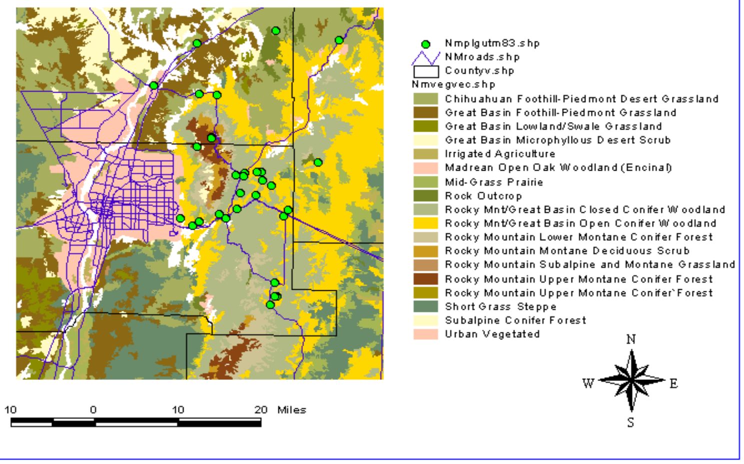


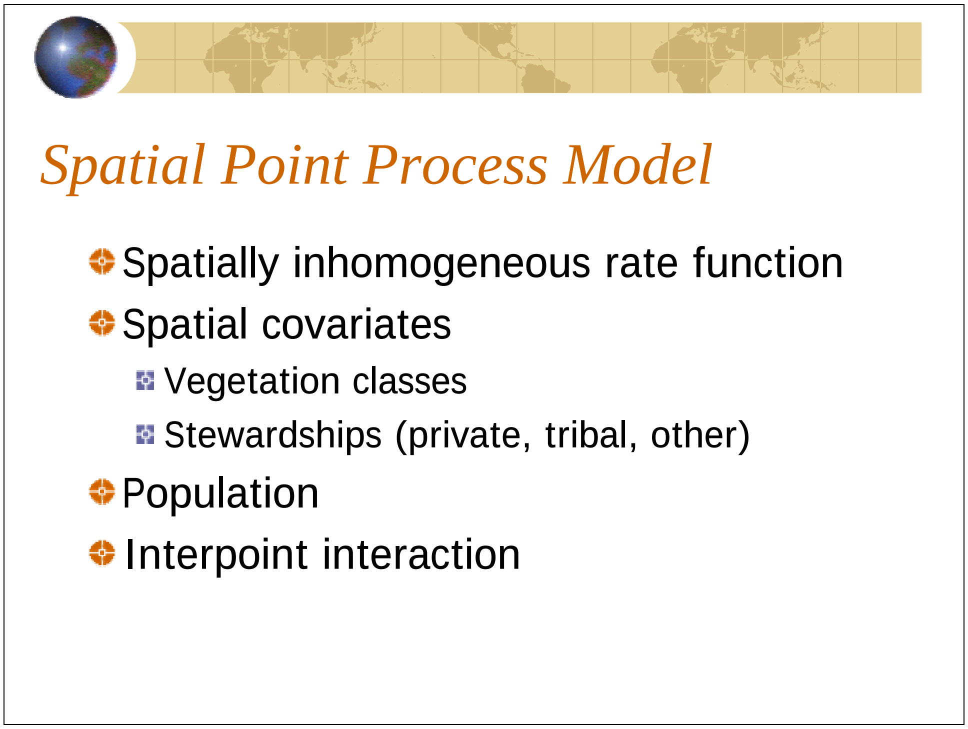
Human Plague Cases within
Combined Rocky Mountain Great Basin
Open and Closed Coniferous Woodlands

Human Cases and Rocky Mountain Great Basin Open and Closed Coniferous Woodlands (Private and Tribal Lands)



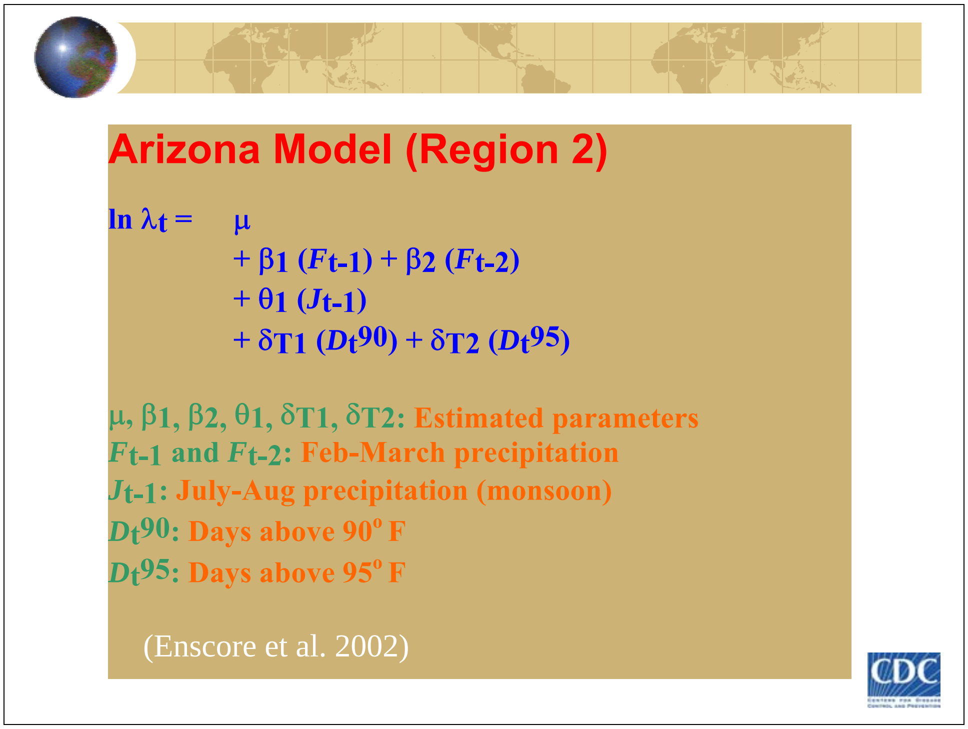
Albuquerque Area Plague Case Exposure Sites by Habitat Type





Spatial Point Process Model

- Spatially inhomogeneous rate function
- Spatial covariates
  - Vegetation classes
  - Stewardships (private, tribal, other)
- Population
- Interpoint interaction



Arizona Model (Region 2)

$$\begin{aligned} \ln \lambda_t = \; & \mu \\ & + \beta_1 (F_{t-1}) + \beta_2 (F_{t-2}) \\ & + \theta_1 (J_{t-1}) \\ & + \delta_{T1} (D_t^{90}) + \delta_{T2} (D_t^{95}) \end{aligned}$$

$\mu, \beta_1, \beta_2, \theta_1, \delta_{T1}, \delta_{T2}$: **Estimated parameters**

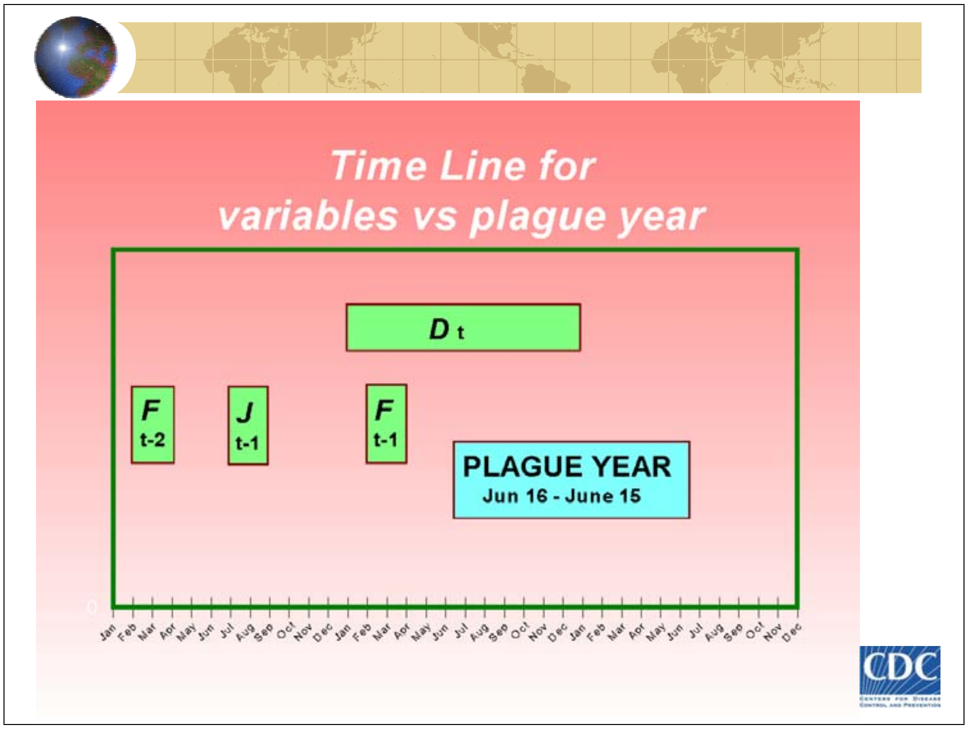
F_{t-1} and F_{t-2}: **Feb-March precipitation**

J_{t-1}: **July-Aug precipitation (monsoon)**

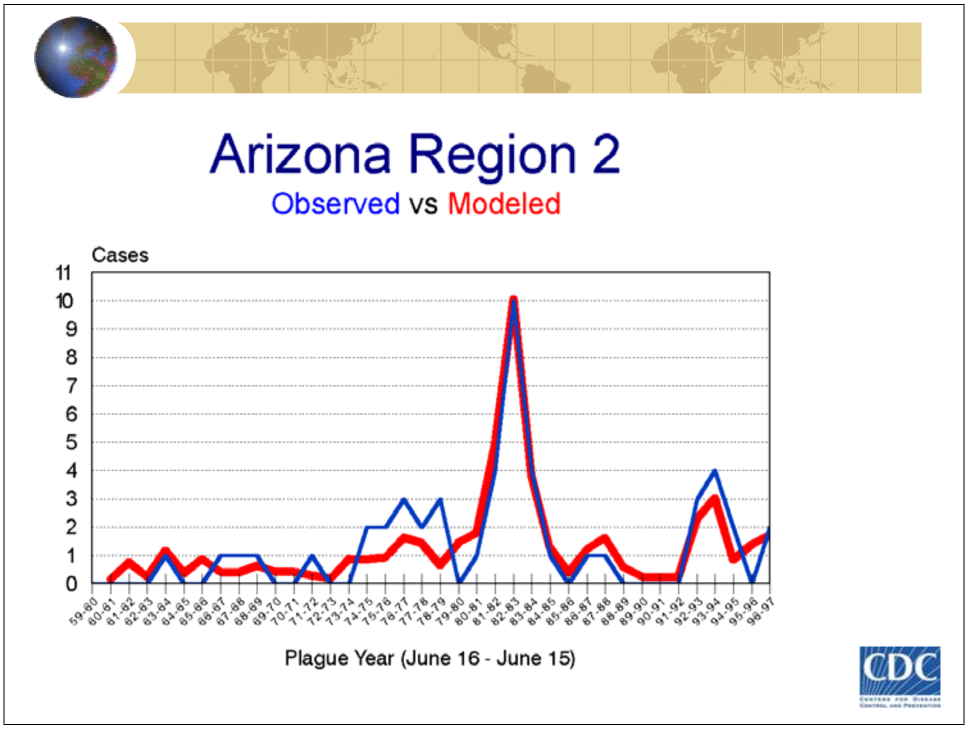
D_t^{90}: **Days above 90° F**

D_t^{95}: **Days above 95° F**

(Enscore et al. 2002)

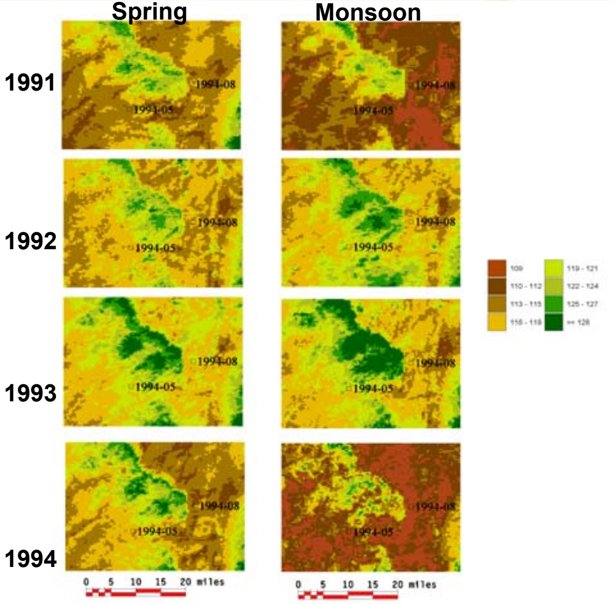


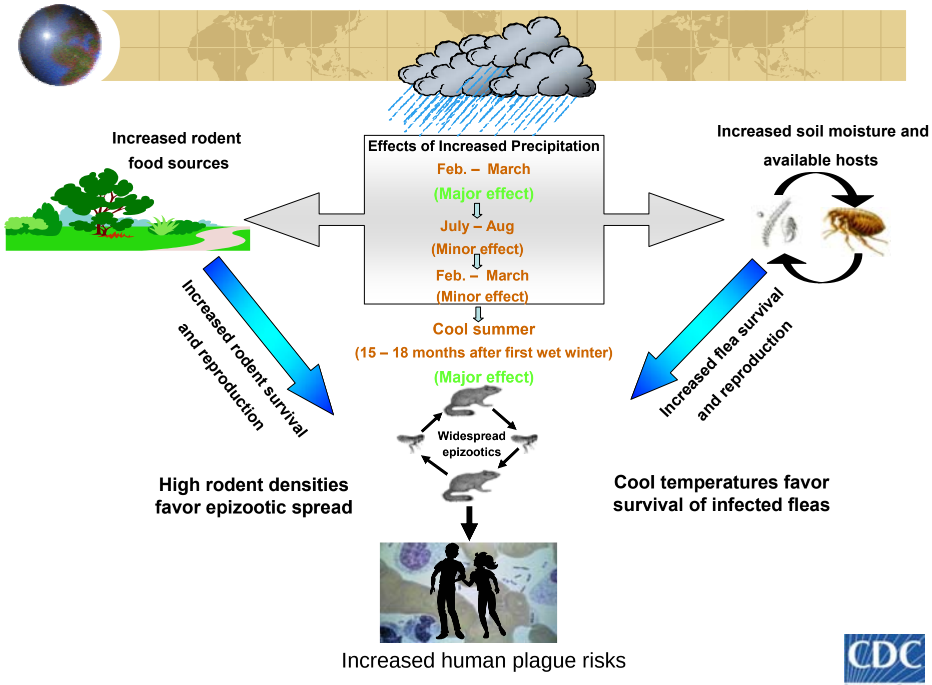
Time Line for variables vs plague year



Arizona Region 2

Observed vs Modeled





Effects of Increased Precipitation

Feb. – March

(Major effect)

⇩

July – Aug

(Minor effect)

⇩

Feb. – March

(Minor effect)

⇩

Cool summer

(15 – 18 months after first wet winter)

(Major effect)

Increased rodent food sources

Increased rodent survival and reproduction

High rodent densities favor epizootic spread

Increased soil moisture and available hosts

Increased flea survival and reproduction

Cool temperatures favor survival of infected fleas

Widespread epizootics

Increased human plague risks

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

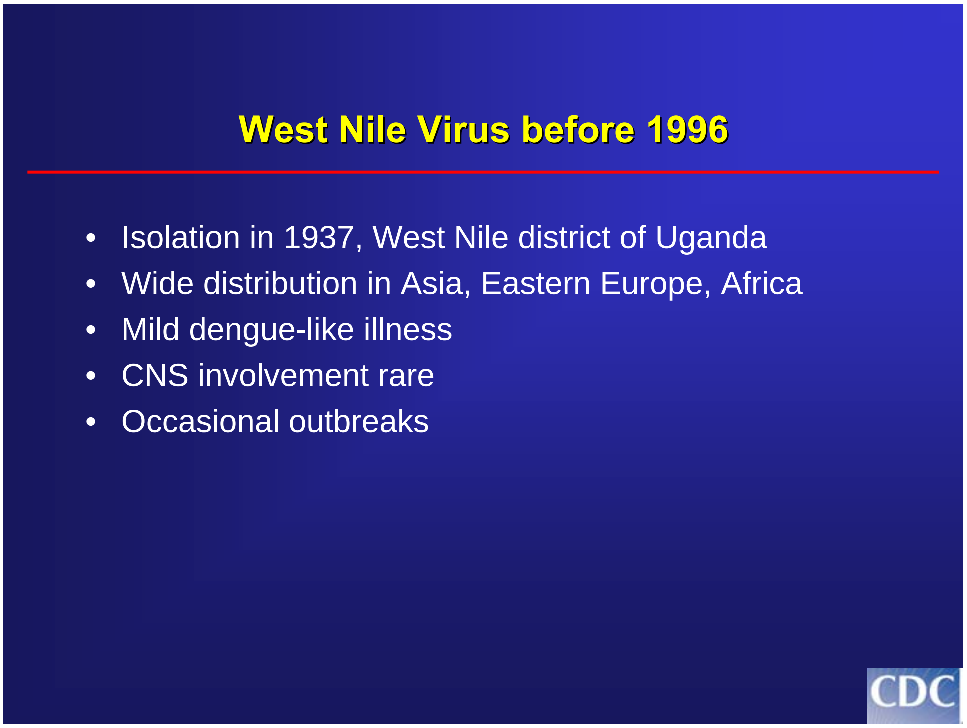
West Nile Virus –An Emerging Arbovirus in the United States

CDC

2002: A Season of Surprises

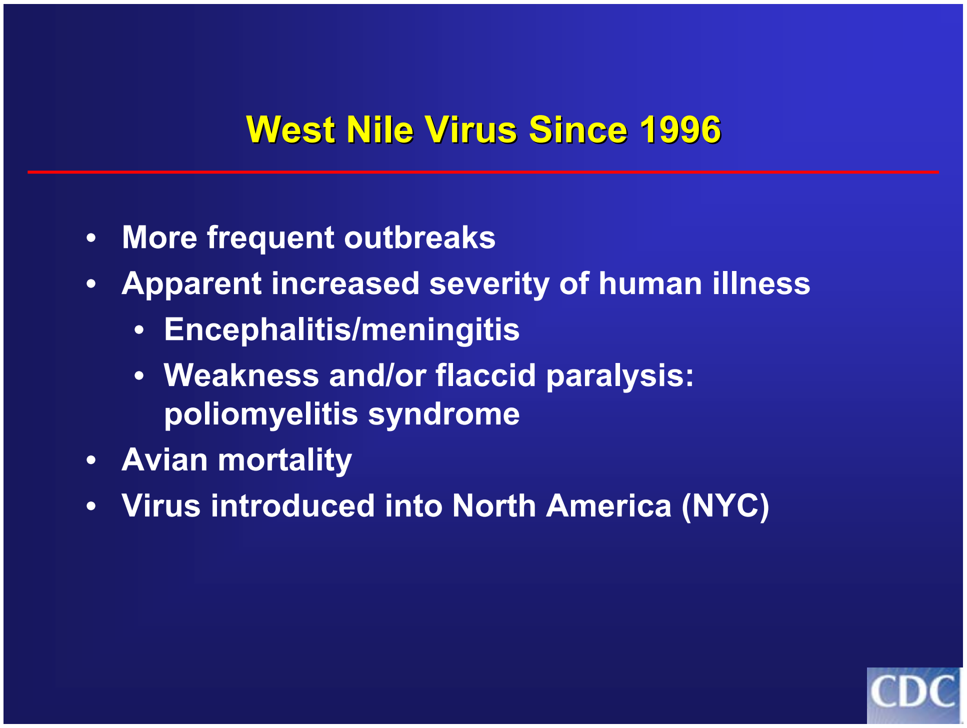
- Largest arbovirus meningoencephalitis outbreak epidemic ever documented in western hemisphere
- Largest WNME epidemic ever documented
- Geographic spread to the Pacific Coast
- Five novel modes of transmission
- New clinical syndromes
  - Prolonged viremia and incubation period and delayed antibody response in immunocompromised
  - Most AFP not Guillian-Barre syndrome
  - High frequency of cogwheel rigidity, tremor, myoclonus

CDC



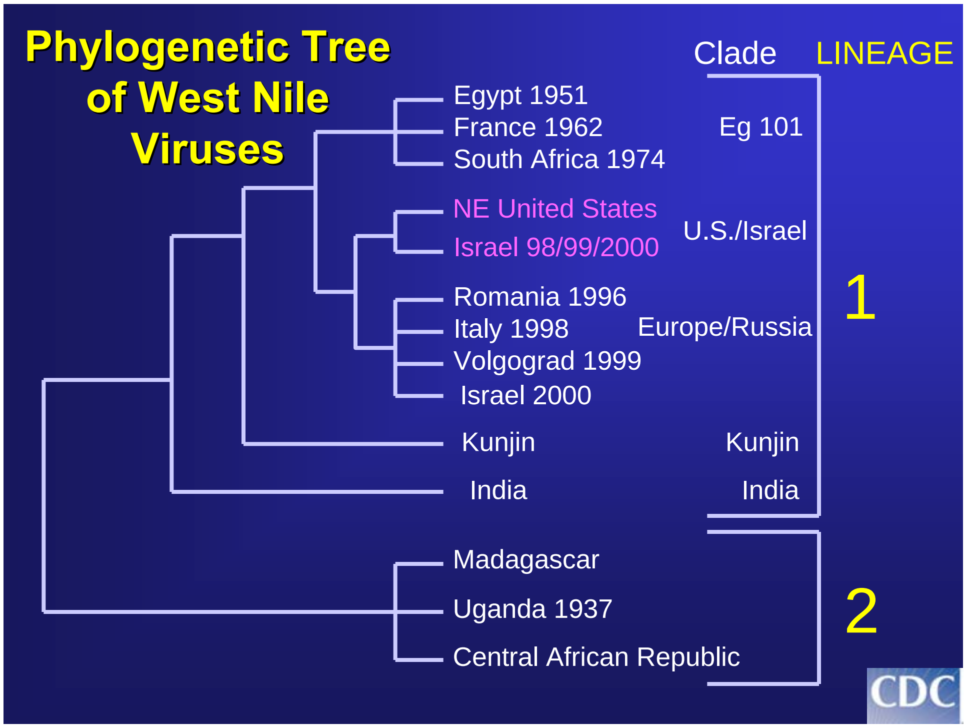
West Nile Virus before 1996

- Isolation in 1937, West Nile district of Uganda
- Wide distribution in Asia, Eastern Europe, Africa
- Mild dengue-like illness
- CNS involvement rare
- Occasional outbreaks



West Nile Virus Since 1996

- **More frequent outbreaks**
- **Apparent increased severity of human illness**
  - **Encephalitis/meningitis**
  - **Weakness and/or flaccid paralysis: poliomyelitis syndrome**
- **Avian mortality**
- **Virus introduced into North America (NYC)**



Phylogenetic Tree of West Nile Viruses

Clade

LINEAGE

Egypt 1951
France 1962
South Africa 1974

Eg 101

NE United States
Israel 98/99/2000

U.S./Israel

Romania 1996
Italy 1998
Volgograd 1999
Israel 2000

Europe/Russia

Kunjin

Kunjin

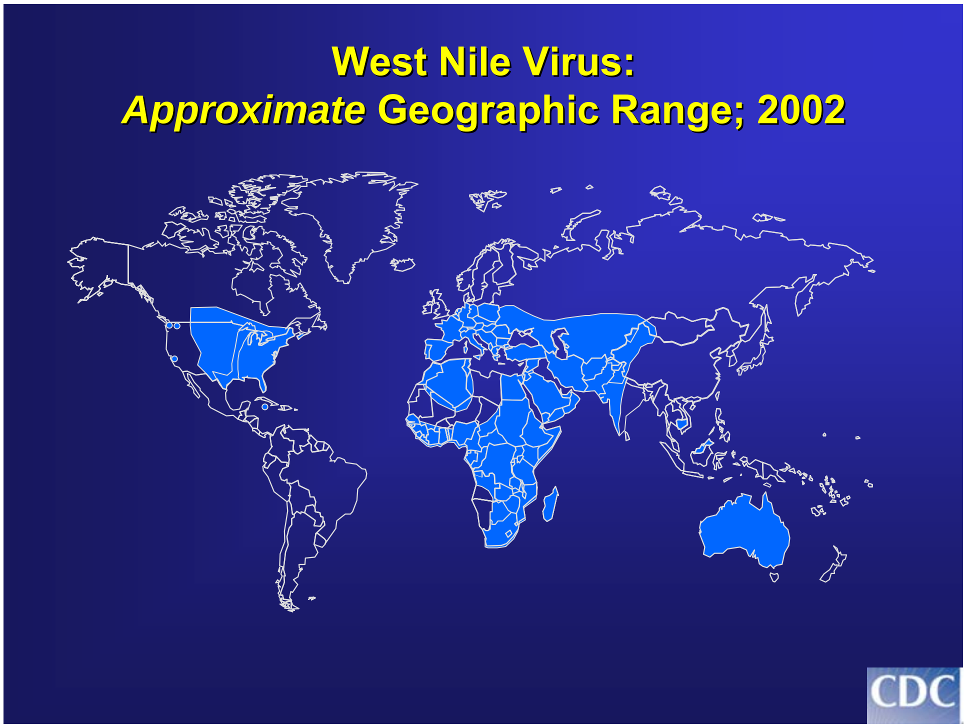
India

India

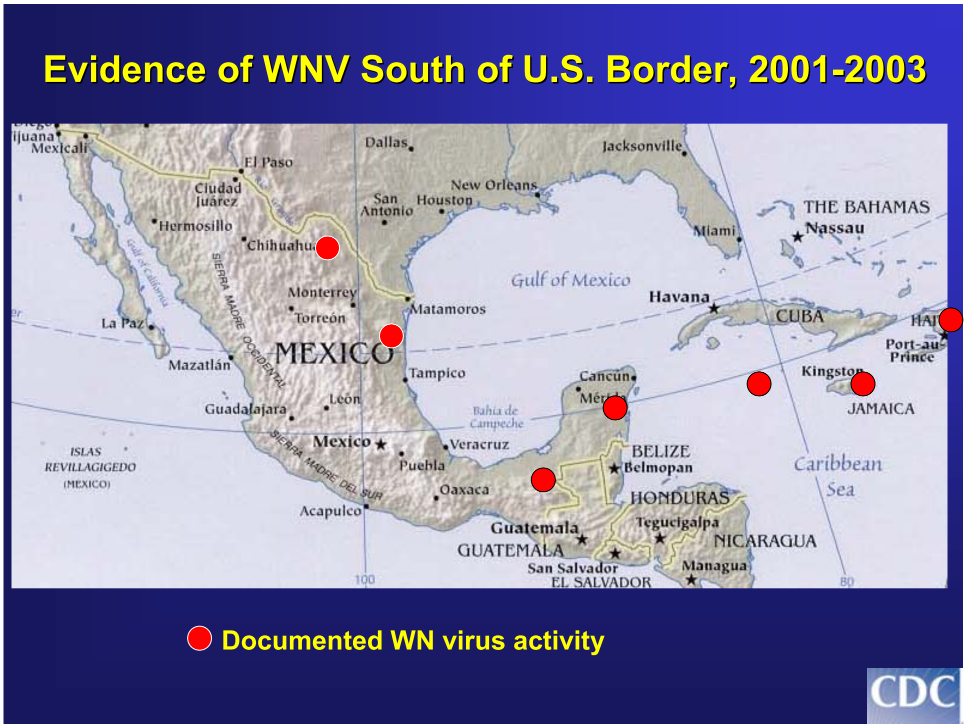
1

Madagascar
Uganda 1937
Central African Republic

2



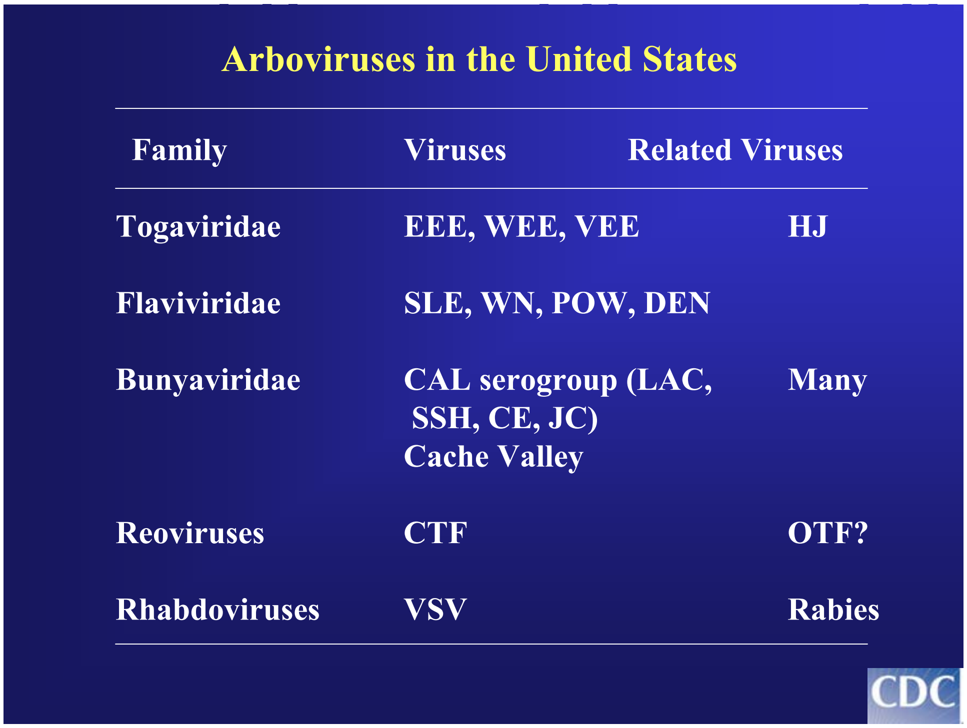
West Nile Virus: *Approximate* Geographic Range; 2002



Evidence of WNV South of U.S. Border, 2001-2003

● Documented WN virus activity

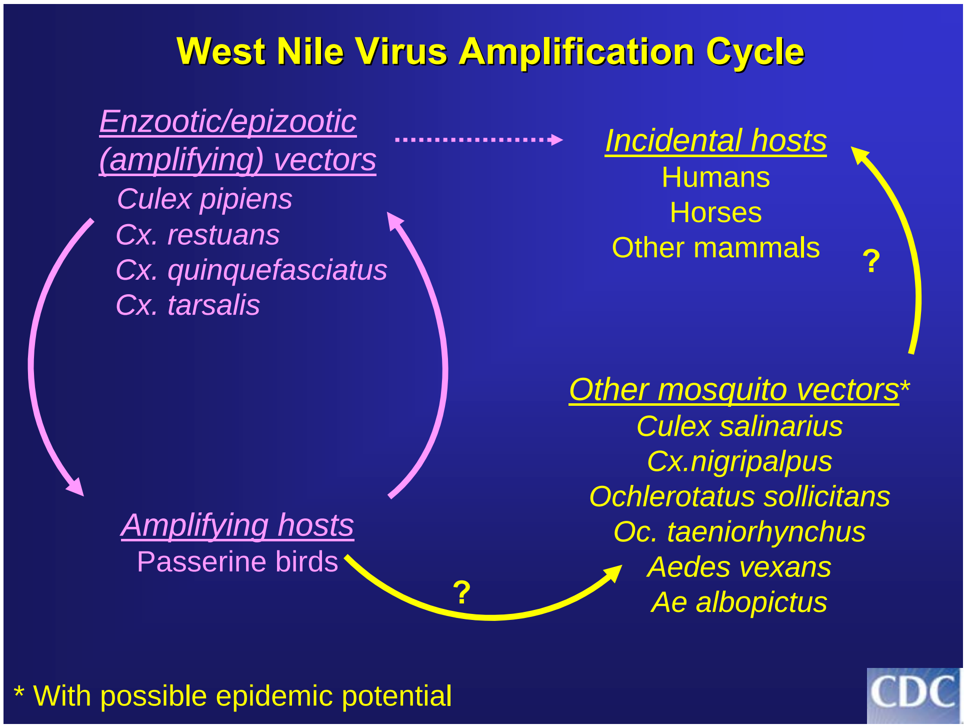
CDC



Arboviruses in the United States

Family	Viruses	Related Viruses
Togaviridae	EEE, WEE, VEE	HJ
Flaviviridae	SLE, WN, POW, DEN	
Bunyaviridae	CAL serogroup (LAC, SSH, CE, JC) Cache Valley	Many
Reoviruses	CTF	OTF?
Rhabdoviruses	VSV	Rabies

CDC



West Nile Virus Amplification Cycle

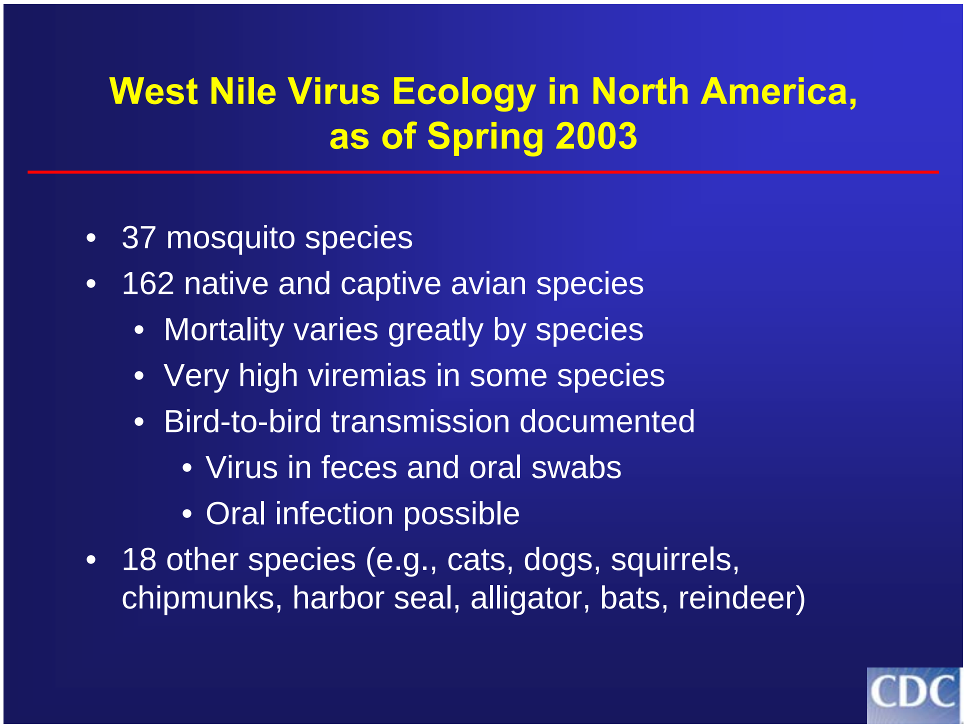
Enzootic/epizootic (amplifying) vectors
Culex pipiens
Cx. restuans
Cx. quinquefasciatus
Cx. tarsalis

Incidental hosts
Humans
Horses
Other mammals

*Other mosquito vectors**
Culex salinarius
Cx.nigripalpus
Ochlerotatus sollicitans
Oc. taeniorhynchus
Aedes vexans
Ae albopictus

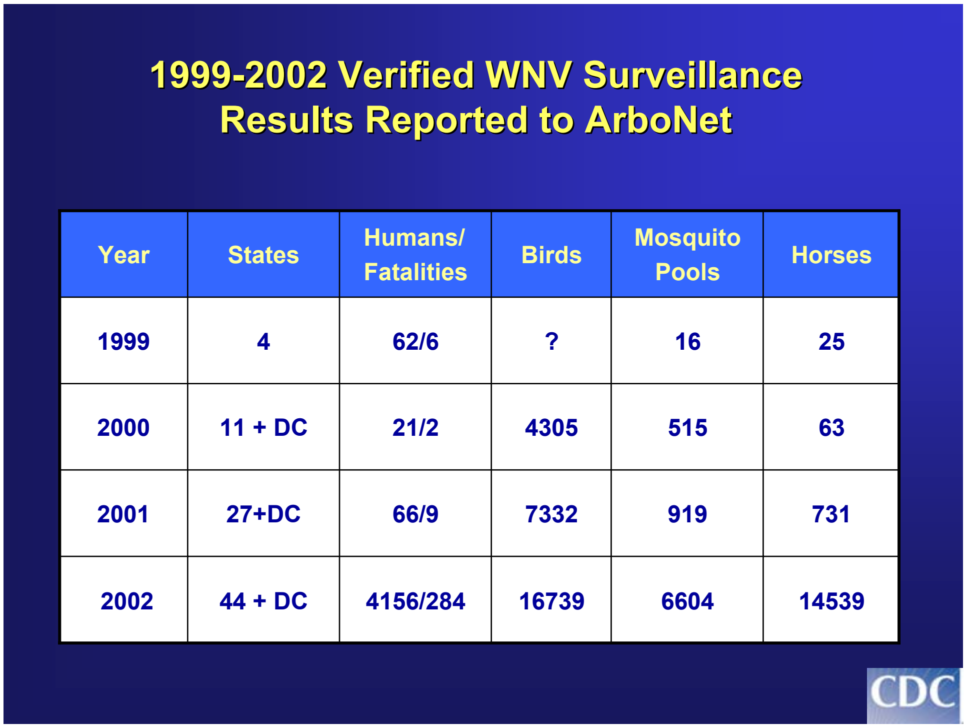
Amplifying hosts
Passerine birds

* With possible epidemic potential



West Nile Virus Ecology in North America, as of Spring 2003

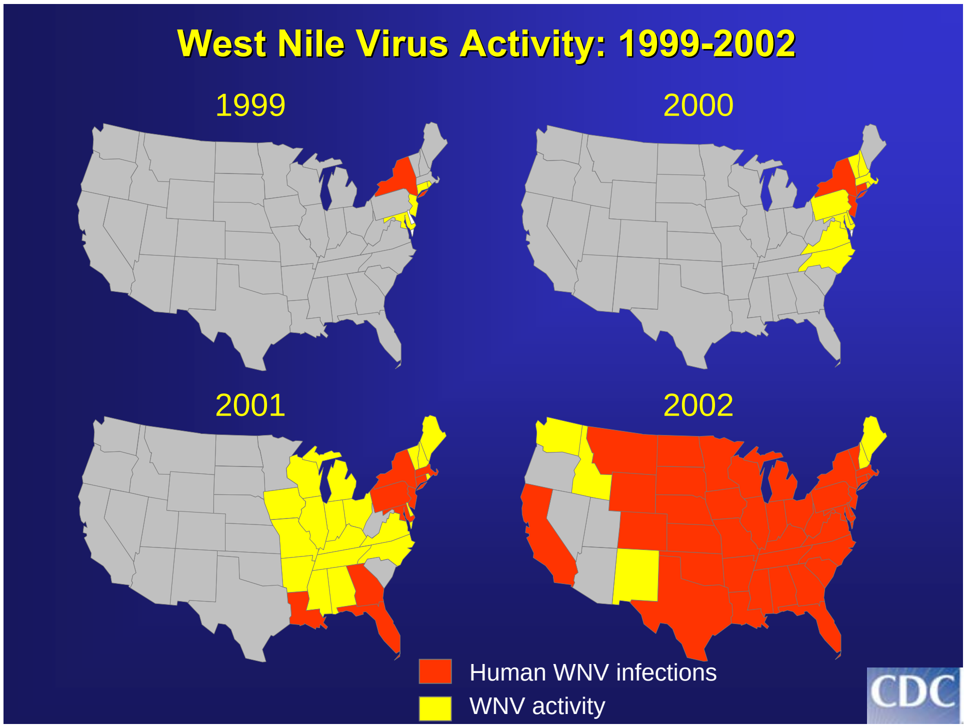
- 37 mosquito species
- 162 native and captive avian species
  - Mortality varies greatly by species
  - Very high viremias in some species
  - Bird-to-bird transmission documented
    - Virus in feces and oral swabs
    - Oral infection possible
- 18 other species (e.g., cats, dogs, squirrels, chipmunks, harbor seal, alligator, bats, reindeer)



1999-2002 Verified WNV Surveillance Results Reported to ArboNet

Year	States	Humans/ Fatalities	Birds	Mosquito Pools	Horses
1999	4	62/6	?	16	25
2000	11 + DC	21/2	4305	515	63
2001	27+DC	66/9	7332	919	731
2002	44 + DC	4156/284	16739	6604	14539

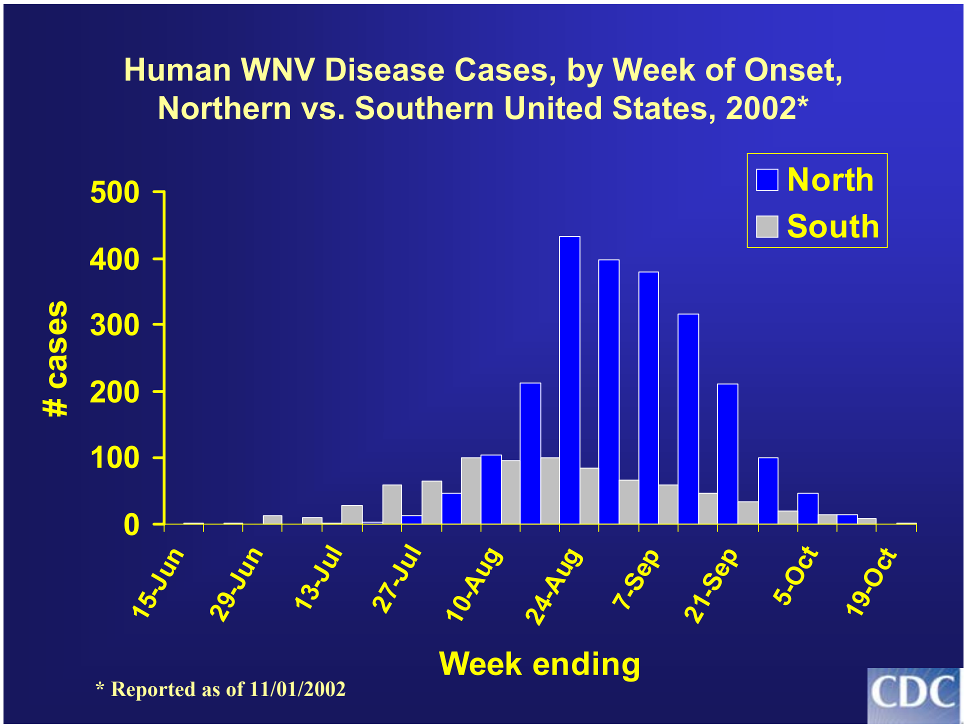
CDC



West Nile Virus Activity: 1999-2002

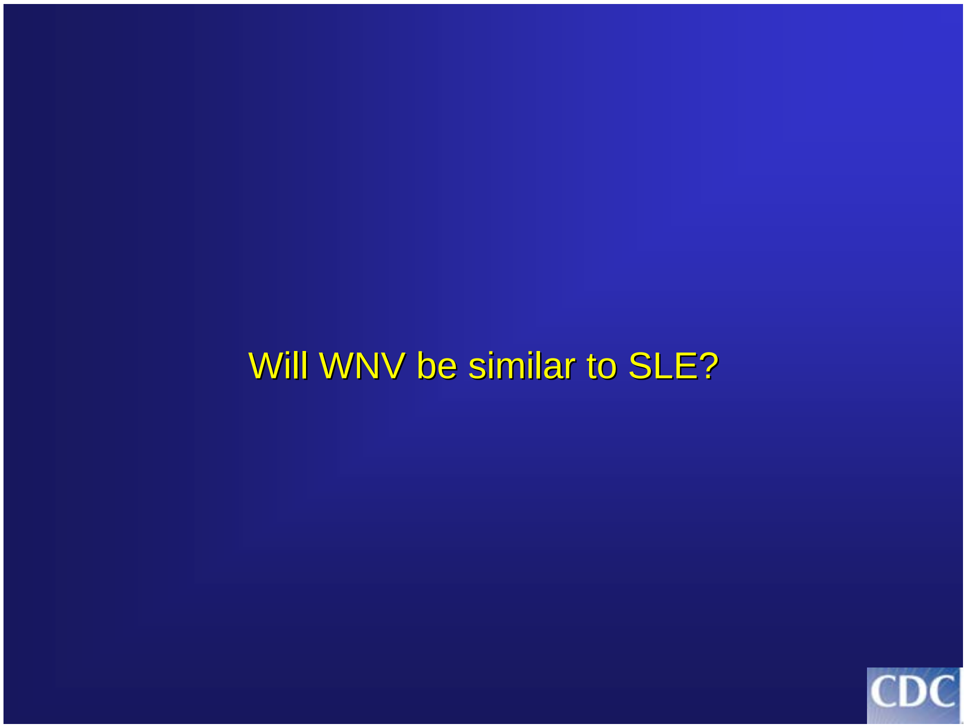
🟥 Human WNV infections
🟨 WNV activity

CDC

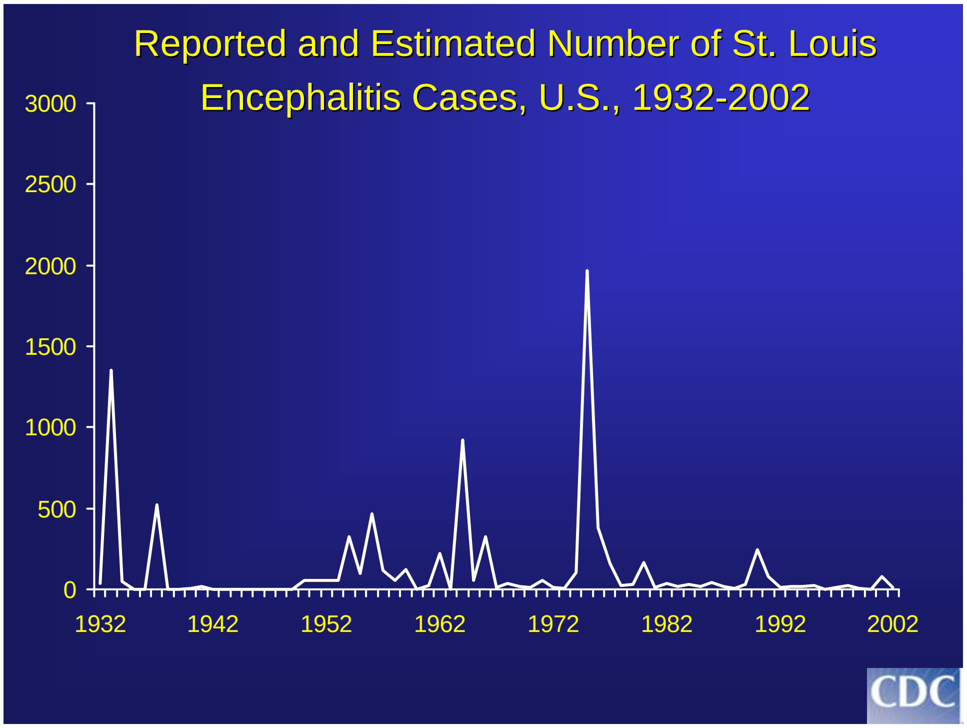


Human WNV Disease Cases, by Week of Onset, Northern vs. Southern United States, 2002*

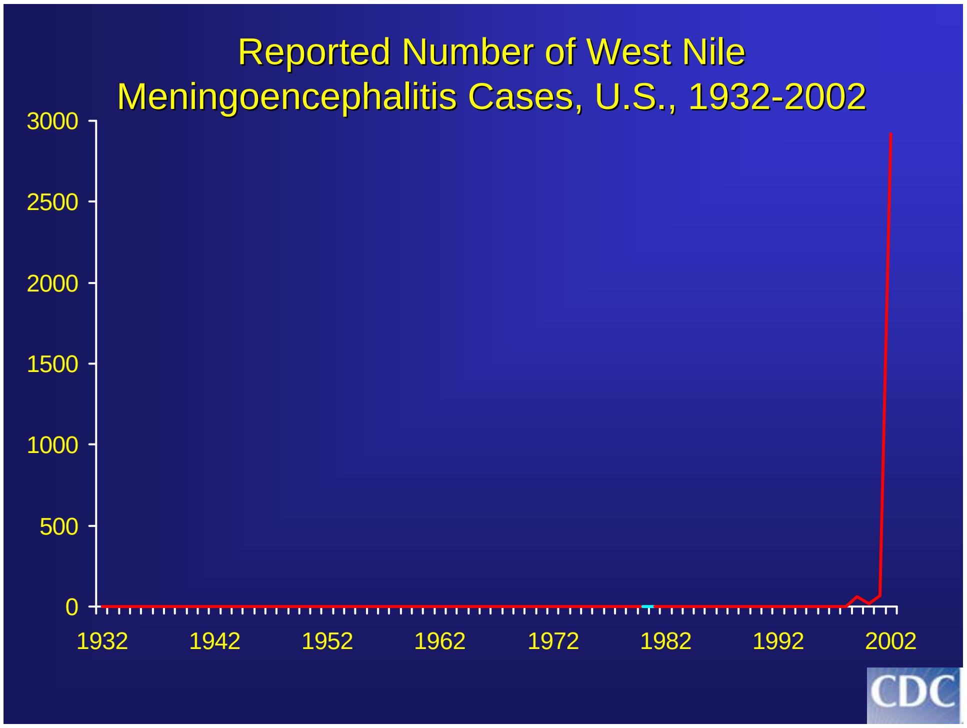
* Reported as of 11/01/2002



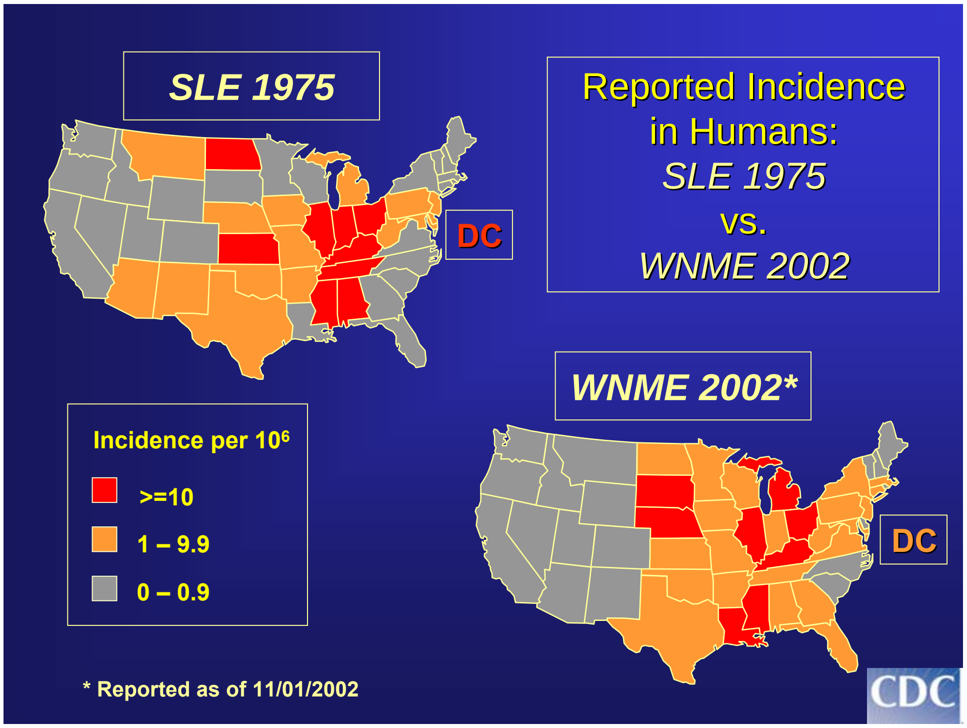
Will WNV be similar to SLE?



Reported and Estimated Number of St. Louis Encephalitis Cases, U.S., 1932-2002



Reported Number of West Nile Meningoencephalitis Cases, U.S., 1932-2002



Reported Incidence in Humans:
SLE 1975
vs.
WNME 2002

SLE 1975

*WNME 2002**

Incidence per 10^6

🟥 >=10

🟧 1 – 9.9

◼ 0 – 0.9

* Reported as of 11/01/2002

West Nile Virus Future in the United States

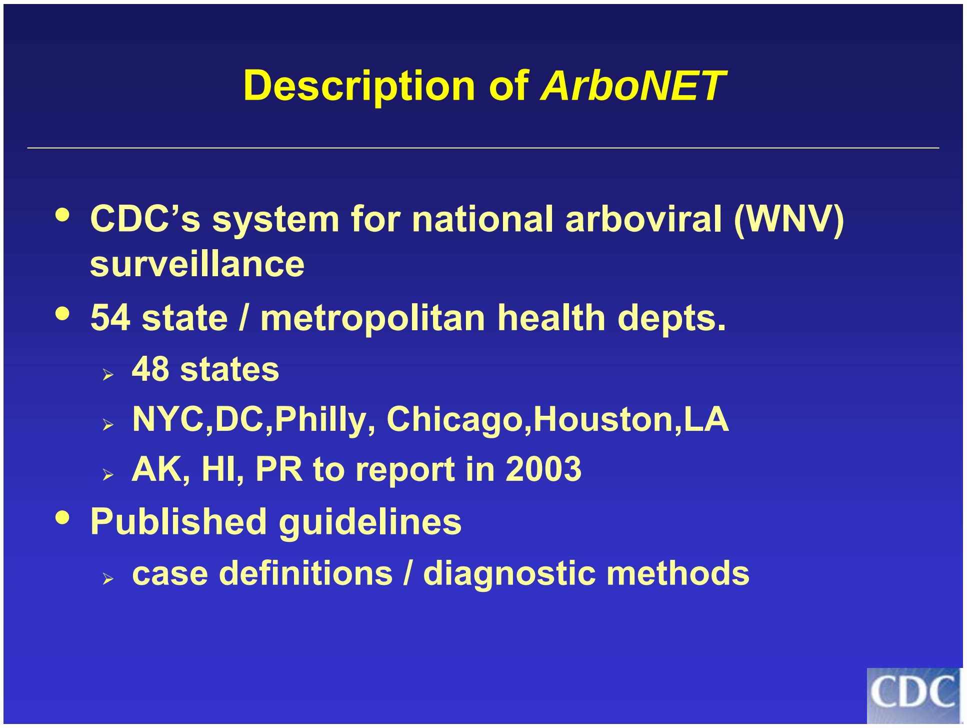
- Worrisome for several reasons
  - Prolonged transmission season
  - Wide geographic range
  - Many potential amplifying avian hosts
  - High viremias in birds
  - Many potential mosquito vectors
  - Many potential human-biting mosquito species
  - Persistence infections in areas over 4 years
  - Urban / suburban / rural transmission

National Surveillance for West Nile Virus (WNV): Nuts and Bolts

Dan O’Leary, D.V.M., Epidemiologist
Division of Vector-Borne Infectious Diseases
National Center for Infectious Diseases
Centers for Disease Control and Prevention
Fort Collins, CO USA

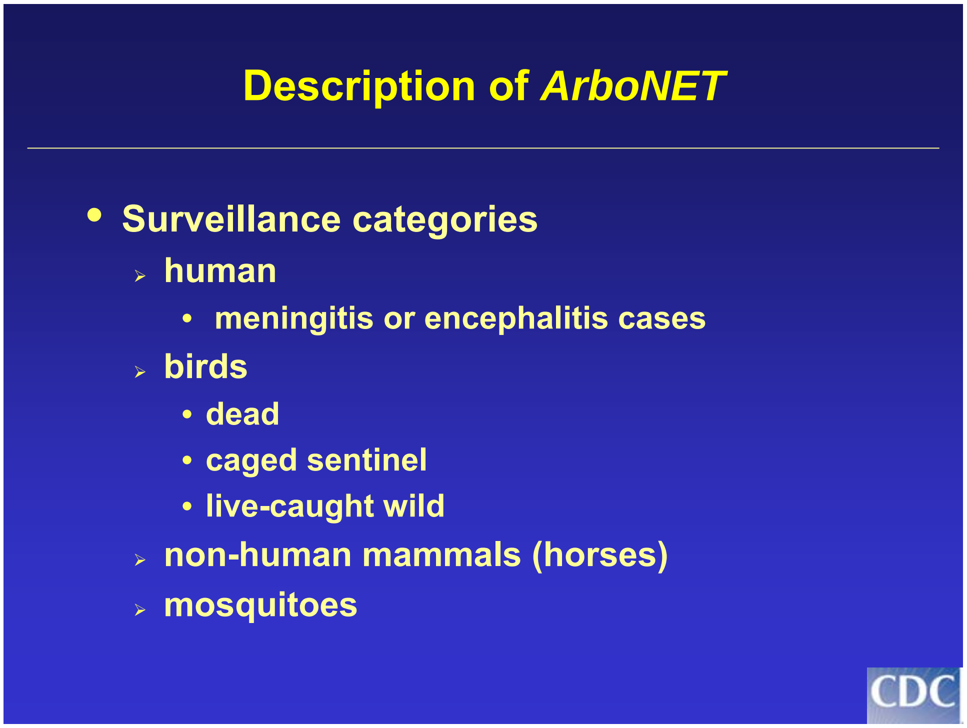
Overview: Introducing *ArboNET*

- System description
- Cast of players
- Data flow
- ArboNET data
- End users
- Limitations of data



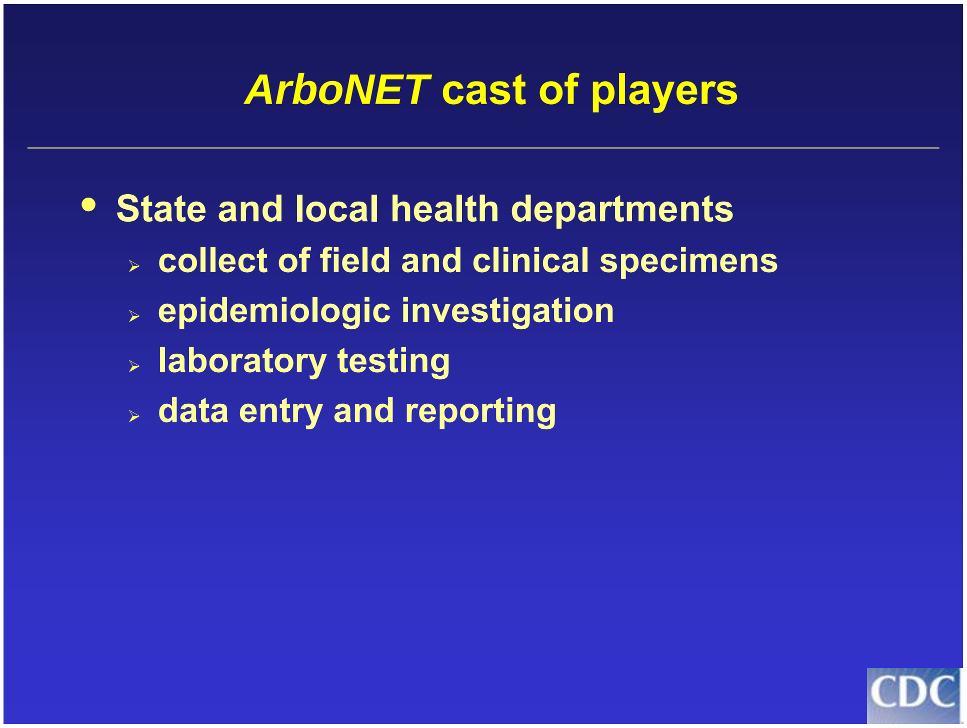
Description of *ArboNET*

- CDC’s system for national arboviral (WNV) surveillance
- 54 state / metropolitan health depts.
  - 48 states
  - NYC,DC,Philly, Chicago,Houston,LA
  - AK, HI, PR to report in 2003
- Published guidelines
  - case definitions / diagnostic methods



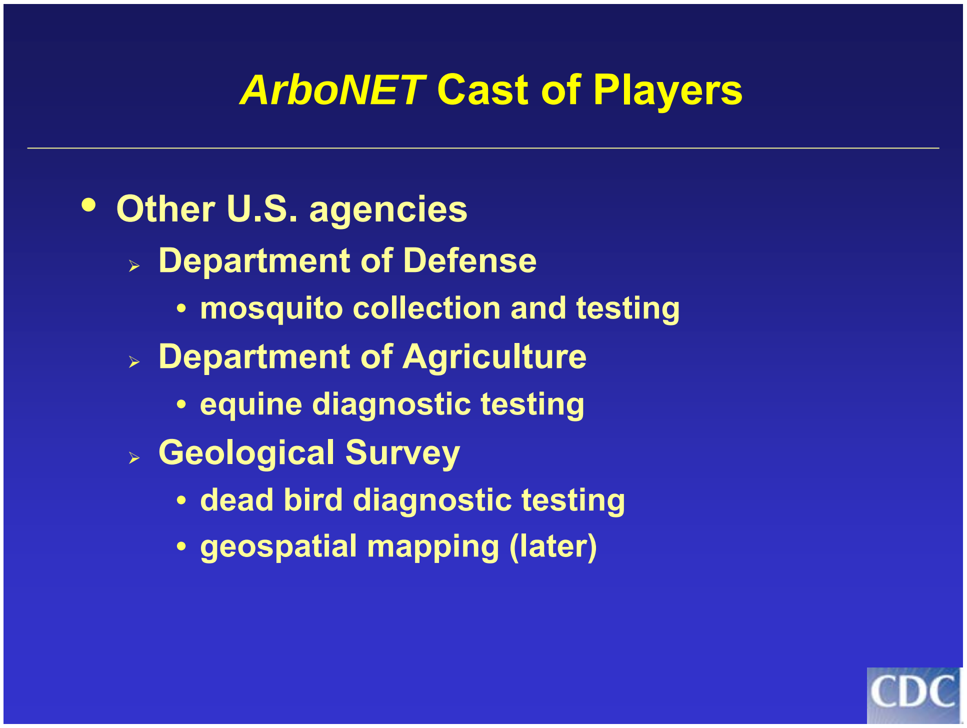
Description of *ArboNET*

- Surveillance categories
  - human
    - meningitis or encephalitis cases
  - birds
    - dead
    - caged sentinel
    - live-caught wild
  - non-human mammals (horses)
  - mosquitoes



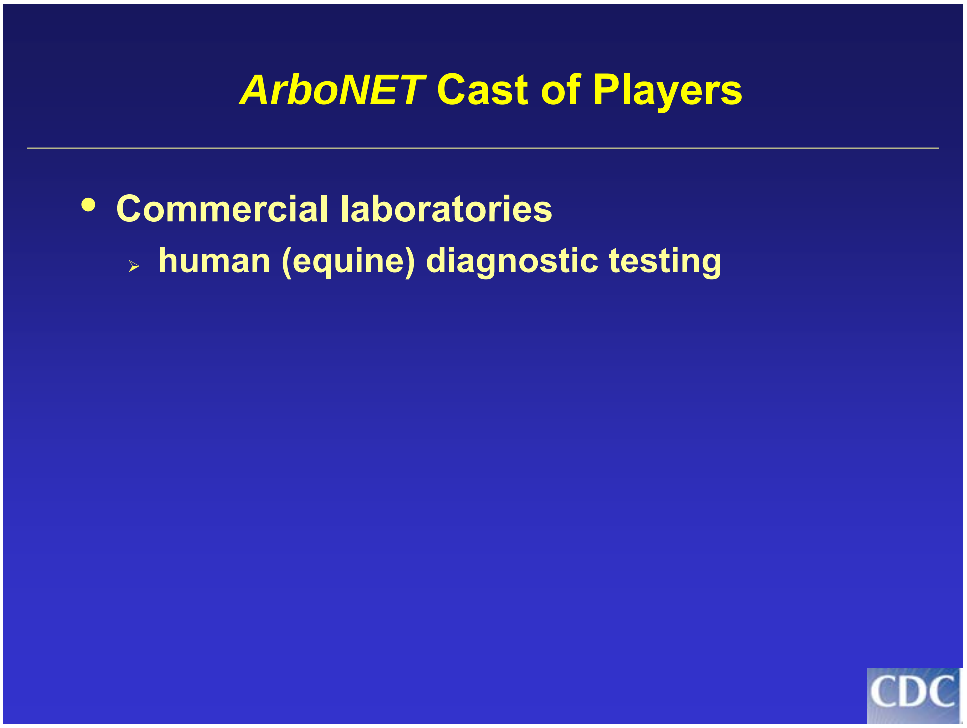
ArboNET cast of players

- State and local health departments
  - collect of field and clinical specimens
  - epidemiologic investigation
  - laboratory testing
  - data entry and reporting



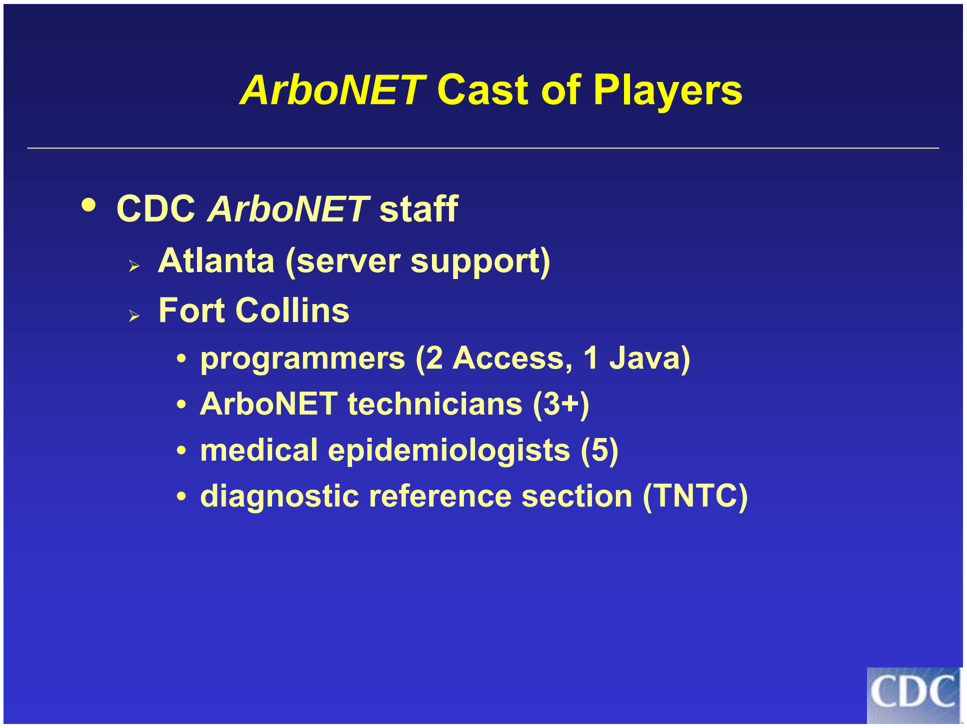
ArboNET Cast of Players

- Other U.S. agencies
  - Department of Defense
    - mosquito collection and testing
  - Department of Agriculture
    - equine diagnostic testing
  - Geological Survey
    - dead bird diagnostic testing
    - geospatial mapping (later)



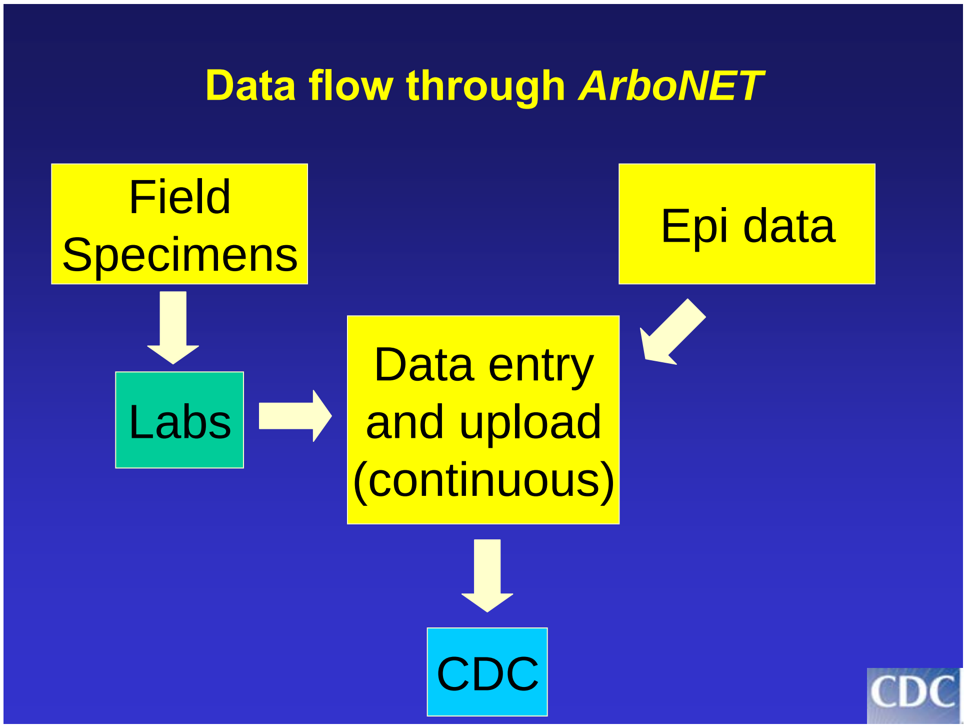
ArboNET Cast of Players

- Commercial laboratories
  - human (equine) diagnostic testing



ArboNET Cast of Players

- CDC *ArboNET* staff
  - Atlanta (server support)
  - Fort Collins
    - programmers (2 Access, 1 Java)
    - ArboNET technicians (3+)
    - medical epidemiologists (5)
    - diagnostic reference section (TNTC)



Data flow through *ArboNET*

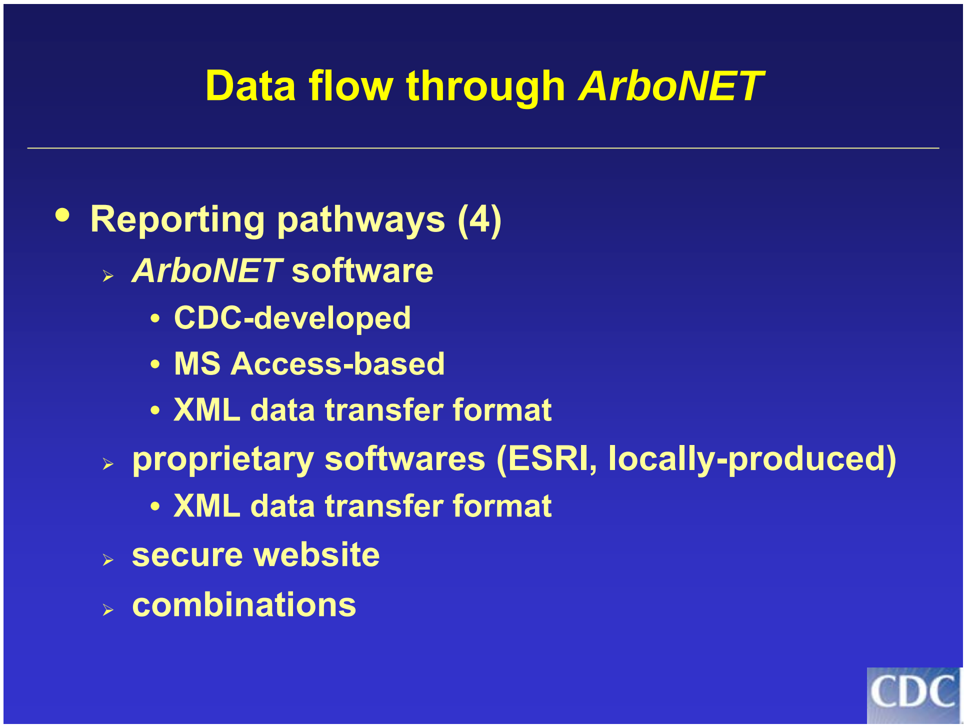
Field Specimens

Epi data

Labs

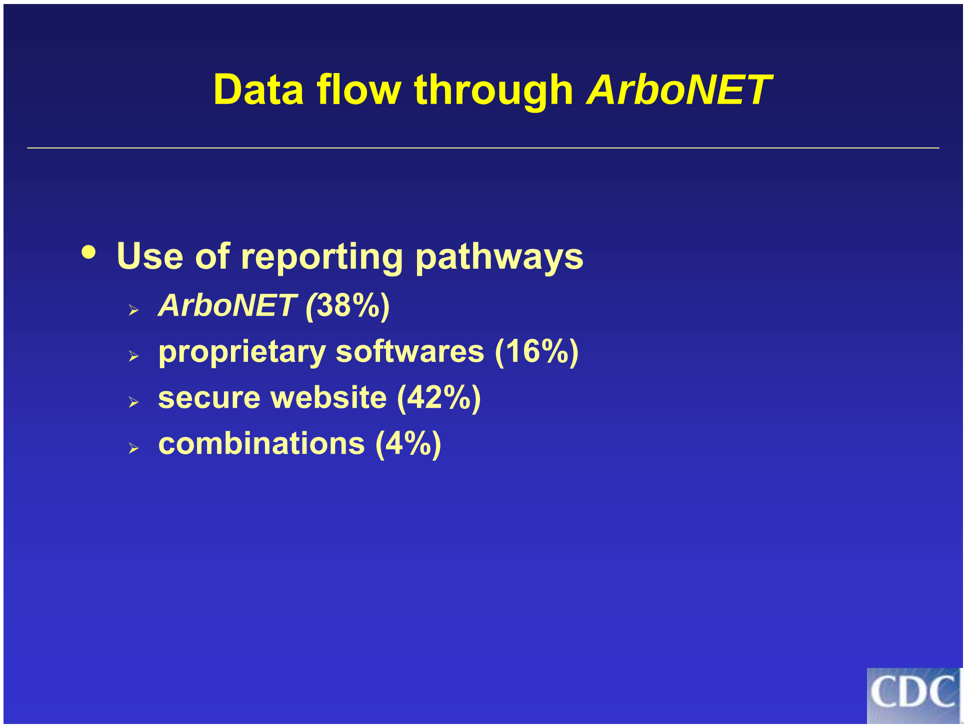
Data entry and upload (continuous)

CDC



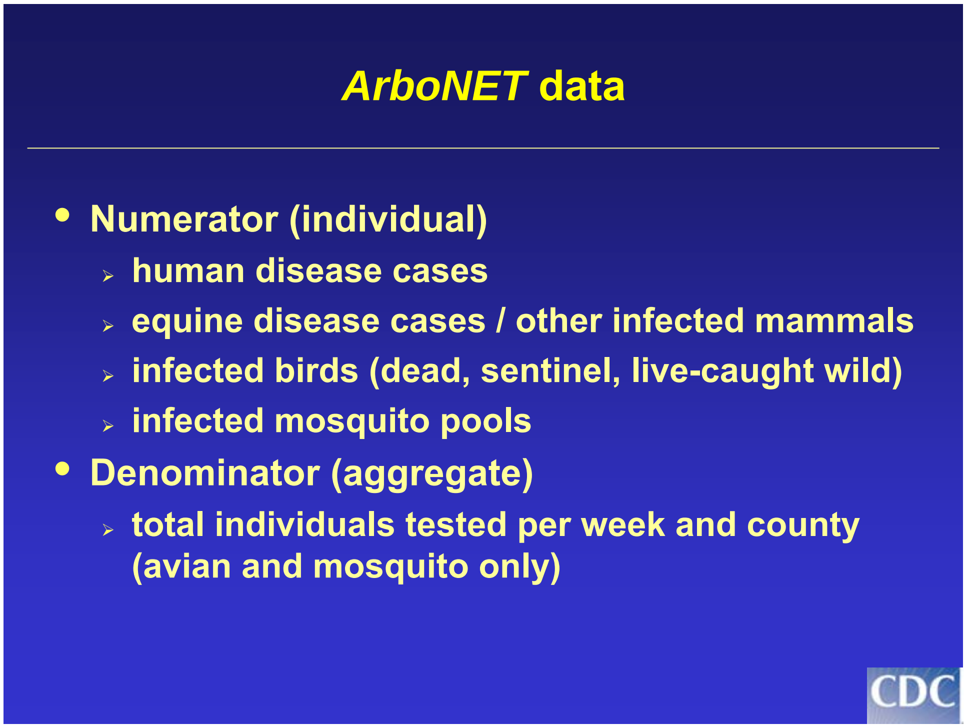
Data flow through *ArboNET*

- Reporting pathways (4)
  - *ArboNET* software
    - CDC-developed
    - MS Access-based
    - XML data transfer format
  - proprietary softwares (ESRI, locally-produced)
    - XML data transfer format
  - secure website
  - combinations



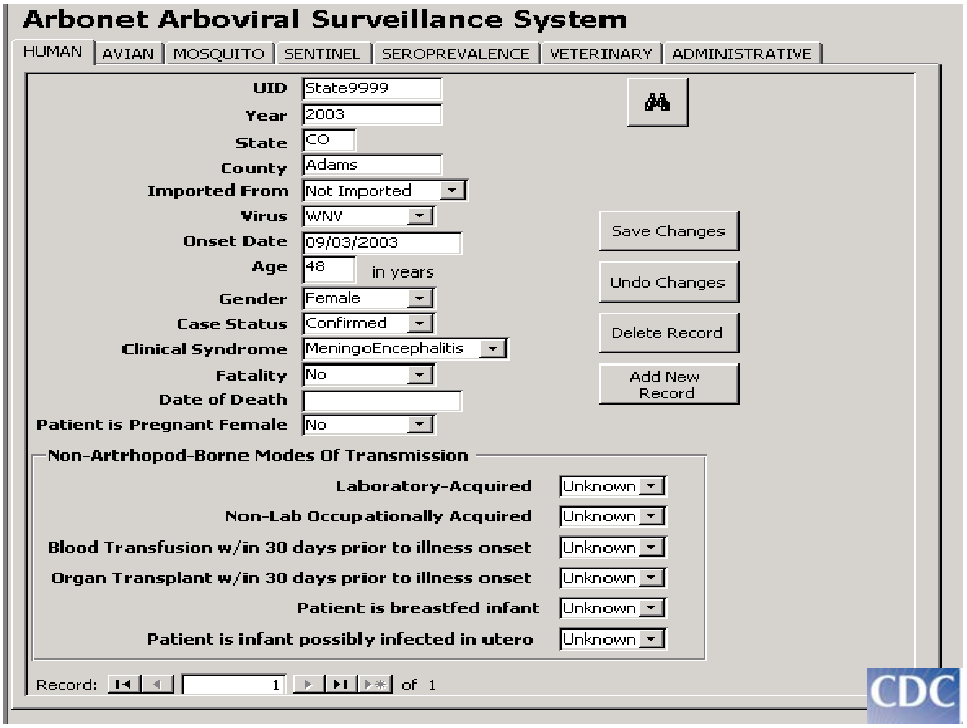
Data flow through *ArboNET*

- Use of reporting pathways
  - *ArboNET* (38%)
  - proprietary softwares (16%)
  - secure website (42%)
  - combinations (4%)



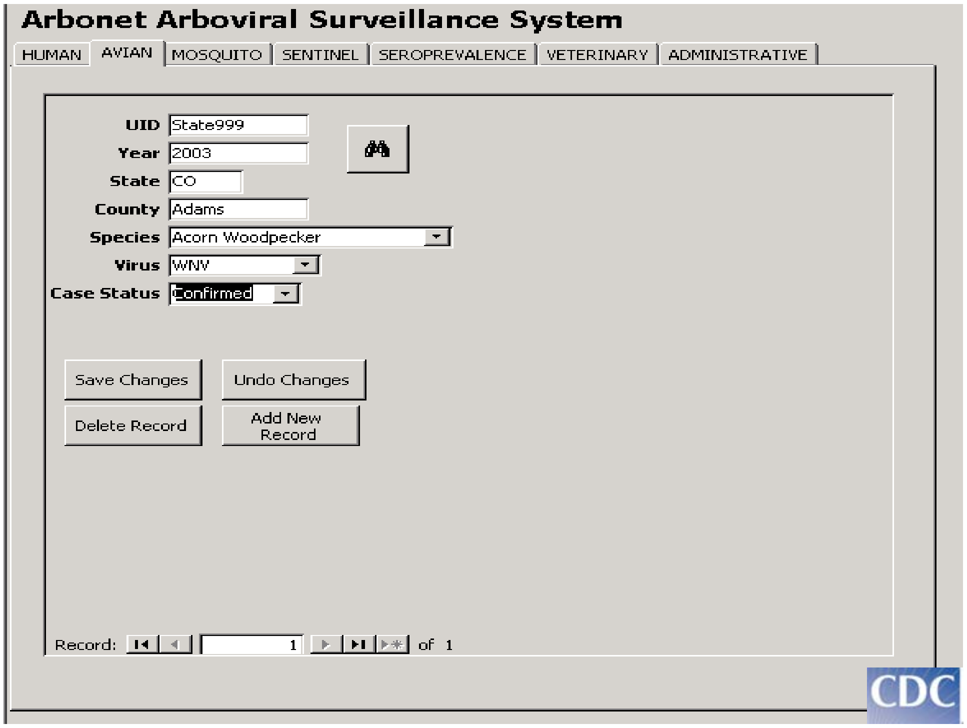
ArboNET data

- Numerator (individual)
  - human disease cases
  - equine disease cases / other infected mammals
  - infected birds (dead, sentinel, live-caught wild)
  - infected mosquito pools
- Denominator (aggregate)
  - total individuals tested per week and county (avian and mosquito only)



UID: State9999
Year: 2003
State: CO
County: Adams
Imported From: Not Imported
Virus: WNV
Onset Date: 09/03/2003
Age: 48 in years
Gender: Female
Case Status: Confirmed
Clinical Syndrome: MeningoEncephalitis
Fatality: No
Date of Death:
Patient is Pregnant Female: No

Non-Artrhopod-Borne Modes Of Transmission
Laboratory-Acquired: Unknown
Non-Lab Occupationally Acquired: Unknown
Blood Transfusion w/in 30 days prior to illness onset: Unknown
Organ Transplant w/in 30 days prior to illness onset: Unknown
Patient is breastfed infant: Unknown
Patient is infant possibly infected in utero: Unknown



UID: State999
Year: 2003
State: CO
County: Adams
Species: Acorn Woodpecker
Virus: WNV
Case Status: Confirmed

ArboNet data

- Denominator fields
  - arbovirus
  - county
  - week
  - species
  - individuals tested

ArboNET data

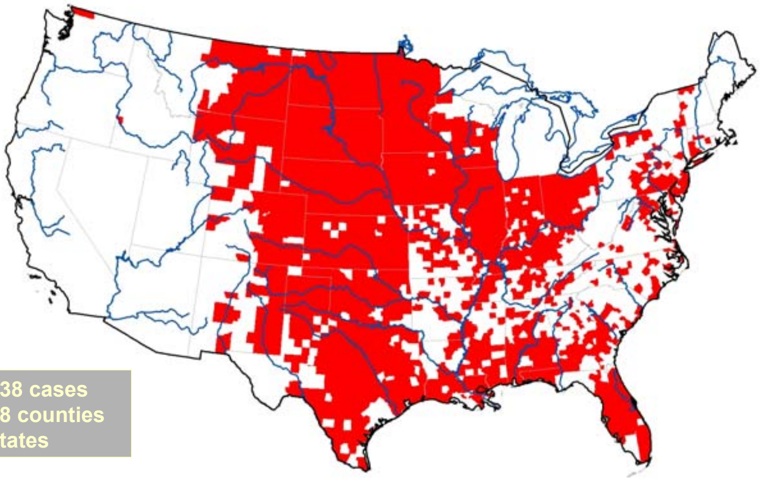
- Numerator records
- (individual totals)
  - 2000 (5,001)
  - 2001 (9,324)
  - 2002 (44,157)

- Denominator records
- (aggregate totals)
  - 2000 (18,881)
  - 2001 (42,208)
  - 2002 (54,375)

End-users of *ArboNET* data

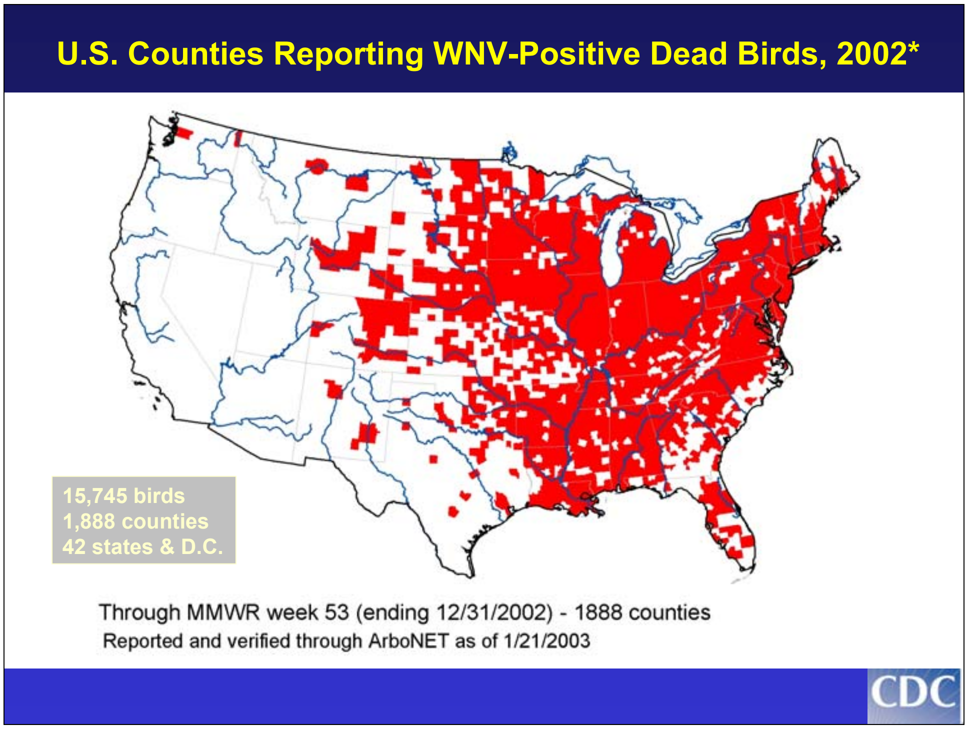
- Participating health departments
    - weekly national surveillance updates
- USGS
    - weekly data dump---surveillance maps
- Public
    - peer reviewed publications
    - CDC publications (MMWR)
    - maps (via CDC and USGS websites)
    - media interviews

U.S. Counties Reporting Equine WNV Disease Cases, 2002*



12,038 cases
1,678 counties
39 states

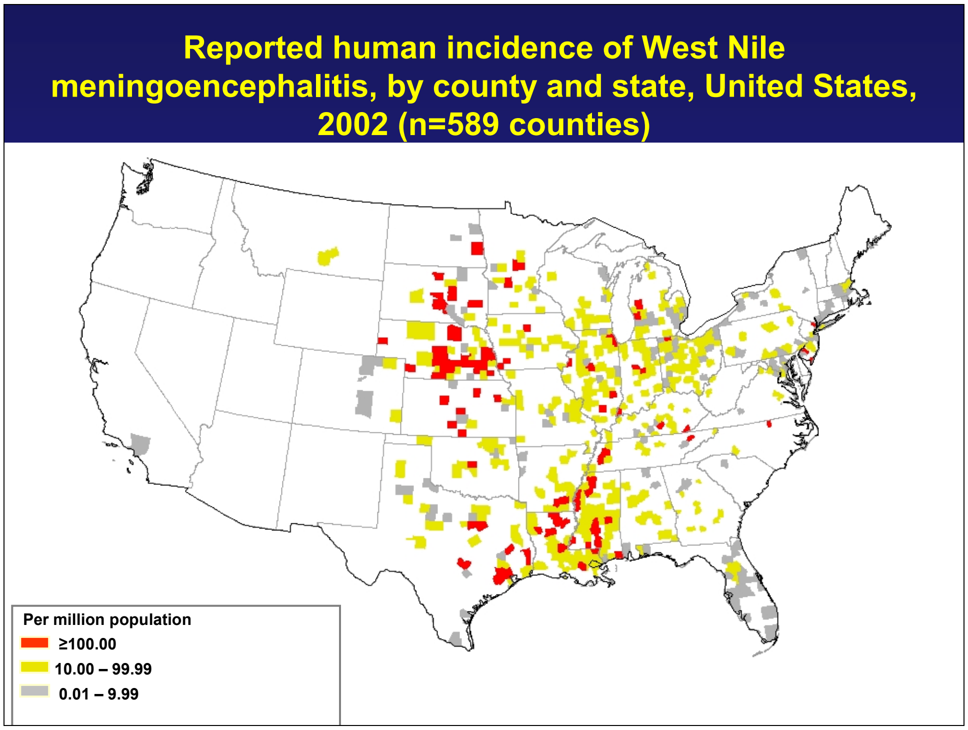
Through MMWR week 53 (ending 12/31/2002) - 1678 counties
Reported and verified through ArboNET as of 1/21/2003



U.S. Counties Reporting WNV-Positive Dead Birds, 2002*

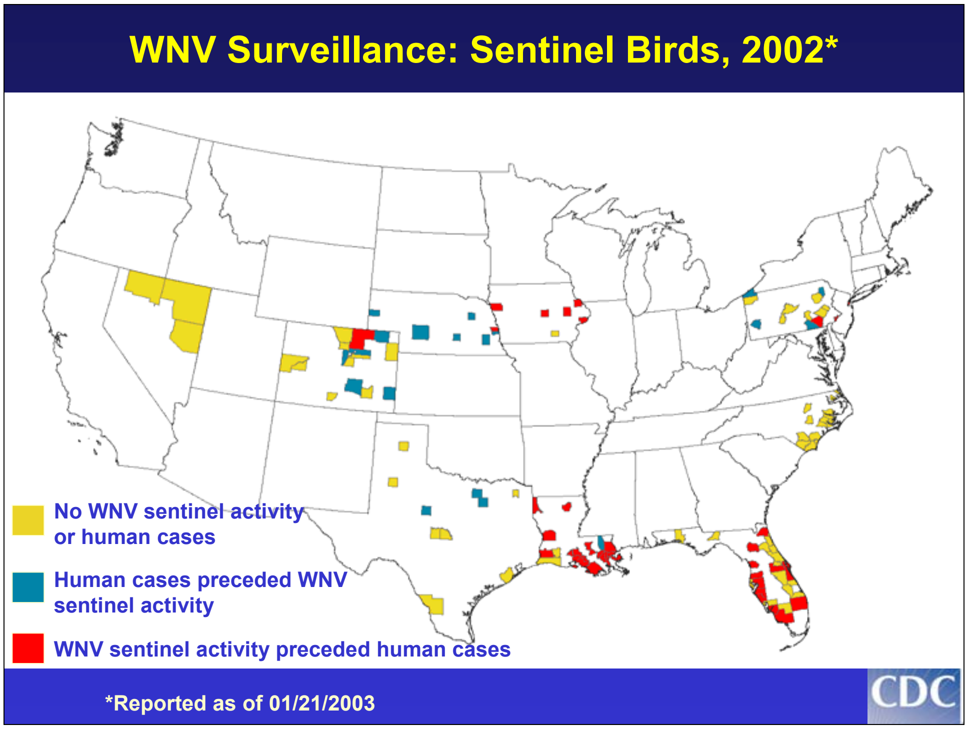
15,745 birds
1,888 counties
42 states & D.C.

Through MMWR week 53 (ending 12/31/2002) - 1888 counties
Reported and verified through ArboNET as of 1/21/2003



Reported human incidence of West Nile meningoencephalitis, by county and state, United States, 2002 (n=589 counties)

Per million population
🟥 ≥100.00
🟨 10.00 – 99.99
▨ 0.01 – 9.99



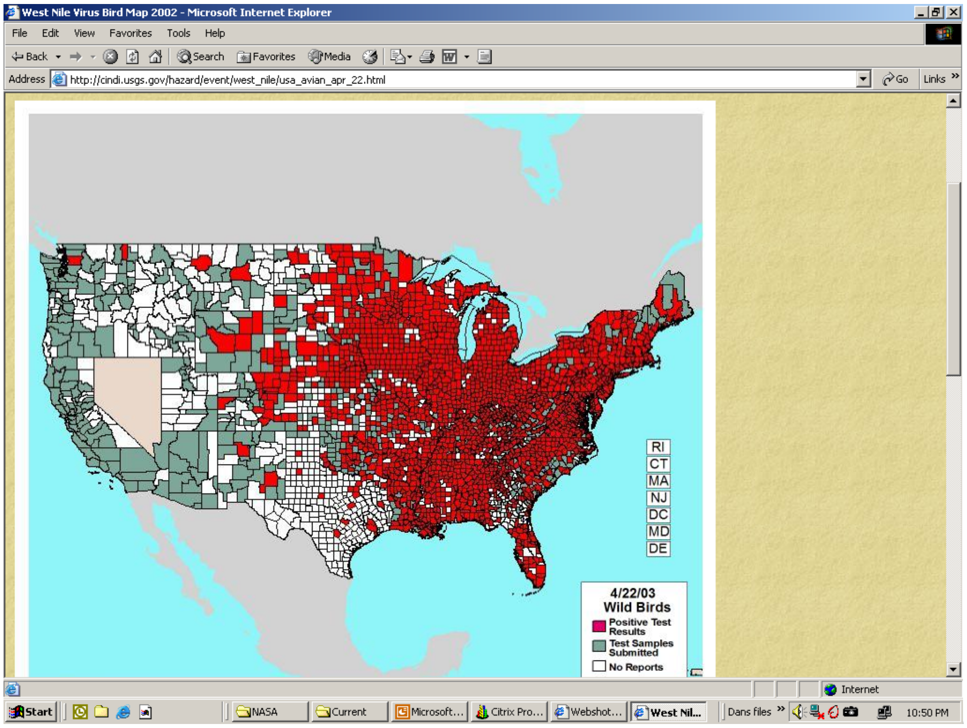
WNV Surveillance: Sentinel Birds, 2002*

🟨 No WNV sentinel activity or human cases

🟦 Human cases preceded WNV sentinel activity

🟥 WNV sentinel activity preceded human cases

*Reported as of 01/21/2003



West Nile Virus Bird Map 2002 - Microsoft Internet Explorer

Address http://cindi.usgs.gov/hazard/event/west_nile/usa_avian_apr_22.html

4/22/03
Wild Birds

- 🟥 Positive Test Results
- ▨ Test Samples Submitted
- ☐ No Reports

ArboNET data limitations

- Timeliness
  - delays in testing and reporting
- Quality
  - adherence to national surveillance guidelines currently unknown
    - Case definitions (case misclassification)
    - Testing procedures (false pos and negs)
  - variabile emphasis on respective surveillance categories
  - incomplete reporting of denominator data

CDC

Acknowledgements

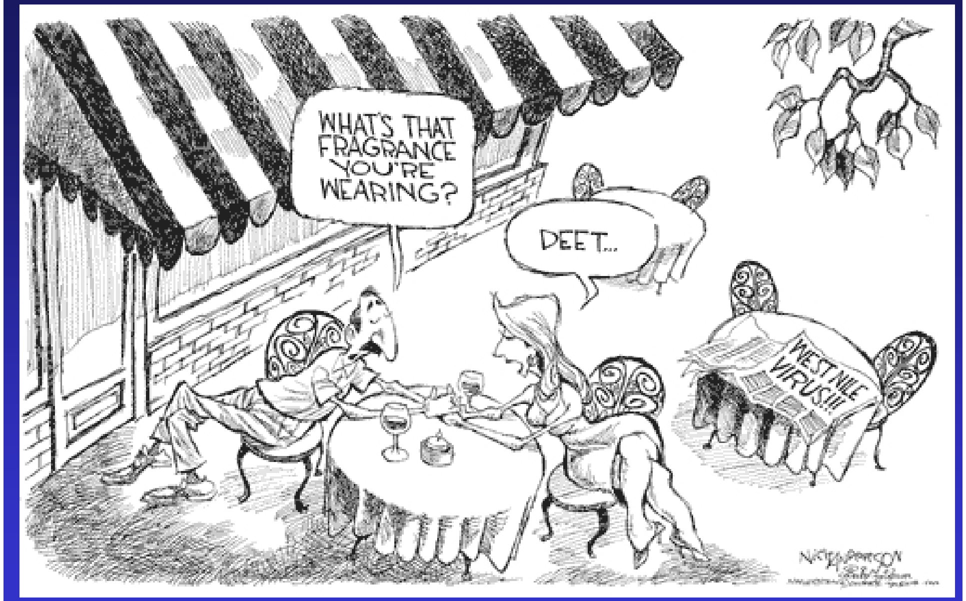
- ArboNET: Scores of partners in state and local health departments and other federal agencies
- CDC:

Jennifer Lehman
Aaron Kipp
Peggy Collins
John Jones
Veronica Elko
Keith Olsen
Cathy Chow
Sue Montgomery

Tony Marfin
Roy Campbell
Nick Komar
Roger Nasci
John Roehrig
Lyle Petersen
Duane Gubler

ArboNET

CDC


WHAT'S THAT FRAGRANCE YOU'RE WEARING?
DEET...
WEST NILE VIRUS!!!
NICK ANDERSON

Louisa Beck
"NASA Science Technologies and Human Health"

NASA Science, Technologies, and Human Health

Louisa R. Beck

Brad Lobitz

Cindy Schmidt

Center for Health Applications of
Aerospace Related Technologies

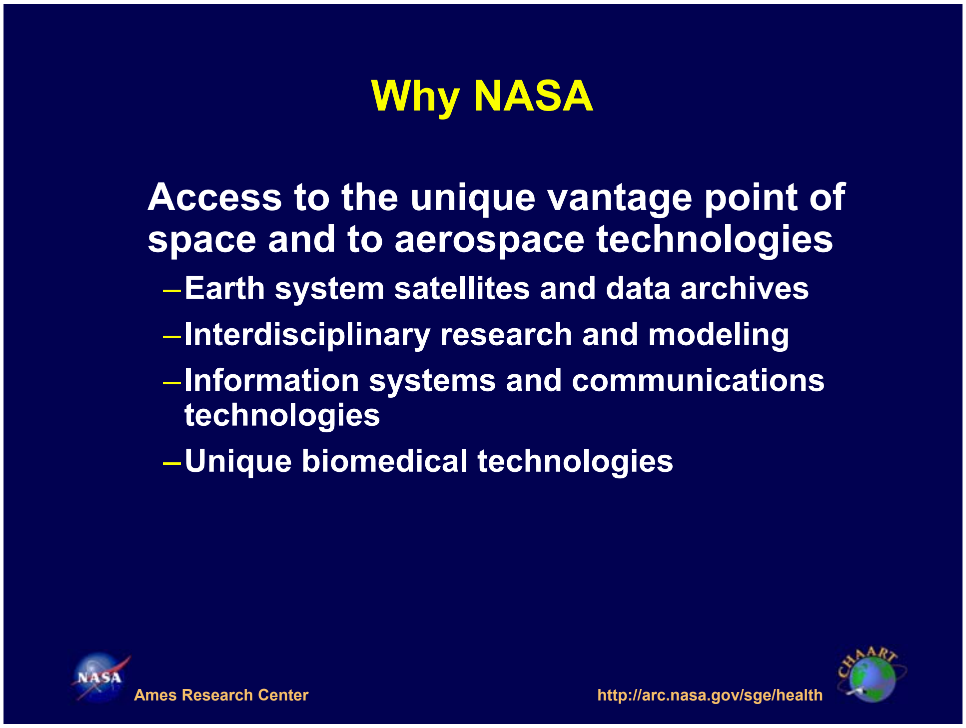
NASA Ames Research Center
Moffett Field, CA

Jackson, MS

21 May 2003

Ames Research Center

http://arc.nasa.gov/sge/health



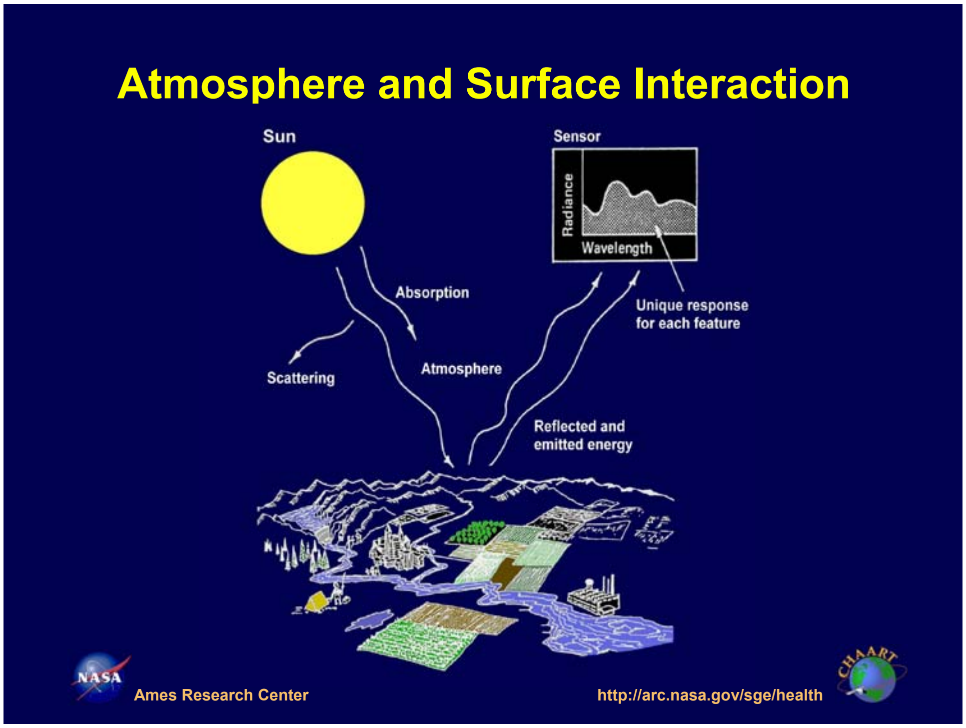
Why NASA

Access to the unique vantage point of space and to aerospace technologies

- Earth system satellites and data archives
- Interdisciplinary research and modeling
- Information systems and communications technologies
- Unique biomedical technologies

Ames Research Center

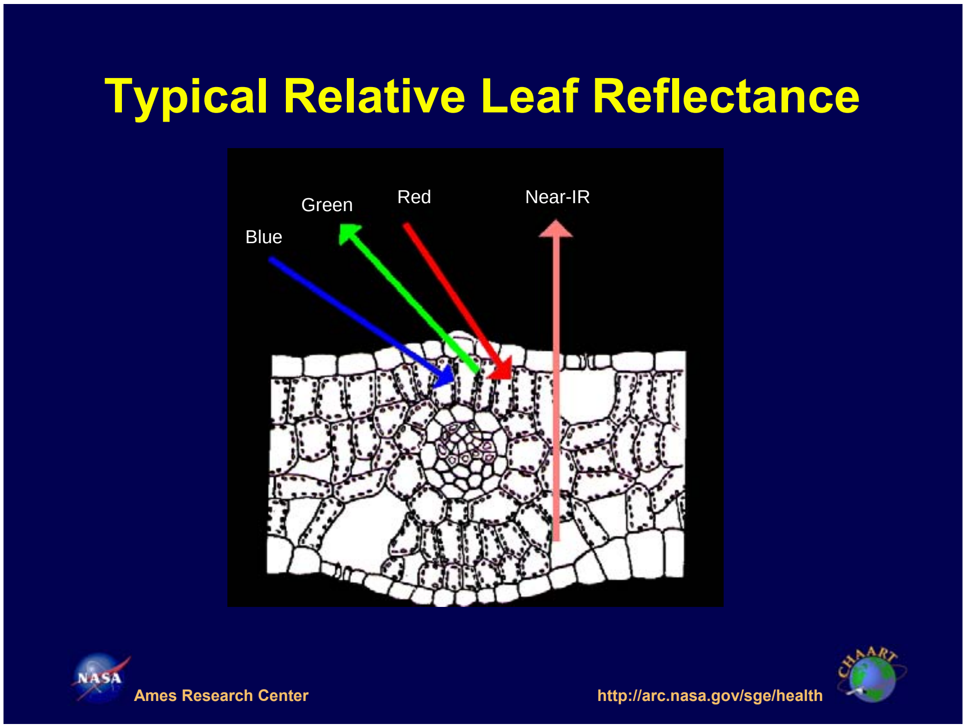
http://arc.nasa.gov/sge/health



Atmosphere and Surface Interaction

Ames Research Center

http://arc.nasa.gov/sge/health

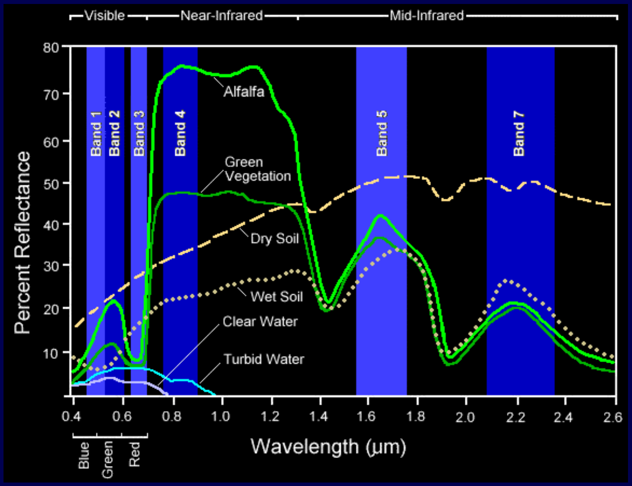


Typical Relative Leaf Reflectance

Ames Research Center

http://arc.nasa.gov/sge/health

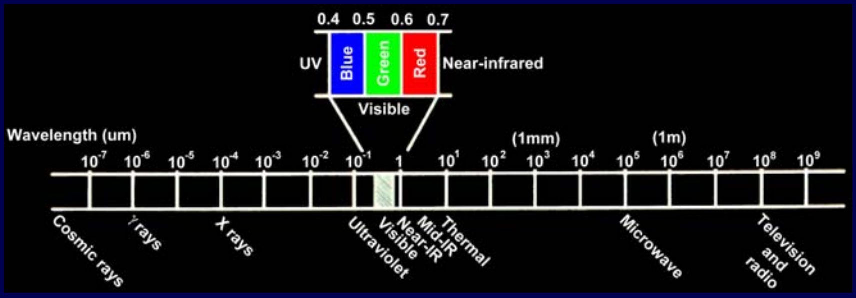
Spectral Reflectance Curves and TM Bands



Ames Research Center

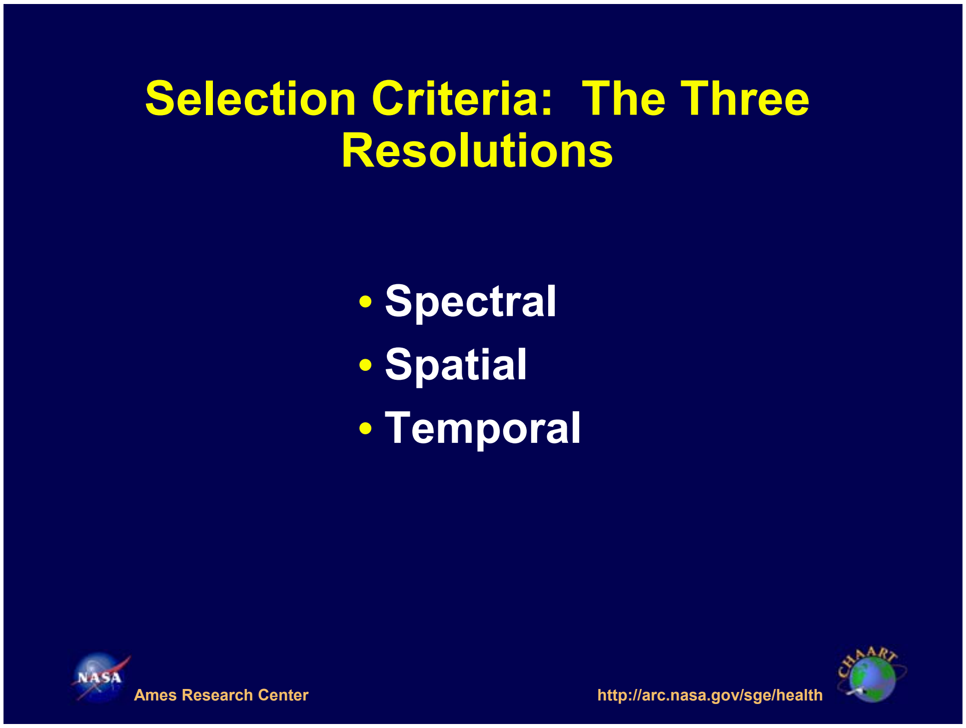
http://arc.nasa.gov/sge/health

Electromagnetic Spectrum



Ames Research Center

http://arc.nasa.gov/sge/health

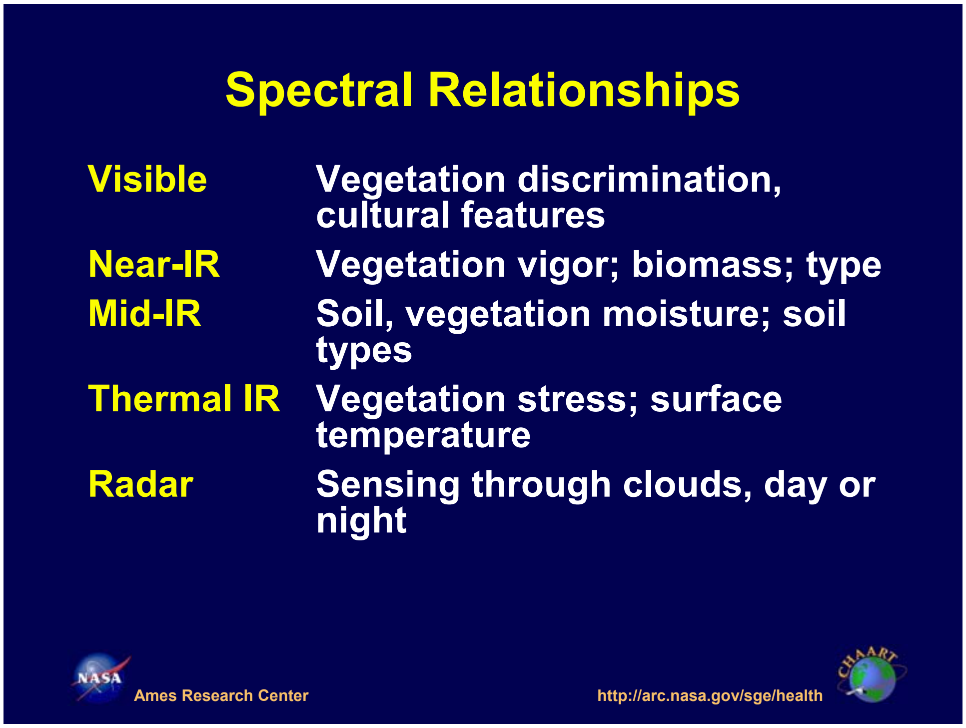


Selection Criteria: The Three Resolutions

- Spectral
- Spatial
- Temporal

Ames Research Center

http://arc.nasa.gov/sge/health

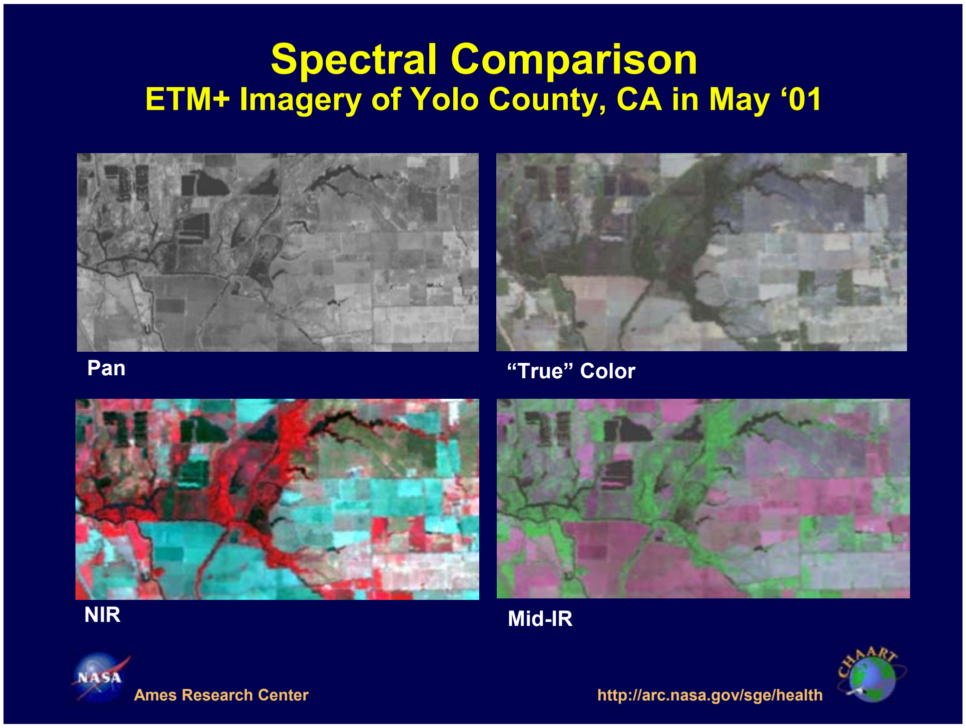


Spectral Relationships

Visible	Vegetation discrimination, cultural features
Near-IR	Vegetation vigor; biomass; type
Mid-IR	Soil, vegetation moisture; soil types
Thermal IR	Vegetation stress; surface temperature
Radar	Sensing through clouds, day or night

Ames Research Center

http://arc.nasa.gov/sge/health

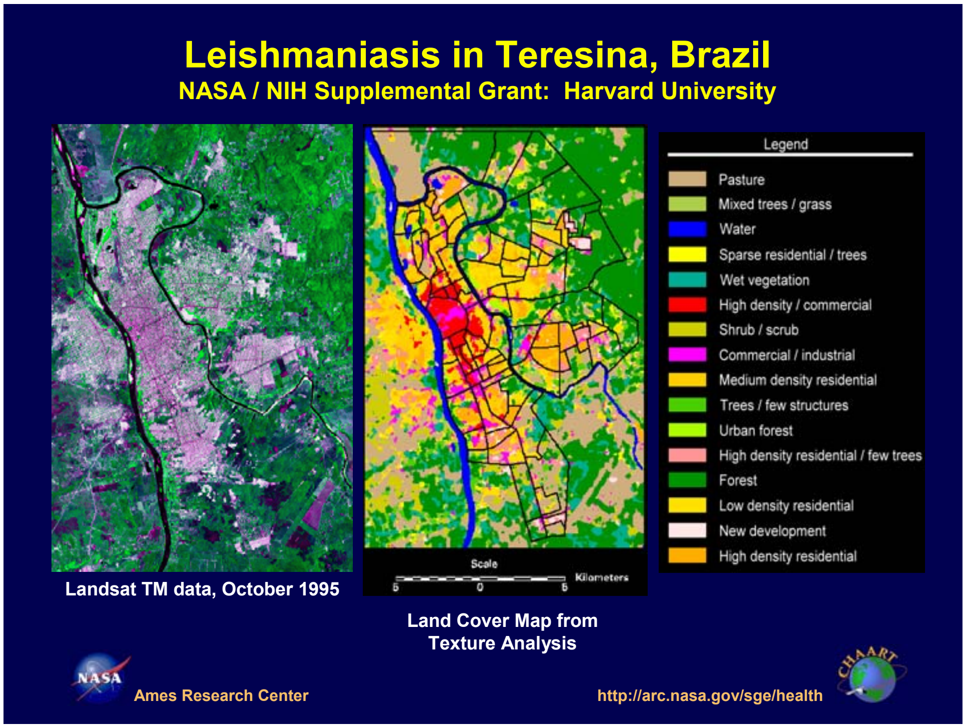


Spectral Comparison

ETM+ Imagery of Yolo County, CA in May '01

Ames Research Center

http://arc.nasa.gov/sge/health



Leishmaniasis in Teresina, Brazil

NASA / NIH Supplemental Grant: Harvard University

Landsat TM data, October 1995

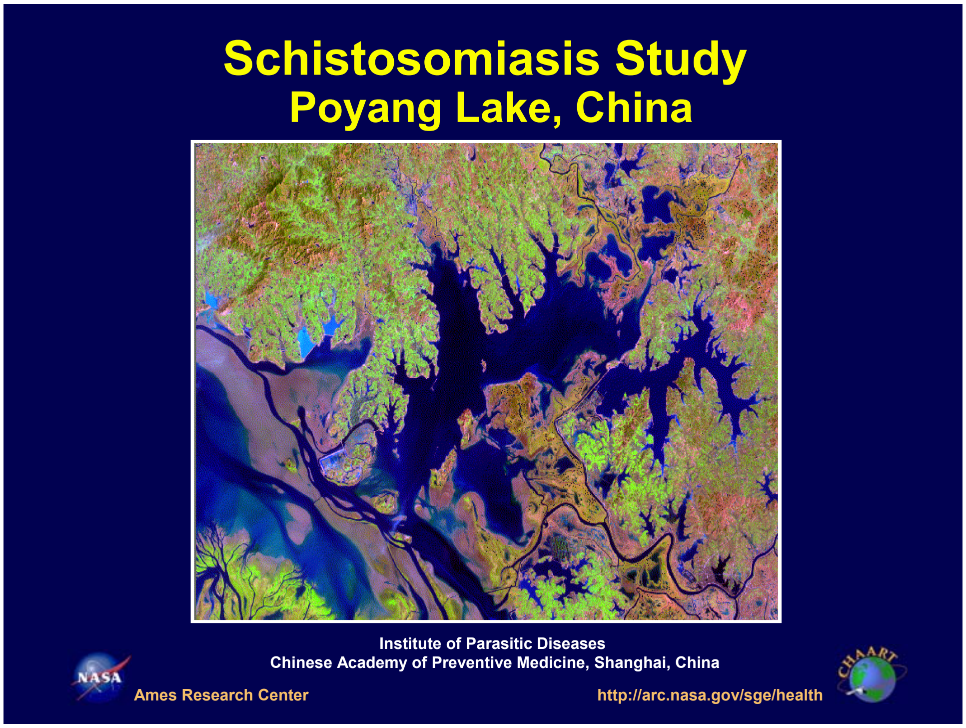
Land Cover Map from
Texture Analysis

Legend

- 🟫 Pasture
- 🟩 Mixed trees / grass
- 🟦 Water
- 🟨 Sparse residential / trees
- 🟩 Wet vegetation
- 🟥 High density / commercial
- 🟨 Shrub / scrub
- 🟪 Commercial / industrial
- 🟧 Medium density residential
- 🟩 Trees / few structures
- 🟩 Urban forest
- 🟥 High density residential / few trees
- 🟩 Forest
- 🟨 Low density residential
- ⬜ New development
- 🟧 High density residential

Ames Research Center

http://arc.nasa.gov/sge/health



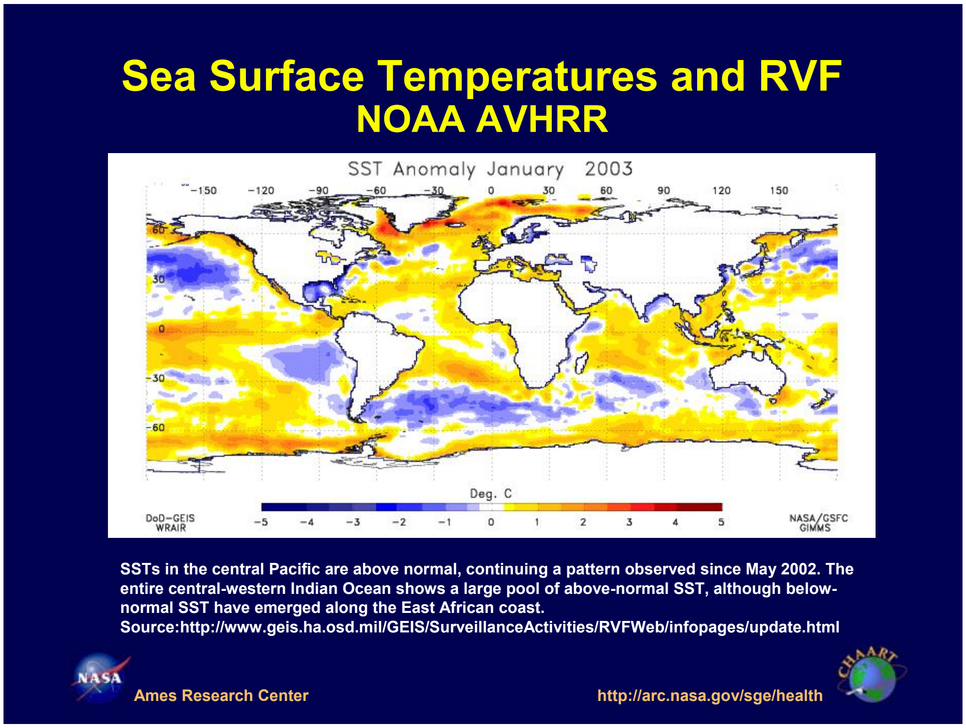
Schistosomiasis Study

Poyang Lake, China

Institute of Parasitic Diseases
Chinese Academy of Preventive Medicine, Shanghai, China

Ames Research Center

http://arc.nasa.gov/sge/health



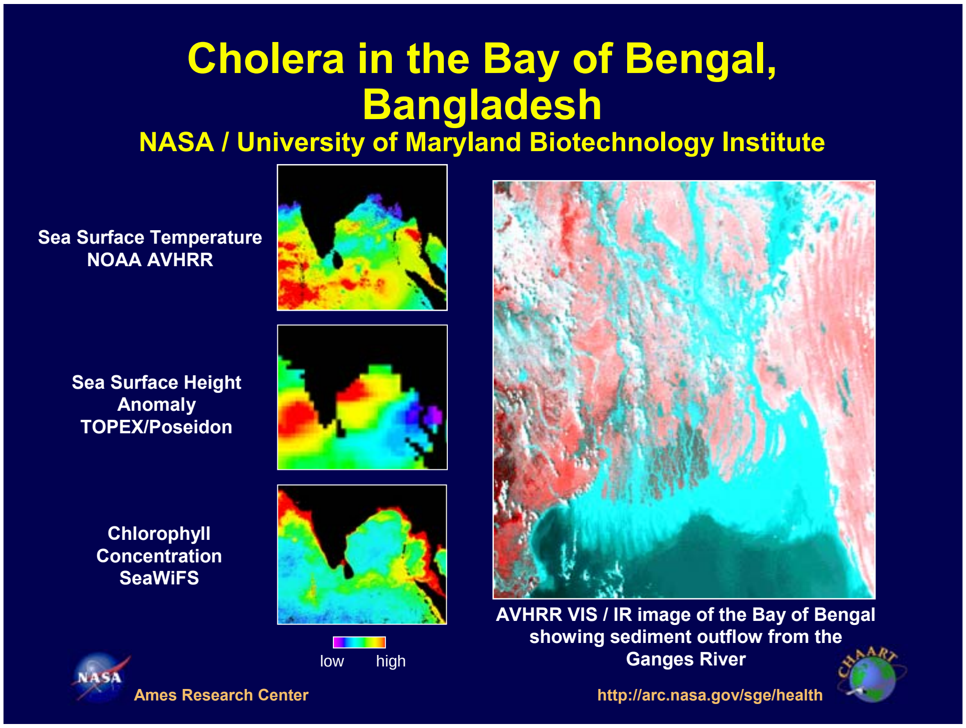
Sea Surface Temperatures and RVF

NOAA AVHRR

SSTs in the central Pacific are above normal, continuing a pattern observed since May 2002. The entire central-western Indian Ocean shows a large pool of above-normal SST, although below-normal SST have emerged along the East African coast.
Source:http://www.geis.ha.osd.mil/GEIS/SurveillanceActivities/RVFWeb/infopages/update.html

Ames Research Center

http://arc.nasa.gov/sge/health



Cholera in the Bay of Bengal, Bangladesh

NASA / University of Maryland Biotechnology Institute

Sea Surface Temperature
NOAA AVHRR

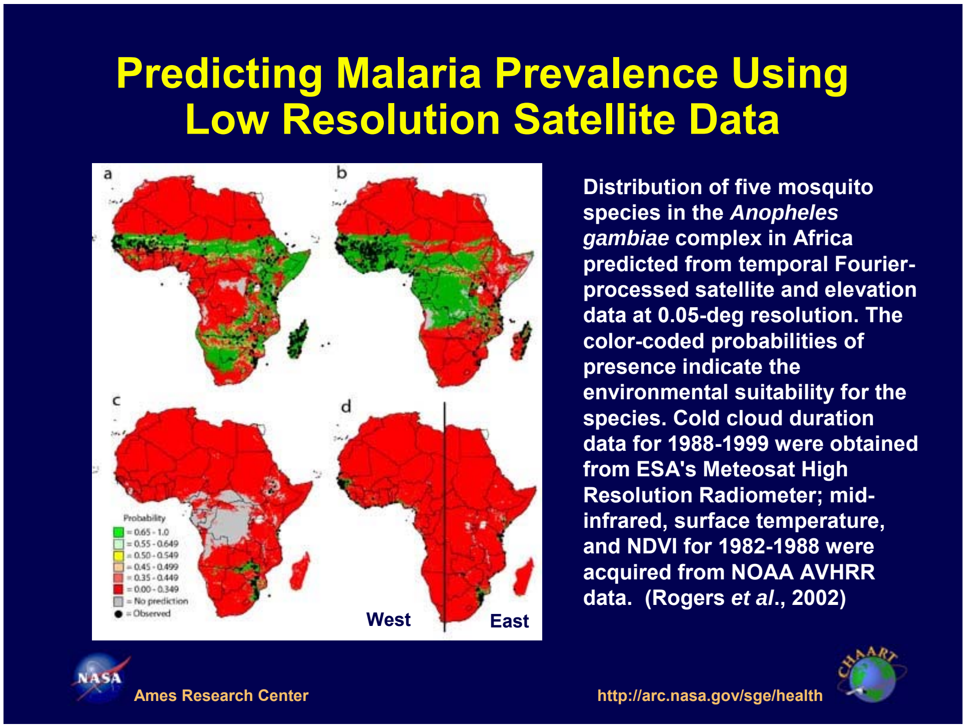
Sea Surface Height
Anomaly
TOPEX/Poseidon

Chlorophyll
Concentration
SeaWiFS

AVHRR VIS / IR image of the Bay of Bengal showing sediment outflow from the Ganges River

Ames Research Center

http://arc.nasa.gov/sge/health

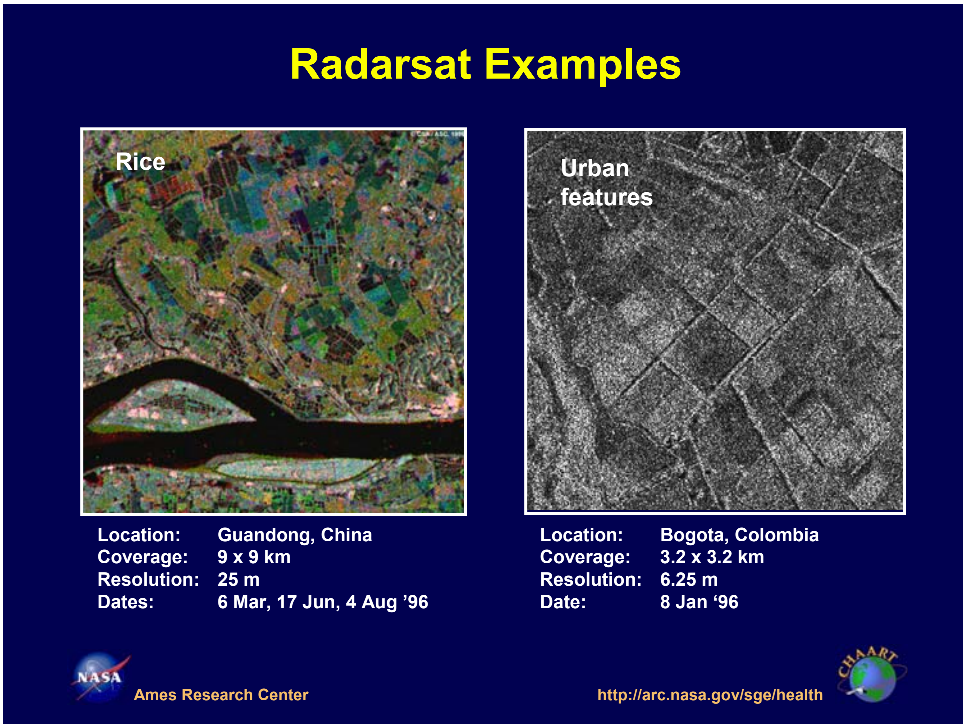


Predicting Malaria Prevalence Using Low Resolution Satellite Data

Distribution of five mosquito species in the *Anopheles gambiae* complex in Africa predicted from temporal Fourier-processed satellite and elevation data at 0.05-deg resolution. The color-coded probabilities of presence indicate the environmental suitability for the species. Cold cloud duration data for 1988-1999 were obtained from ESA's Meteosat High Resolution Radiometer; mid-infrared, surface temperature, and NDVI for 1982-1988 were acquired from NOAA AVHRR data. (Rogers *et al*., 2002)

Ames Research Center

http://arc.nasa.gov/sge/health



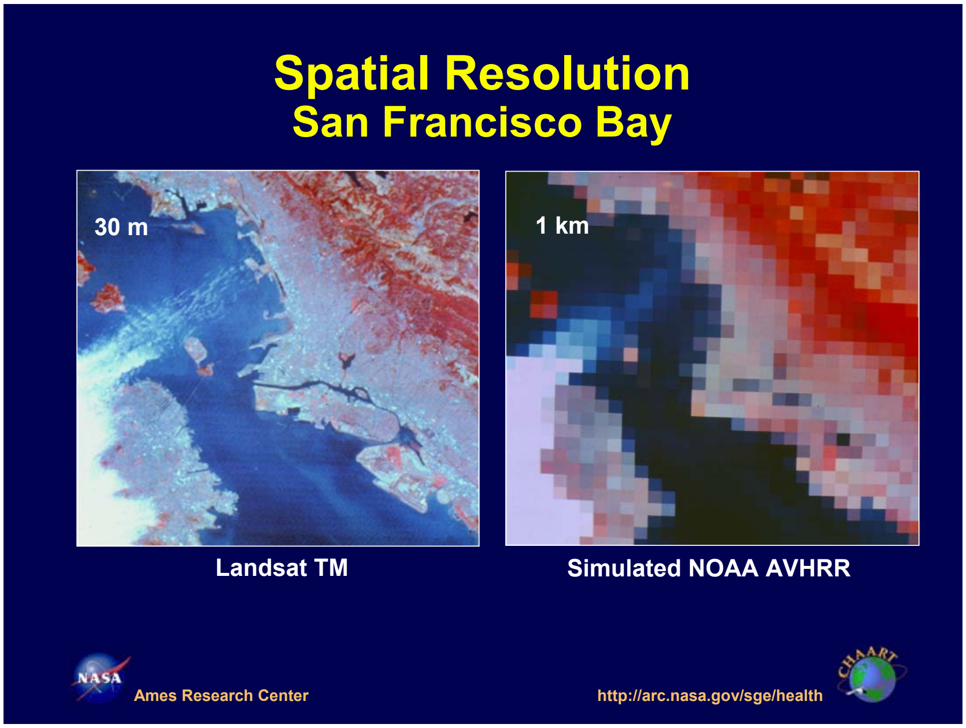
Radarsat Examples

Location:	Guandong, China
Coverage:	9 x 9 km
Resolution:	25 m
Dates:	6 Mar, 17 Jun, 4 Aug ’96

Location:	Bogota, Colombia
Coverage:	3.2 x 3.2 km
Resolution:	6.25 m
Date:	8 Jan ‘96

Ames Research Center

http://arc.nasa.gov/sge/health



Spatial Resolution
San Francisco Bay

Landsat TM

Simulated NOAA AVHRR

Ames Research Center

http://arc.nasa.gov/sge/health

Ikonos 1-m Data of San Francisco

Pixel Sizes

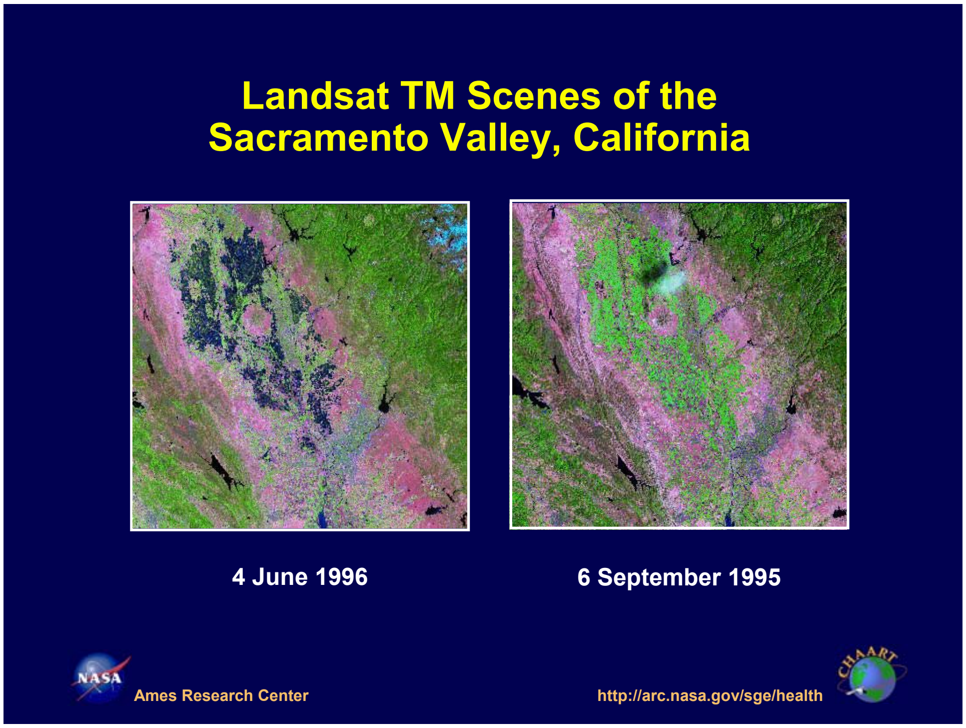
	Panchromatic	Multispectral
Commercial	1-3 m	4-15 m
ASTER		15-20 m
IRS	6 m	23 m
SPOT	10 m	20 m
Landsat ETM+	15 m	30 m
MODIS		250-1000 m
AVHRR		1100 m

Temporal Resolution

- Seasonal
- Year-to-year

Ames Research Center

http://arc.nasa.gov/sge/health



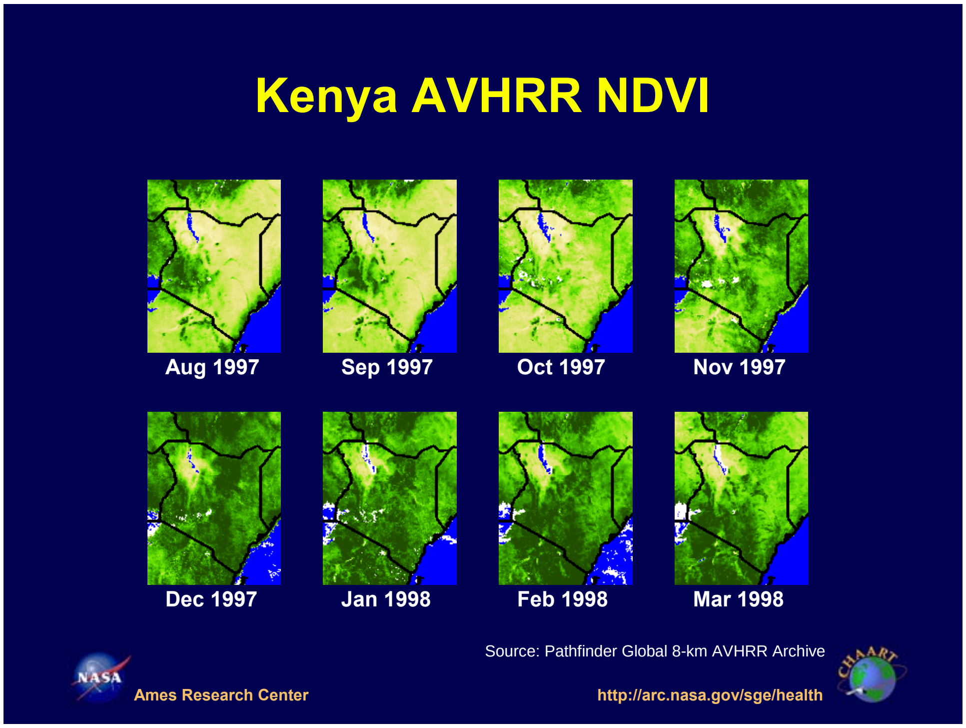
Landsat TM Scenes of the Sacramento Valley, California

4 June 1996

6 September 1995

Ames Research Center

http://arc.nasa.gov/sge/health

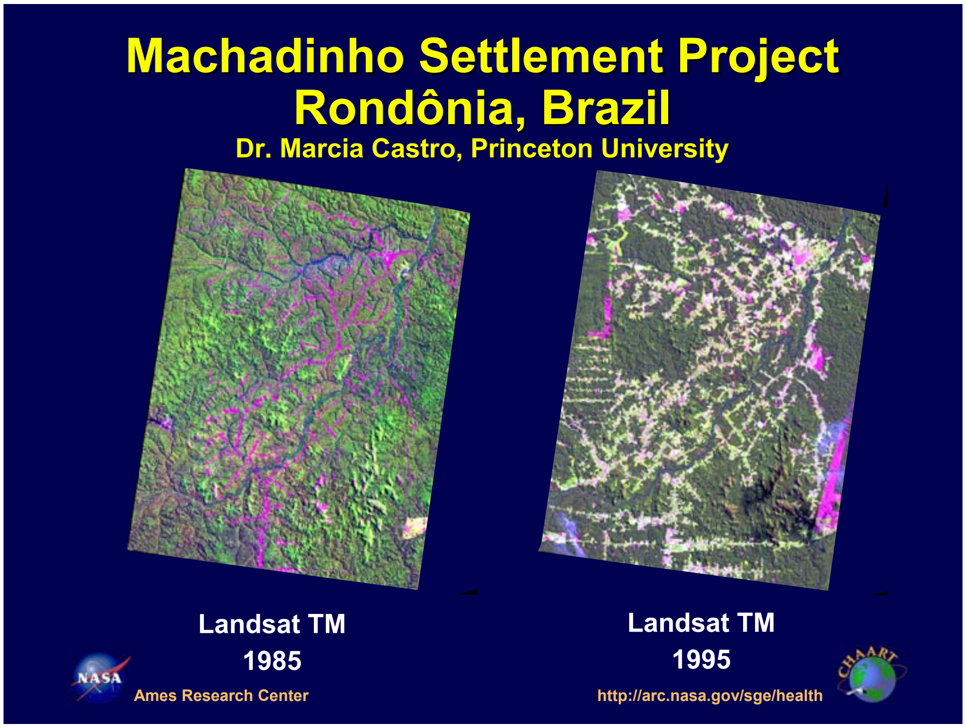


Kenya AVHRR NDVI

Source: Pathfinder Global 8-km AVHRR Archive

Ames Research Center

http://arc.nasa.gov/sge/health



Machadinho Settlement Project Rondônia, Brazil

Dr. Marcia Castro, Princeton University

Ames Research Center

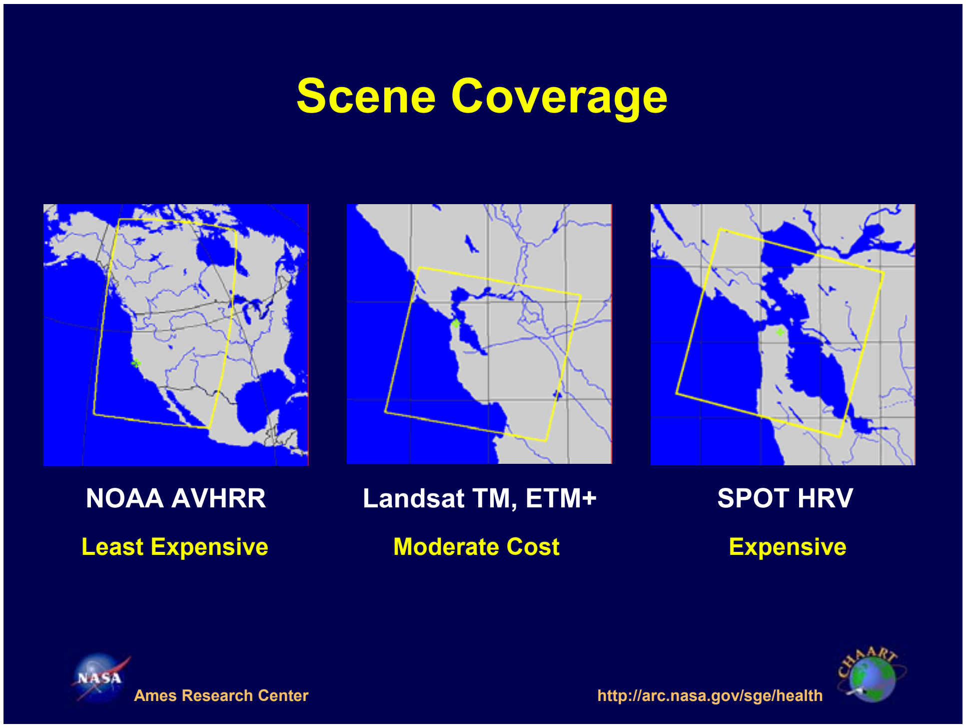
http://arc.nasa.gov/sge/health

Repeat Coverage

AVHRR	0.5 day
MODIS	2 days
Commercial	2-11 days
SPOT	3 days
ASTER; ETM+	16 days
IRS LISS III	24 days

Ames Research Center

http://arc.nasa.gov/sge/health



Scene Coverage

NOAA AVHRR	Landsat TM, ETM+	SPOT HRV
Least Expensive	Moderate Cost	Expensive

Ames Research Center

http://arc.nasa.gov/sge/health

Environmental Parameters
Vector-Borne Diseases

Rainfall	Formation of breeding sites
Temperature	Survival of pathogens, vectors, hosts/reservoirs
Soil type	Survival of ticks, helminths, mosquitoes
Elevation/Topography	Vector distribution
Human activities	Creation of new habitats; contact risk
Water bodies	Mosquitoes, snails
Vegetation	Resting sites; food sources; vector habitat characteristics

All parameters can be sensed remotely and modeled spatially

Ames Research Center http://arc.nasa.gov/sge/health

Panchromatic: Local Scale

Very high spatial resolution B&W imagery, with limited geographic coverage; expensive

Parameter	Link	Disease
House type	Socio-economic status	Chagas', Leishmaniasis
Containers	Breeding sites	Dengue, Malaria, Filariasis
Ditches, canals	Vector/reservoir/host habitat	Malaria, RVF, Schisto
Roads, paths	Human settlement patterns	Malaria, Schisto
Gen'l land use	Bloodmeals, resting sites	Vector-, Tick-borne diseases

ALOS AVNIR-2; OrbView-3; QuickBird-2; SPOT-4, -5; ARIES; IRS-1C,D PAN; Ikonos

Color code: Unlaunched; Operational

Ames Research Center http://arc.nasa.gov/sge/health

Multispectral: Local Scale

High spatial resolution (<20 m) imagery, with limited geographic coverage; expensive

Parameter	Link	Disease
House type	Socio-economic status	Chagas', Leishmaniasis
Containers	Breeding sites	Dengue, Malaria, Filariasis
Ditches, ponds	Vector/reservoir/host habitat	Malaria, RVF, Schisto
Roads	Human settlement patterns	Malaria, Schisto
Vegetation	Bloodmeals, resting sites	VBDs, TBDs

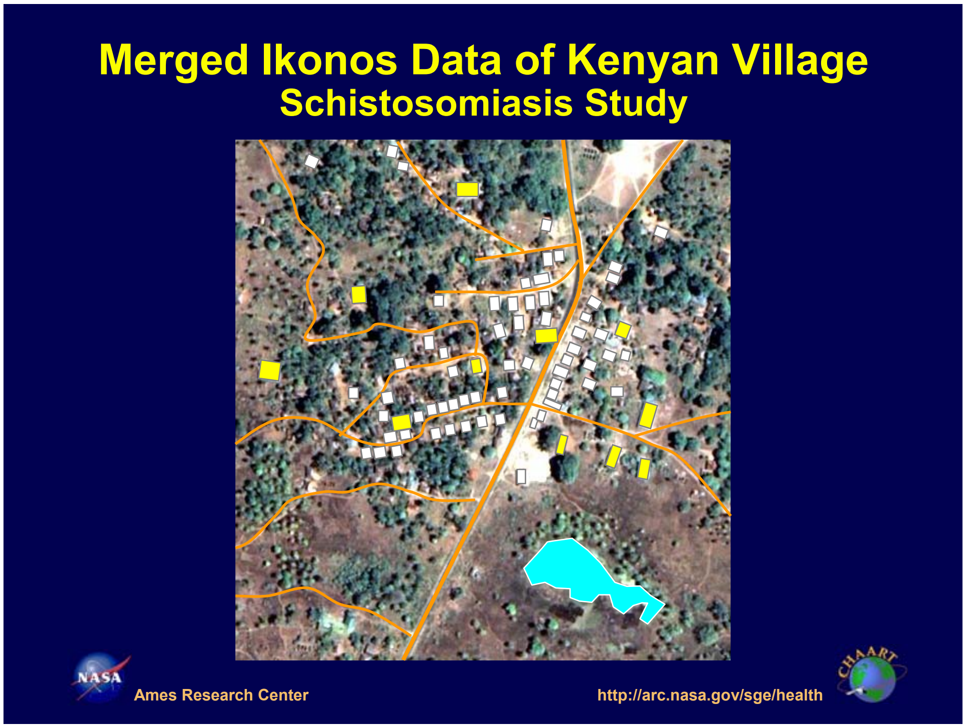
ALOS AVNIR-2; OrbView-3; QuickBird-2; Ikonos

Color code: Unlaunched; Operational

Ikonos Spectral Comparison

Panchromatic

Multispectral

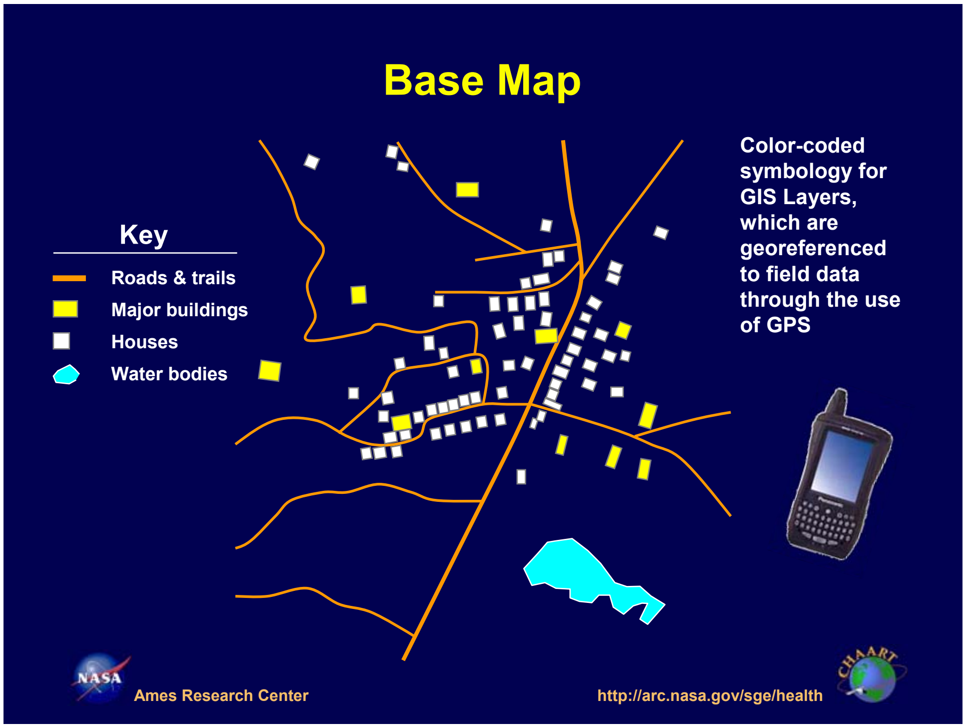


Merged Ikonos Data of Kenyan Village

Schistosomiasis Study

Ames Research Center

http://arc.nasa.gov/sge/health



Base Map

Key

- 🟧 Roads & trails
- 🟨 Major buildings
- ⬜ Houses
- 💧 Water bodies

Color-coded symbology for GIS Layers, which are georeferenced to field data through the use of GPS

Ames Research Center

http://arc.nasa.gov/sge/health

Multispectral: Regional Scale

20-1000 m spatial resolution, with frequent regional coverage; moderate cost (some free!)

Parameter	Link	Disease
Settlements	Human population density	Leishmaniasis, Malaria
Vegetation type	Vector/reservoir/host habitat	Vector-borne diseases
Ecotones	Human-vector contact risk	Lyme disease, YF, Chagas'
Soil type	Vector survival	TBDs
Soil, leaf moisture	Vector survival	TBDs, Schisto, RVF
Chlorophyll	Plankton	Cholera
Water quality	Pollution	Cryptosporidiosis

ALOS AVNIR-2; ARIES; CBERS; Ikonos; IRS-1C, D LISS III; Landsat ETM+; OrbView-3; QuickBird-2; SPOT-4, -5; Terra ASTER, MISR, MODIS

Color code: Unlaunched; Operational

Multispectral: Global Scale

Greater than 1-km spatial resolution, with very frequent, regional-to-global coverage; moderate to low cost

Parameter	Link	Disease
Gen'l veg. pattern	Habitat opportunities	VBDs (e.g., Tryps)
Veg. green-up	Habitat opportunities	VBDs (Hanta, RVF, WNV)
Water properties	Sediments, pollution	Cholera
Surface temps	Wet soils, p/v/r/h survival	Schisto, TBDs, WNV
Ocean temps	Plankton blooms, climate	Cholera, RVF
Ocean color	Plankton mats	Cholera

ENVISAT MERIS; Meteosat; NOAA AVHRR; OrbView-2 SeaWiFS; SPOT Vegetation

Radar: Local-to-Regional Scales

Day-night, all-weather active sensor with high spatial resolution and moderate geographic coverage; processing requires more expertise

Parameter	Link	Disease
Water, flooding	Larval habitat	Mosquito-borne diseases
Wet soils	Snail, larval habitat	Schistosomiasis, Filariasis
Precipitation	Larval habitat formation	VBDs (e.g., Malaria, RVF)
Forest structure	Deforestation	VBDs (e.g., Malaria, YF)
Surface structure	Topography (aspect)	TBDs, Oncho
Land cover	Habitat opportunities	Vector-borne diseases
Human settlements	Human pop'n density	Vector-borne diseases

ALOS VSAR; Aqua AMSR; ENVISAT ASAR; ERS-2 AMI-SAR; Radarsat-1, -2; TRMM PR

Color code: Unlaunched; Operational

WNV Studies using RS Data

- **NOAA AVHRR → land surface temperature (Rogers *et al.*, 2002)**
- **Landsat ETM+ → vegetation greenness (Brownstein *et al.*, 2003)**
- **NOAA AVHRR → vegetation greenness (Peterson *et al.*, in press)**

Selected Missions

- **Aqua** – moderate resolution global land cover characterization (AMSR, AMSU, MODIS)
- **Terra** – global land data (MISR, MODIS, ASTER)
- **Landsat-7** – multispectral, moderate resolution earth images (ETM+)
- **EO-1** – land cover, land cover change (ALI, Hyperion)
- **TRMM** – tropical rainfall mapping
- NOAA-L, M – global atmospheric/surface data (AVHRR)
- **SRTM** – elevation mapping at 30-m resolution

AMSR

Advanced Microwave Scanning Radiometer

AMSR is a passive microwave radiometer. It observes atmospheric, land, oceanic, and cryospheric parameters, including precipitation, sea surface temperatures, surface wetness, wind speed, atmospheric cloud water, and water vapor; onboard Aqua.

AMSR-E uses low-frequency (6.9 GHz) microwave observations to monitor surface wetness in low vegetation conditions.

ATTRIBUTES:

- Instrument: Passive microwave radiometer
- Bands: 6 (AMSR-E) and 8 (AMSR) from 6-89 GHz
- Spatial Resolution: from ~5 km at 89 GHz to ~50 km at 6 GHz
- Swath: 1445 km (AMSR-E), 1600 km (AMSR)
- Repeat Time: 4 days

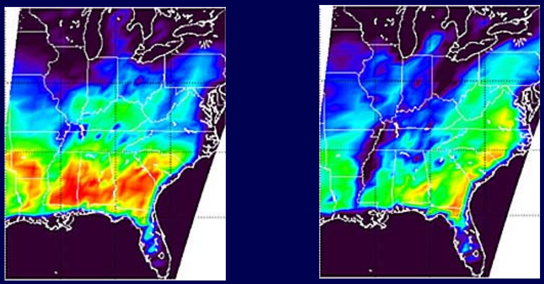
Advanced Microwave Sounding Unit

The Advanced Microwave Sounding Unit (AMSU-A), is a 15-channel microwave sounder designed primarily to obtain temperature profiles in the upper atmosphere (especially the stratosphere) and to provide a cloud-filtering capability for tropospheric temperature observations. The first AMSU was launched in May 1998 onboard NOAA-15. Onboard Aqua.

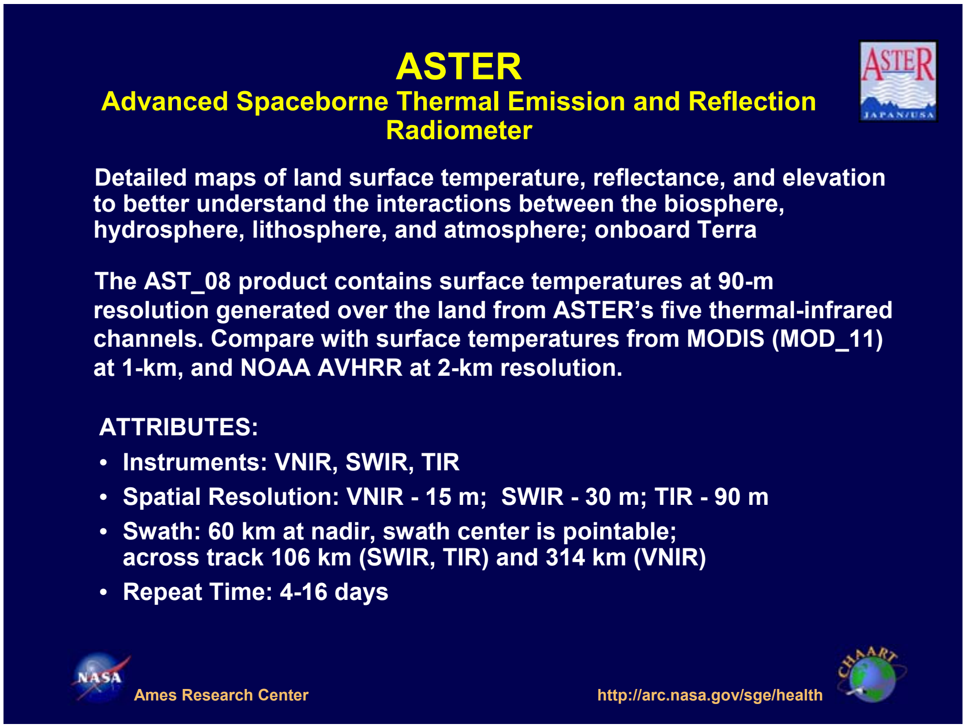
ATTRIBUTES:

- Instrument: Passive multi-channel microwave radiometer
- Bands: 15 channels with frequency range 15-90 GHz
- Vertical coverage: Measurements from surface to 40km
- Spatial Resolution: 40 km horizontal at nadir
- Swath: 1650 km
- Repeat Time: 4 days

AMSU Example



AMSU measures surface emissivities in the microwave region as well as atmospheric emissivities; these, in turn, are used to calculate temperatures. An illustration of end products from this sensor is given by these observations of the eastern half of the U.S. before and after passage of Hurricane Isidore in late September of 2000. The left image was obtained on 12 September; the right on the 28th, one day after the hurricane made landfall. (source: http://rst.gsfc.nasa.gov)



ASTER

Advanced Spaceborne Thermal Emission and Reflection Radiometer

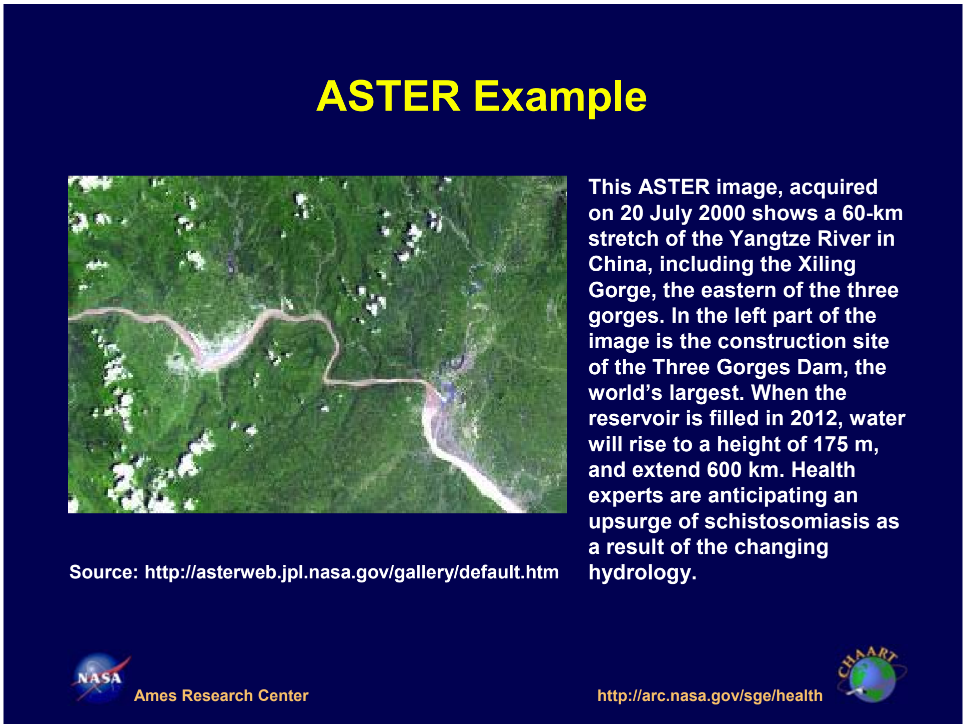
Detailed maps of land surface temperature, reflectance, and elevation to better understand the interactions between the biosphere, hydrosphere, lithosphere, and atmosphere; onboard Terra

The AST_08 product contains surface temperatures at 90-m resolution generated over the land from ASTER's five thermal-infrared channels. Compare with surface temperatures from MODIS (MOD_11) at 1-km, and NOAA AVHRR at 2-km resolution.

ATTRIBUTES:

- Instruments: VNIR, SWIR, TIR
- Spatial Resolution: VNIR - 15 m; SWIR - 30 m; TIR - 90 m
- Swath: 60 km at nadir, swath center is pointable; across track 106 km (SWIR, TIR) and 314 km (VNIR)
- Repeat Time: 4-16 days

Ames Research Center http://arc.nasa.gov/sge/health

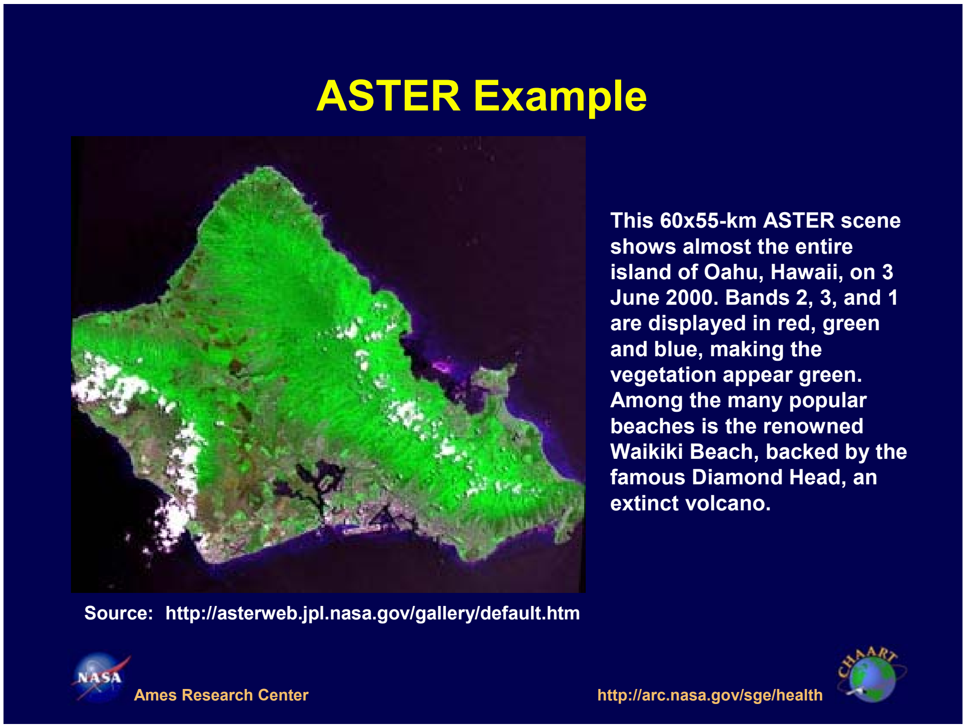


ASTER Example

This ASTER image, acquired on 20 July 2000 shows a 60-km stretch of the Yangtze River in China, including the Xiling Gorge, the eastern of the three gorges. In the left part of the image is the construction site of the Three Gorges Dam, the world's largest. When the reservoir is filled in 2012, water will rise to a height of 175 m, and extend 600 km. Health experts are anticipating an upsurge of schistosomiasis as a result of the changing hydrology.

Source: http://asterweb.jpl.nasa.gov/gallery/default.htm

Ames Research Center http://arc.nasa.gov/sge/health



ASTER Example

This 60x55-km ASTER scene shows almost the entire island of Oahu, Hawaii, on 3 June 2000. Bands 2, 3, and 1 are displayed in red, green and blue, making the vegetation appear green. Among the many popular beaches is the renowned Waikiki Beach, backed by the famous Diamond Head, an extinct volcano.

Source: http://asterweb.jpl.nasa.gov/gallery/default.htm

Ames Research Center http://arc.nasa.gov/sge/health

MODIS

Moderate Resolution Imaging Spectroradiometer

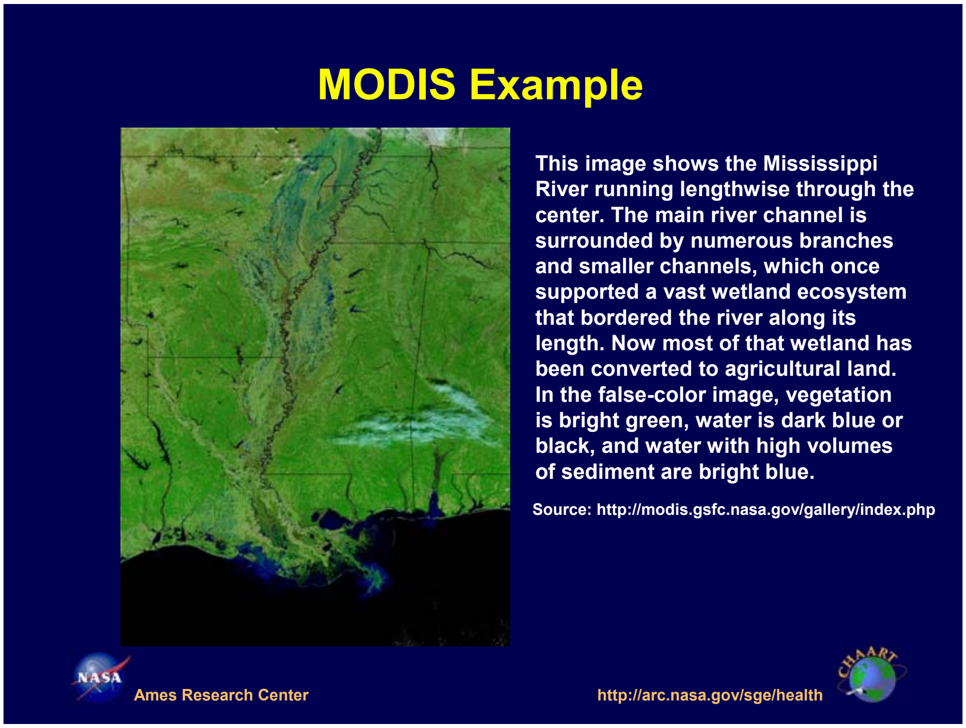
Simultaneous measurements in 36 spectral bands for observations of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere; onboard Terra and Aqua.

The MOD_11 data product provides surface temperatures at 1-km resolution; MOD_13 provides daily NDVI at 250- and 500-m resolutions, as well as a Modified Vegetation Index (MVI).

ATTRIBUTES:

- Instrument: Imaging radiometer
- Bands: 36 from 0.4 to 14.5 µm
- Spatial Resolution: 250 m, 500 m, and 1 km
- Swath: 2330 km (across track) x 10 km (along track at nadir)
- Repeat Time: Global coverage in 1-2 days

Ames Research Center http://arc.nasa.gov/sge/health



MODIS Example

This image shows the Mississippi River running lengthwise through the center. The main river channel is surrounded by numerous branches and smaller channels, which once supported a vast wetland ecosystem that bordered the river along its length. Now most of that wetland has been converted to agricultural land. In the false-color image, vegetation is bright green, water is dark blue or black, and water with high volumes of sediment are bright blue.

Source: http://modis.gsfc.nasa.gov/gallery/index.php

Hyperion
Hyperspectral Imager

The Hyperion instrument provides a new class of Earth observation data for improved Earth surface characterization. The Hyperion capabilities provide resolution of surface properties into hundreds of spectral bands versus the 7 multispectral bands flown on traditional Landsat imaging missions. Through these large number of spectral bands, complex land eco-systems can be imaged and more accurately quantified.

ATTRIBUTES:

- Instrument: Imaging multispectral radiometer
- Bands: 220 from 0.4 to 2.5 µm
- Spatial Resolution: 30 m
- Swath: 7.5 km
- Repeat Time: 16 days

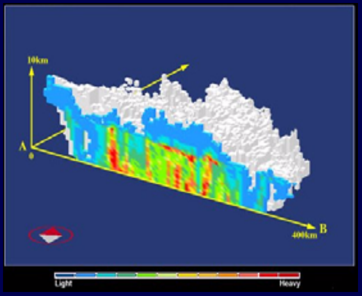
Hyperion Example
Alaska

Image Date: 24 November ’00
VE Record ID: 6932
Source: http://visibleearth.nasa.gov

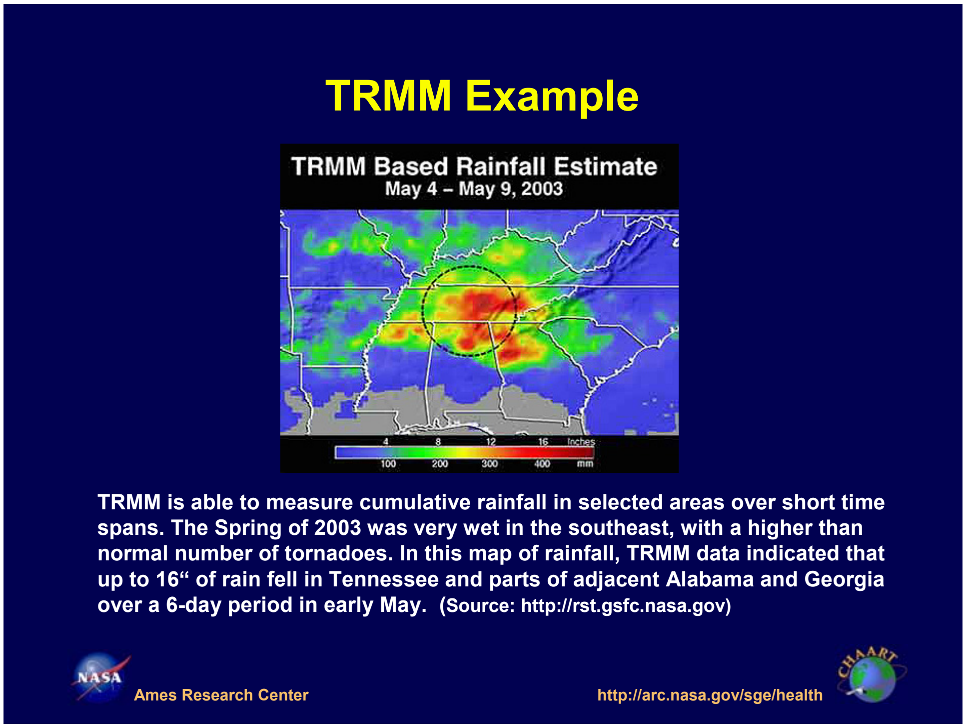
PR
Precipitation Radar

3-D rainfall distribution over land and oceans; onboard TRMM

ATTRIBUTES:
- Instrument: L-band radar
- Channels: 13.796 and 13.802 GHz
- Horizontal Resolution (nadir): 4.3 km
- Vertical Resolution (nadir): 0.25 km
- Vertical Coverage: Surface to 15 km
- Swath: 220 km



PR Rainfall Cross Section



TRMM Example

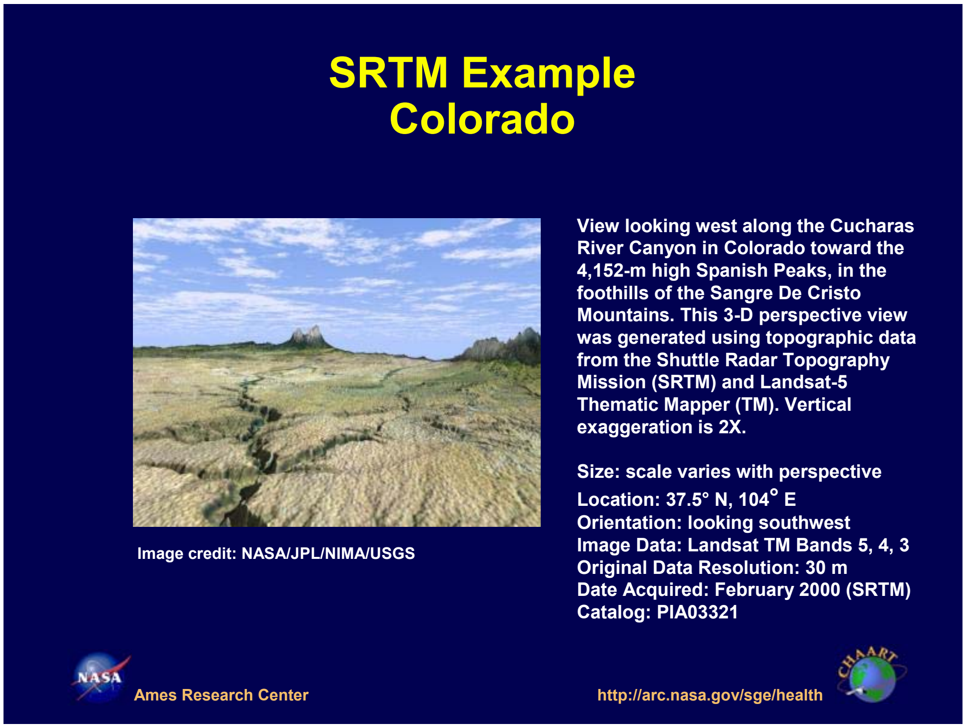
TRMM is able to measure cumulative rainfall in selected areas over short time spans. The Spring of 2003 was very wet in the southeast, with a higher than normal number of tornadoes. In this map of rainfall, TRMM data indicated that up to 16“ of rain fell in Tennessee and parts of adjacent Alabama and Georgia over a 6-day period in early May. (Source: http://rst.gsfc.nasa.gov)

SRTM
Shuttle Radar Topography Mission

The objective of the Shuttle Radar Topography Mission was to obtain elevation radar data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. During the mission, a specially modified radar system flew onboard Space Shuttle Endeavour for 11 days in February 2000. This radar system gathered data that will result in the most accurate and complete topographic map of Earth's surface that has ever been assembled.

ATTRIBUTES:

- Instrument: SIR-C/X-SAR multifrequency, multipolarization imaging radar system
- Wavelength: 5.6 cm
- Spatial Resolution: 30 m
- Swath: 225 km



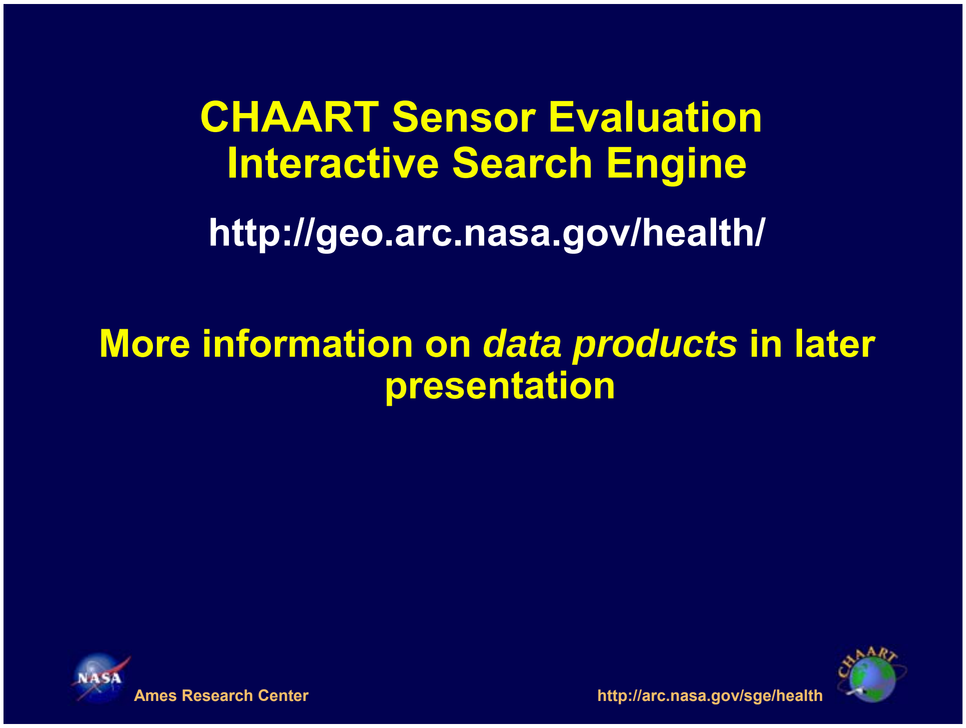
SRTM Example
Colorado

View looking west along the Cucharas River Canyon in Colorado toward the 4,152-m high Spanish Peaks, in the foothills of the Sangre De Cristo Mountains. This 3-D perspective view was generated using topographic data from the Shuttle Radar Topography Mission (SRTM) and Landsat-5 Thematic Mapper (TM). Vertical exaggeration is 2X.

Size: scale varies with perspective
Location: 37.5° N, 104° E
Orientation: looking southwest
Image Data: Landsat TM Bands 5, 4, 3
Original Data Resolution: 30 m
Date Acquired: February 2000 (SRTM)
Catalog: PIA03321

Image credit: NASA/JPL/NIMA/USGS

Ames Research Center http://arc.nasa.gov/sge/health

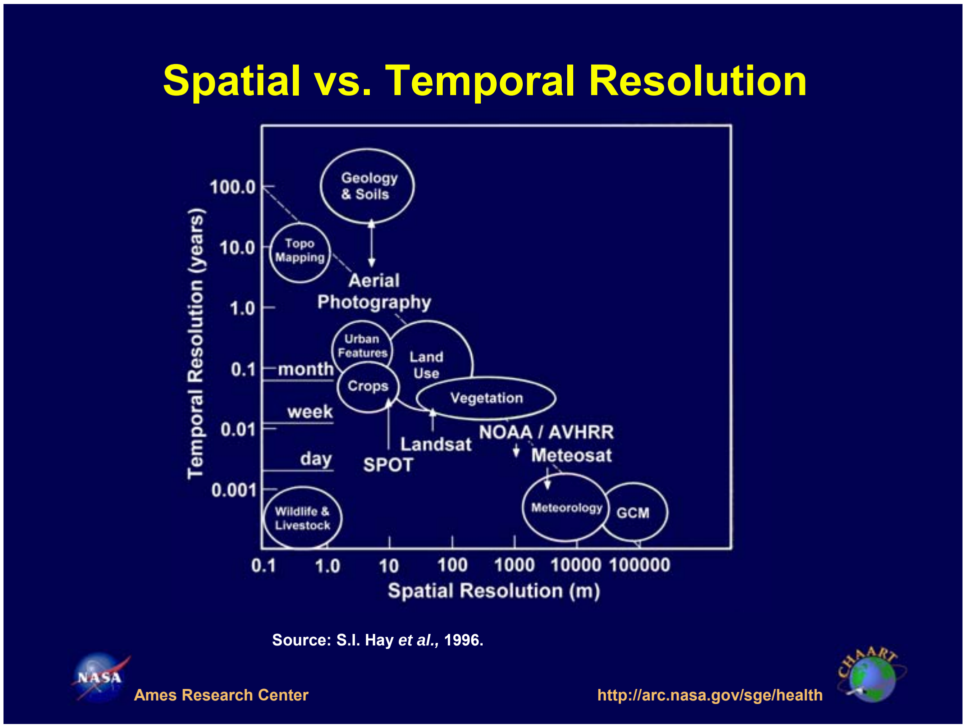


CHAART Sensor Evaluation Interactive Search Engine

http://geo.arc.nasa.gov/health/

More information on *data products* in later presentation

Ames Research Center http://arc.nasa.gov/sge/health

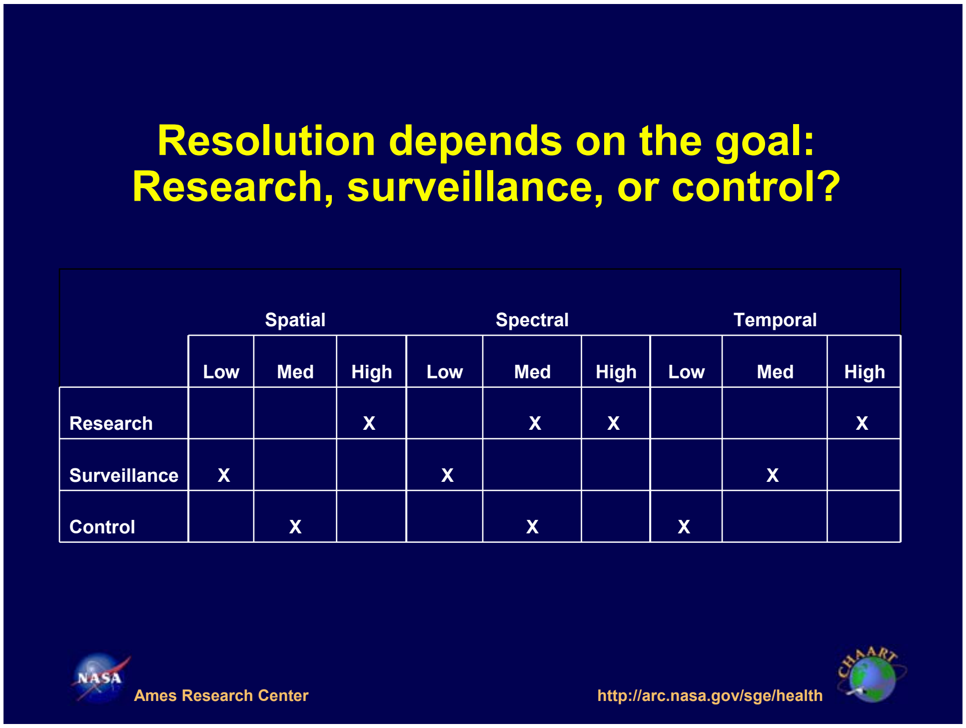


Spatial vs. Temporal Resolution

Source: S.I. Hay *et al.*, 1996.

Ames Research Center

http://arc.nasa.gov/sge/health

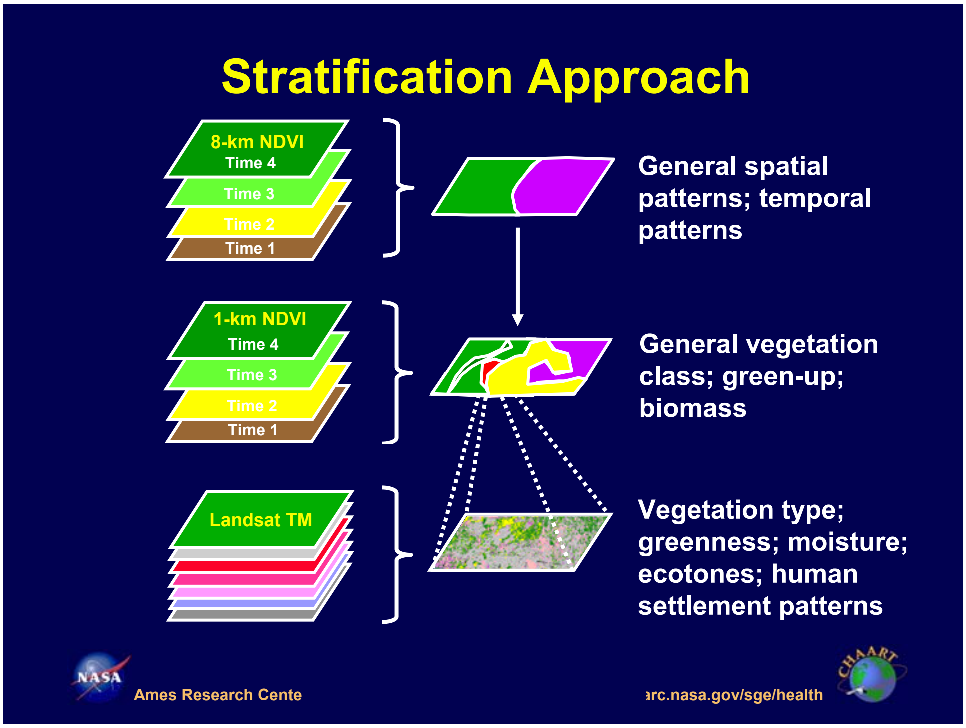


Resolution depends on the goal: Research, surveillance, or control?

	Spatial			Spectral			Temporal		
	Low	Med	High	Low	Med	High	Low	Med	High
Research			X		X	X			X
Surveillance	X			X				X	
Control		X			X		X		

Ames Research Center

http://arc.nasa.gov/sge/health



Stratification Approach

8-km NDVI
Time 4
Time 3
Time 2
Time 1

General spatial patterns; temporal patterns

1-km NDVI
Time 4
Time 3
Time 2
Time 1

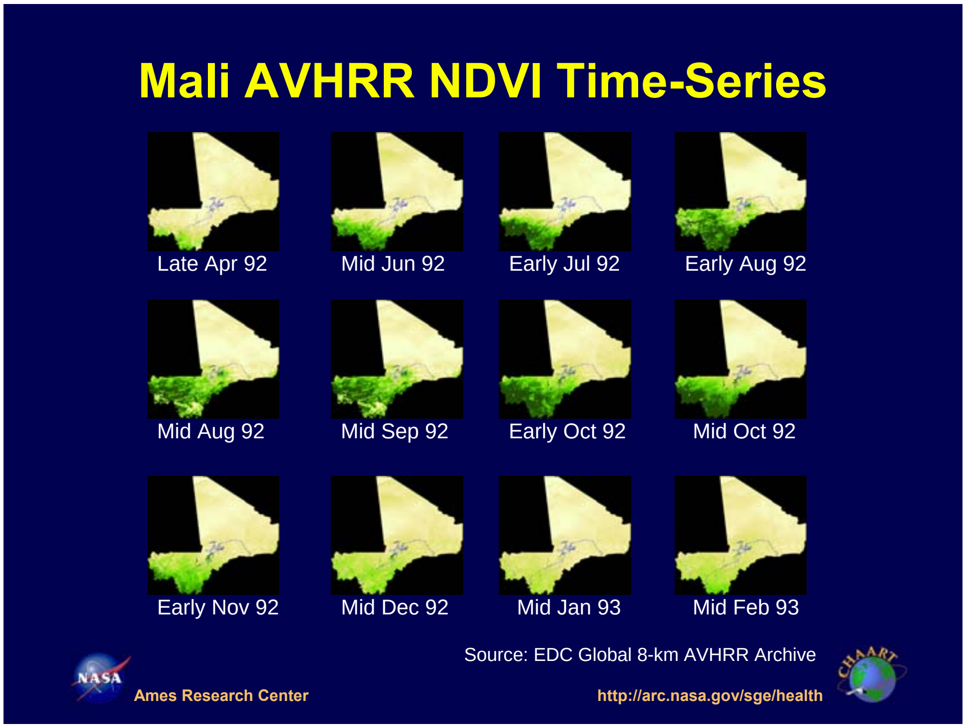
General vegetation class; green-up; biomass

Landsat TM

Vegetation type; greenness; moisture; ecotones; human settlement patterns

Ames Research Cente

arc.nasa.gov/sge/health



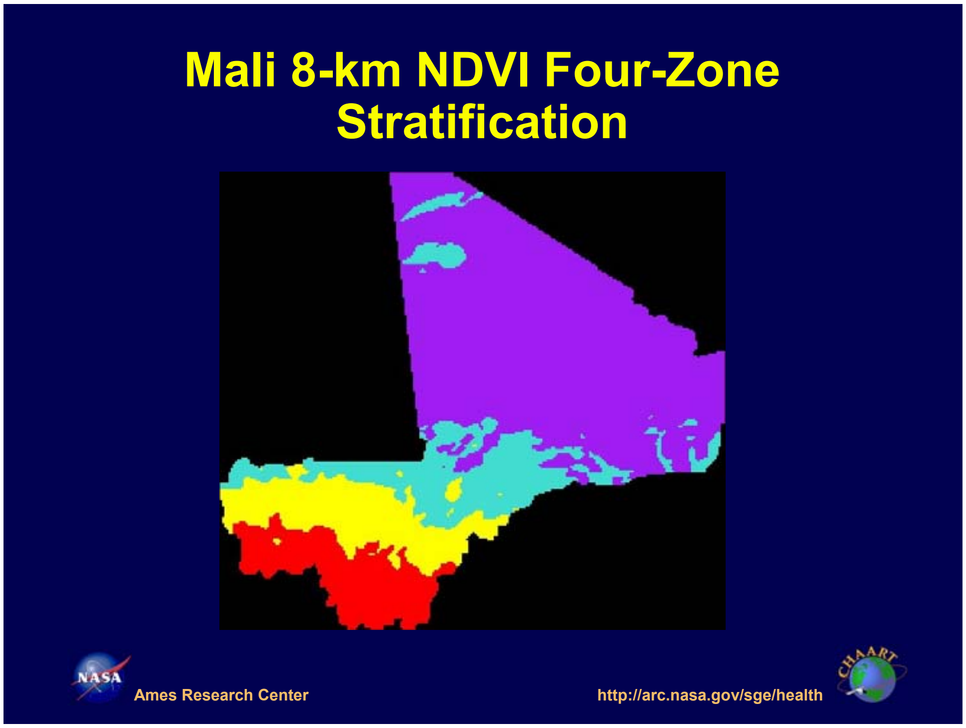
Mali AVHRR NDVI Time-Series

Late Apr 92	Mid Jun 92	Early Jul 92	Early Aug 92
Mid Aug 92	Mid Sep 92	Early Oct 92	Mid Oct 92
Early Nov 92	Mid Dec 92	Mid Jan 93	Mid Feb 93

Source: EDC Global 8-km AVHRR Archive

Ames Research Center

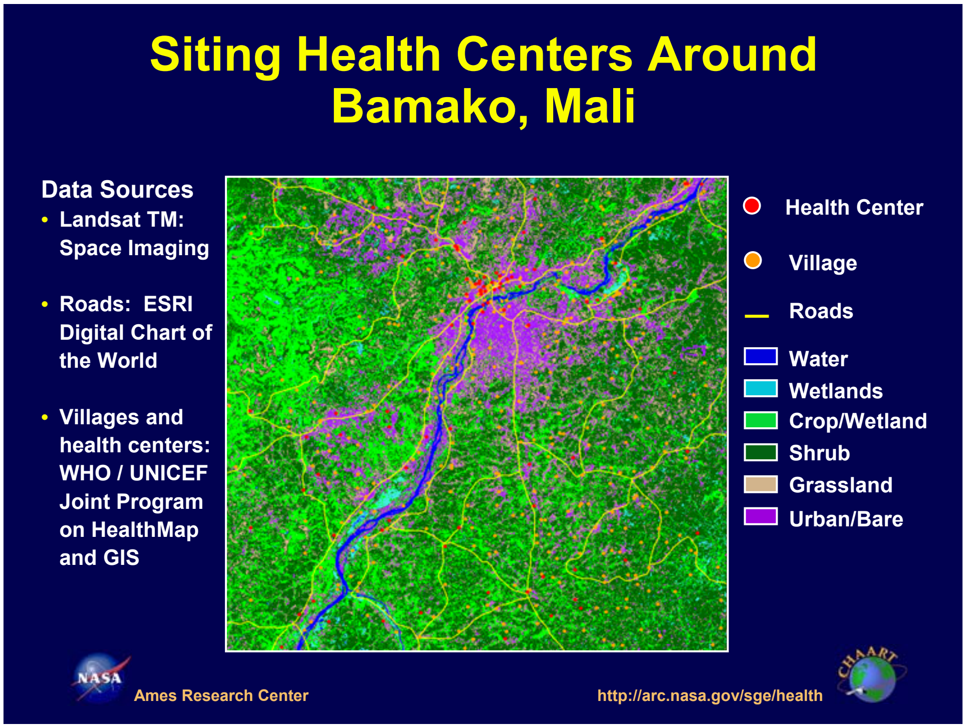
http://arc.nasa.gov/sge/health



Mali 8-km NDVI Four-Zone Stratification

Ames Research Center

http://arc.nasa.gov/sge/health



Siting Health Centers Around Bamako, Mali

Data Sources

- Landsat TM: Space Imaging
- Roads: ESRI Digital Chart of the World
- Villages and health centers: WHO / UNICEF Joint Program on HealthMap and GIS

● Health Center

● Village

— Roads

🟦 Water

🟦 Wetlands

🟩 Crop/Wetland

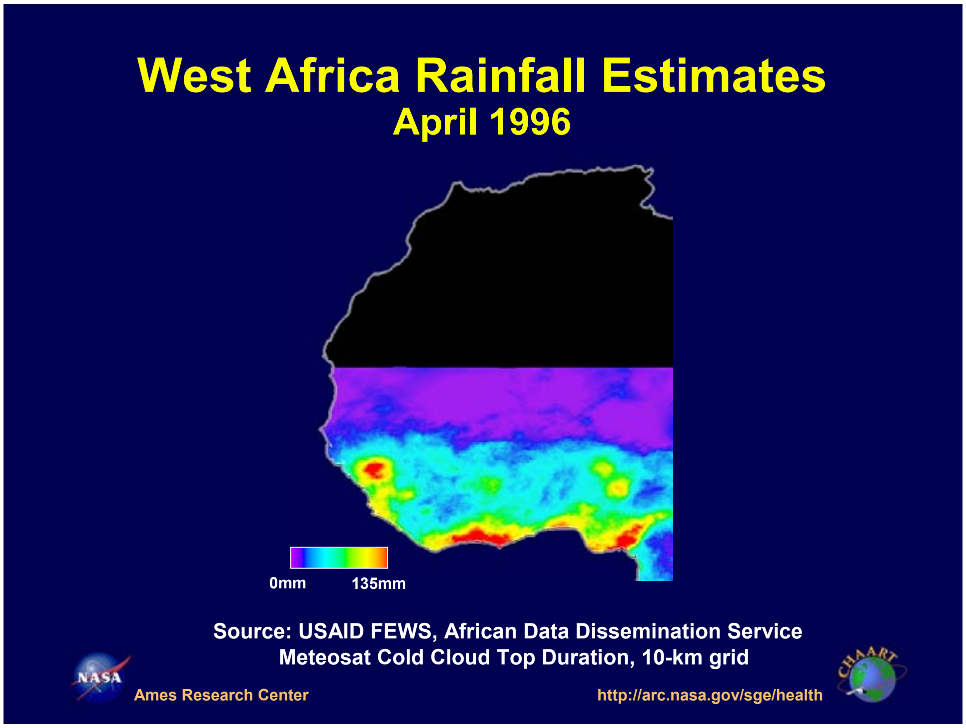
🟩 Shrub

🟫 Grassland

🟪 Urban/Bare

Ames Research Center

http://arc.nasa.gov/sge/health



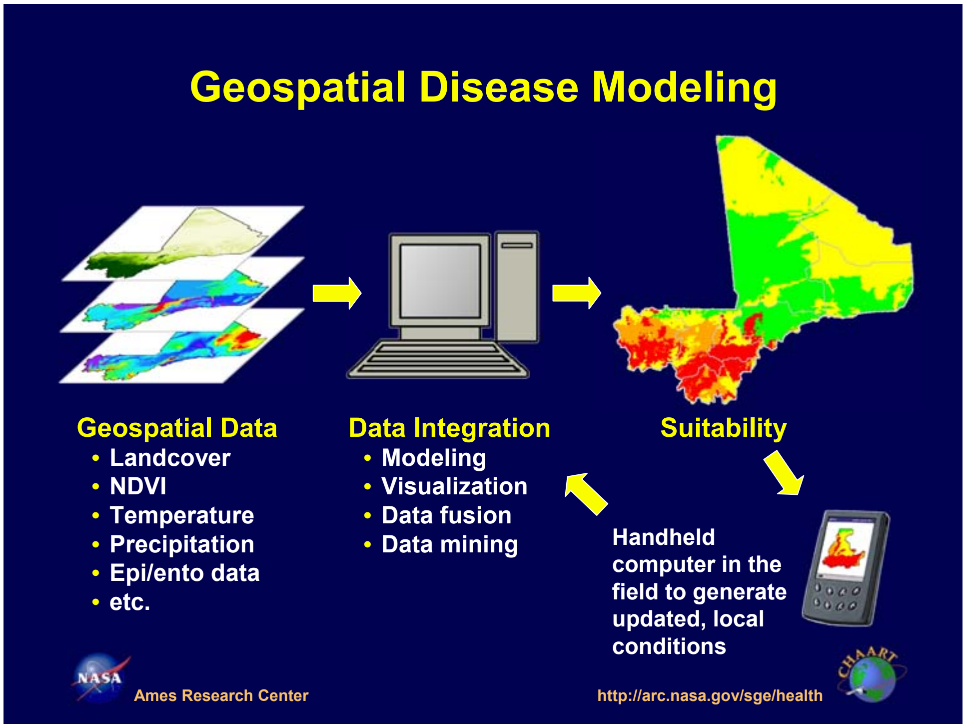
West Africa Rainfall Estimates

April 1996

Source: USAID FEWS, African Data Dissemination Service
Meteosat Cold Cloud Top Duration, 10-km grid

Ames Research Center

http://arc.nasa.gov/sge/health



Geospatial Disease Modeling

Geospatial Data
- Landcover
- NDVI
- Temperature
- Precipitation
- Epi/ento data
- etc.

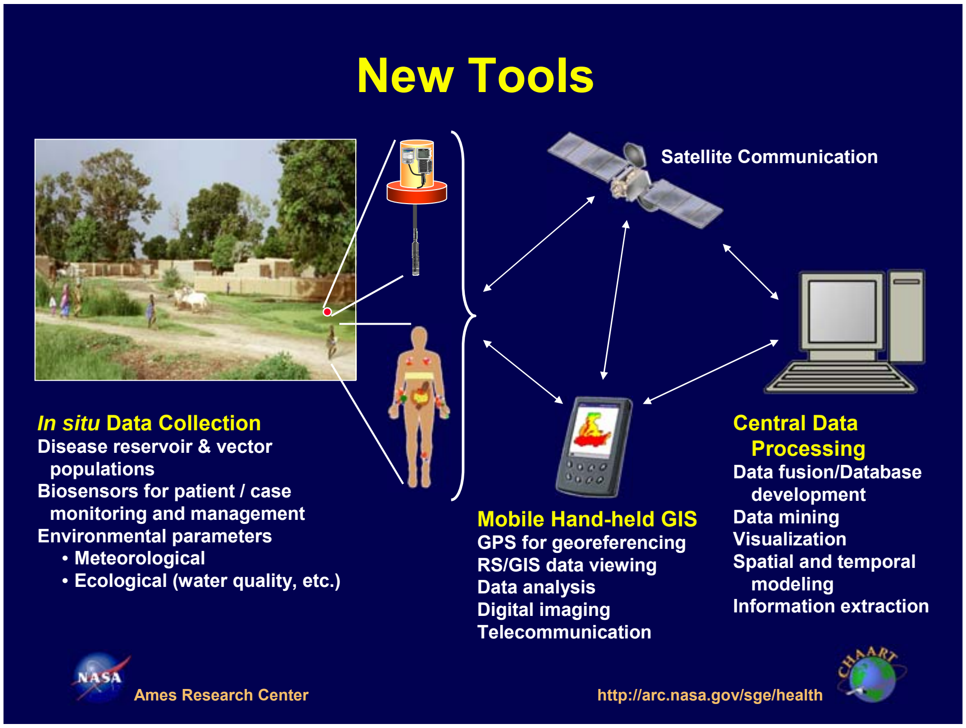
Data Integration
- Modeling
- Visualization
- Data fusion
- Data mining

Suitability

Handheld computer in the field to generate updated, local conditions

Ames Research Center

http://arc.nasa.gov/sge/health

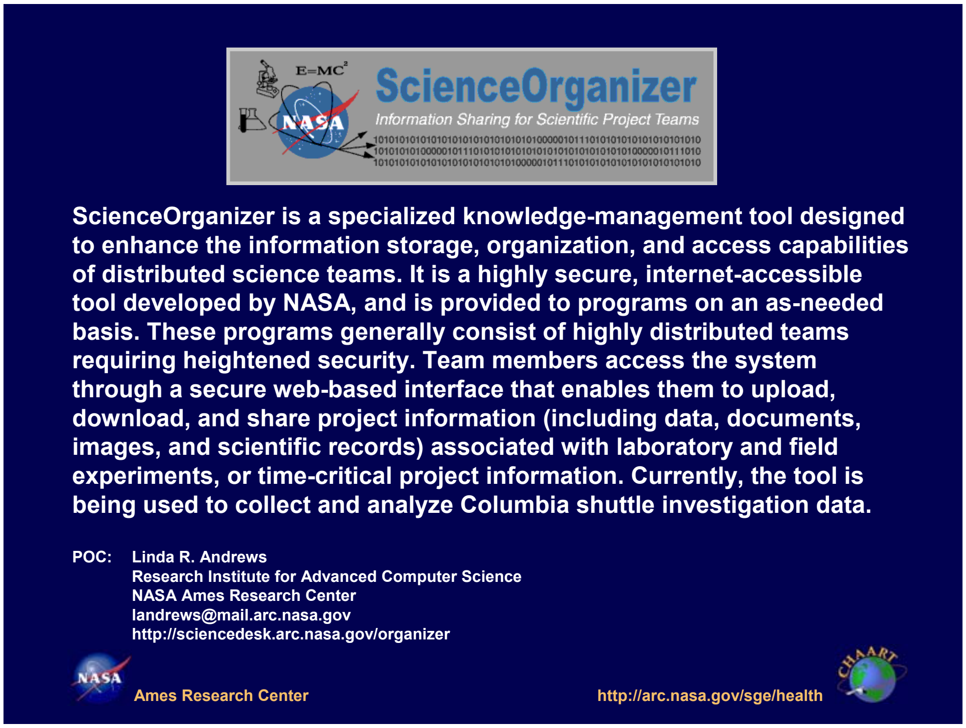


New Tools

In situ Data Collection
Disease reservoir & vector populations
Biosensors for patient / case monitoring and management
Environmental parameters
- Meteorological
- Ecological (water quality, etc.)

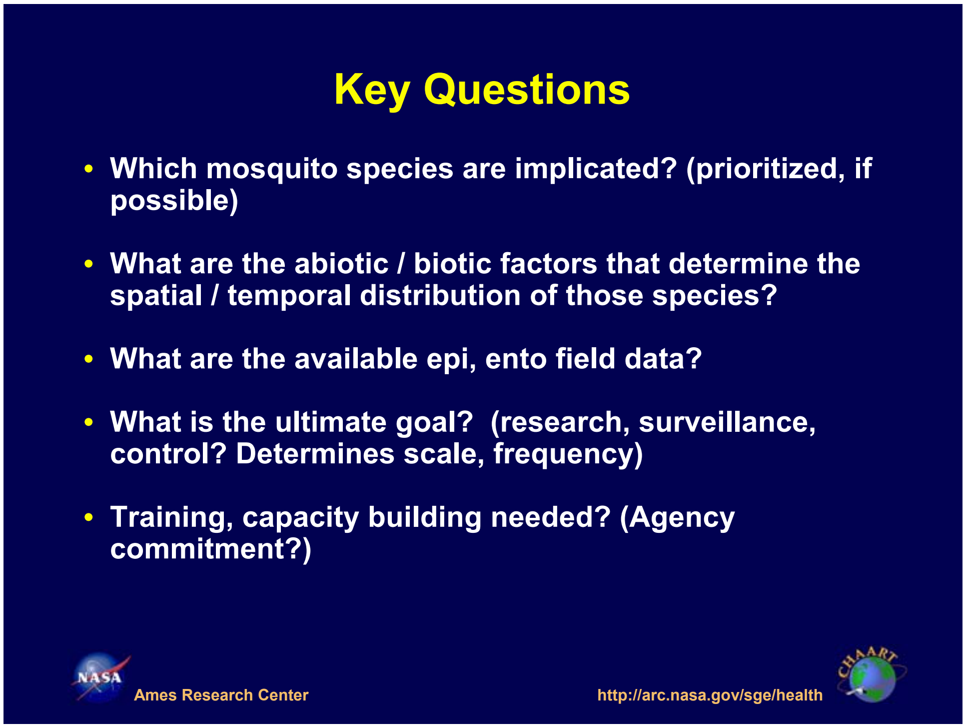
Mobile Hand-held GIS
GPS for georeferencing
RS/GIS data viewing
Data analysis
Digital imaging
Telecommunication

Central Data Processing
Data fusion/Database development
Data mining
Visualization
Spatial and temporal modeling
Information extraction



ScienceOrganizer is a specialized knowledge-management tool designed to enhance the information storage, organization, and access capabilities of distributed science teams. It is a highly secure, internet-accessible tool developed by NASA, and is provided to programs on an as-needed basis. These programs generally consist of highly distributed teams requiring heightened security. Team members access the system through a secure web-based interface that enables them to upload, download, and share project information (including data, documents, images, and scientific records) associated with laboratory and field experiments, or time-critical project information. Currently, the tool is being used to collect and analyze Columbia shuttle investigation data.

POC: Linda R. Andrews
Research Institute for Advanced Computer Science
NASA Ames Research Center
landrews@mail.arc.nasa.gov
http://sciencedesk.arc.nasa.gov/organizer



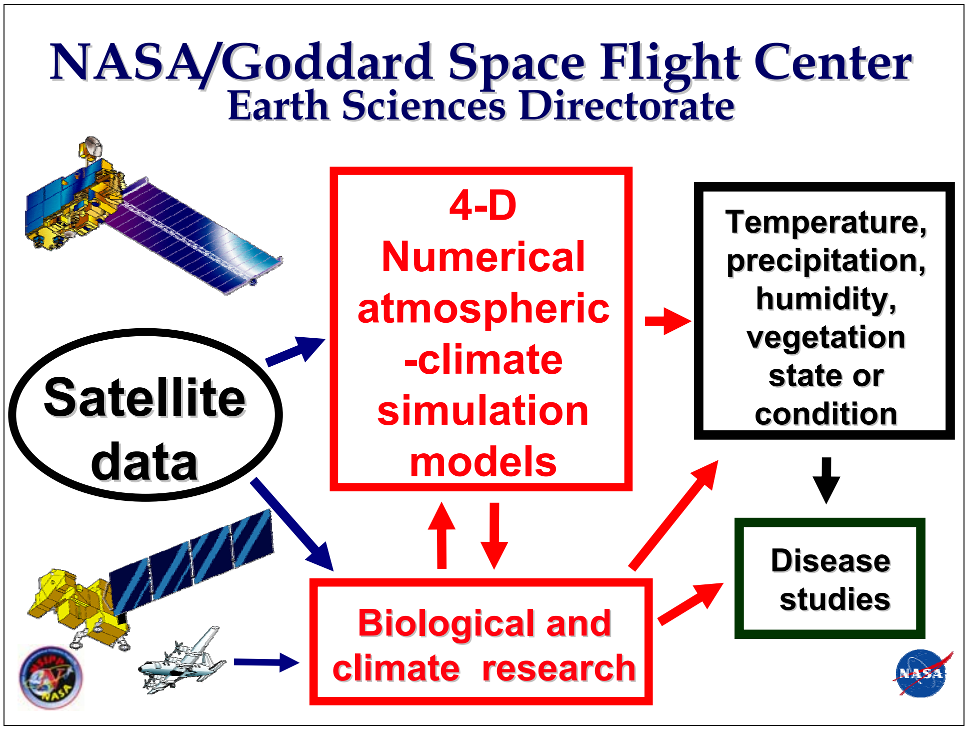
Key Questions

- Which mosquito species are implicated? (prioritized, if possible)
- What are the abiotic / biotic factors that determine the spatial / temporal distribution of those species?
- What are the available epi, ento field data?
- What is the ultimate goal? (research, surveillance, control? Determines scale, frequency)
- Training, capacity building needed? (Agency commitment?)

Ames Research Center

http://arc.nasa.gov/sge/health

Compton Tucker, PhD
“NASA’s Seasonal-to-Interannual Prediction Project (NSIPP)”



NASA/Goddard Space Flight Center
Earth Sciences Directorate

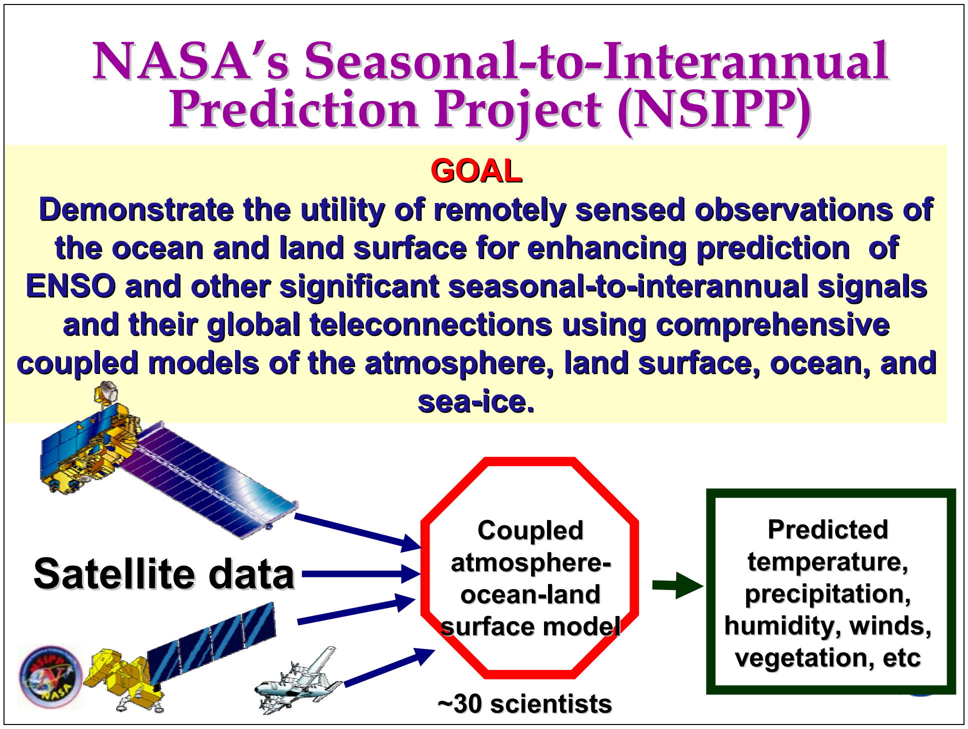
Satellite data

4-D Numerical atmospheric -climate simulation models

Temperature, precipitation, humidity, vegetation state or condition

Biological and climate research

Disease studies



NASA’s Seasonal-to-Interannual Prediction Project (NSIPP)

GOAL

Demonstrate the utility of remotely sensed observations of the ocean and land surface for enhancing prediction of ENSO and other significant seasonal-to-interannual signals and their global teleconnections using comprehensive coupled models of the atmosphere, land surface, ocean, and sea-ice.

Satellite data

Coupled atmosphere-ocean-land surface model

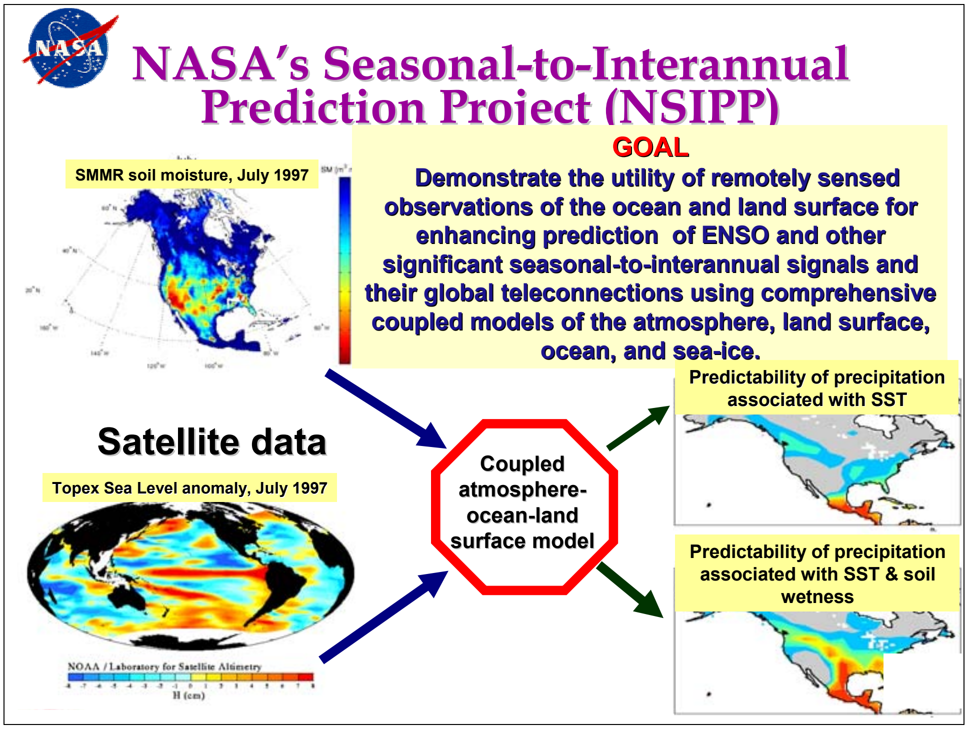
~30 scientists

Predicted temperature, precipitation, humidity, winds, vegetation, etc

Healthy Planet
NASA's Earth Science & Public Health Program
Goddard Space Flight Center

Infectious & Vector-borne Diseases

Measured Variables	Examples of Satellite Sensors
• Temperature • Humidity/Atmospheric Dryness • Rainfall • Water Bodies/Flooding • Vegetation/Crop Type • Land Cover/Use • Soil Moisture/Type • Urban/human Settlements • Sea Surface Temperature	• Land Cover/Use & Vegetation – Landsat – Ikonos – SPOT • Meteorological & Land Cover/Use – NOAA AVHRR – MODIS – NDVI (Normalized Difference Vegetation Index) • Rainfall – TRMM – RadarSAT SAR



NASA's Seasonal-to-Interannual Prediction Project (NSIPP)

GOAL

Demonstrate the utility of remotely sensed observations of the ocean and land surface for enhancing prediction of ENSO and other significant seasonal-to-interannual signals and their global teleconnections using comprehensive coupled models of the atmosphere, land surface, ocean, and sea-ice.

SMMR soil moisture, July 1997

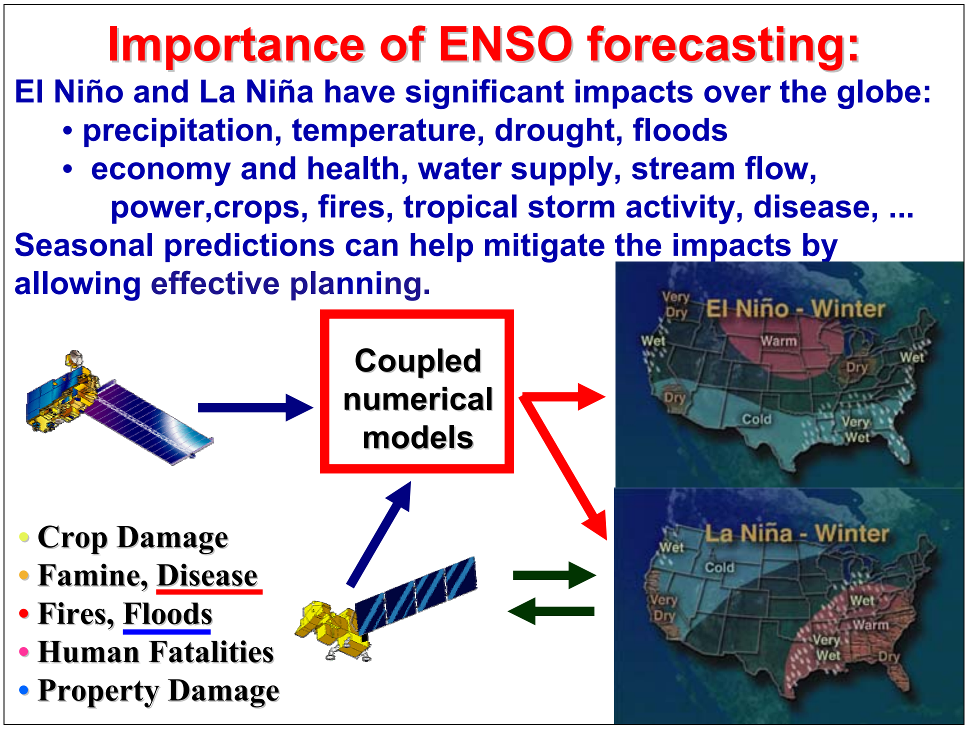
Satellite data

Topex Sea Level anomaly, July 1997

Coupled atmosphere-ocean-land surface model

Predictability of precipitation associated with SST

Predictability of precipitation associated with SST & soil wetness



Importance of ENSO forecasting:

El Niño and La Niña have significant impacts over the globe:

- precipitation, temperature, drought, floods
- economy and health, water supply, stream flow, power,crops, fires, tropical storm activity, disease, ...

Seasonal predictions can help mitigate the impacts by allowing effective planning.

Coupled numerical models

- Crop Damage
- Famine, Disease
- Fires, Floods
- Human Fatalities
- Property Damage

Seasonal-to-Interannual Prediction Project Products and Users

Routine products:

☎ monthly: routine coupled 12-month forecasts, routine seasonal forecasts -> consensus forecast

Global Oceans Data Assimilation Experiment

☎ monthly - daily: routine ocean and land analyses at seasonal-interannual time scales

Research--pushing the envelope:

NSIPP science team, external R&D communities

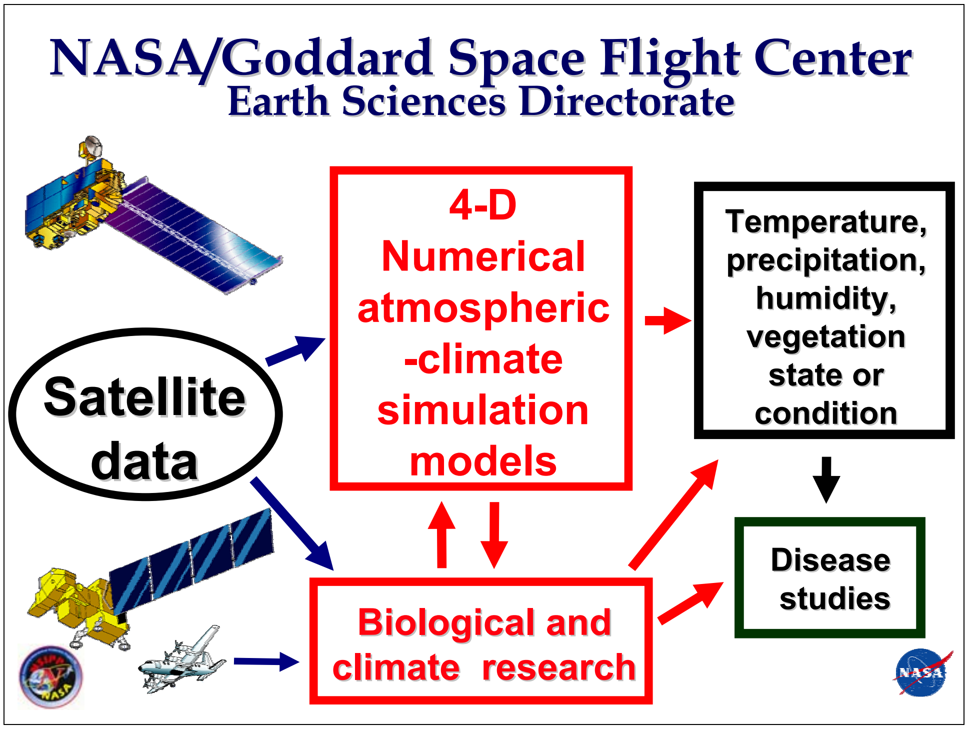
coupled simulations, forecasts
- biennial oscillations
- predictability
- downscaling (S. America impact on agriculture)
- ENSO paradigms

ensemble runs
- predictability
- Indian Monsoon
- N.A. Monsoon

ocean analyses
- Tropical Atlantic Variability
- tropical/subtropical Pacific state estimates

Next phase:

- research-mode for ocean and land analyses, impact on seasonal-interannual forecasts
  - ☎ocean: scatterometer, altimeter, ocean color, precipitation, MODIS SST, TMI SST,
  - ☎land: soil moisture, vegetation cover, NDVI, temperature, precipitation, humidity
  - ☎new ocean: surface salinity, lidar mixed layer



NASA/Goddard Space Flight Center
Earth Sciences Directorate

Satellite data

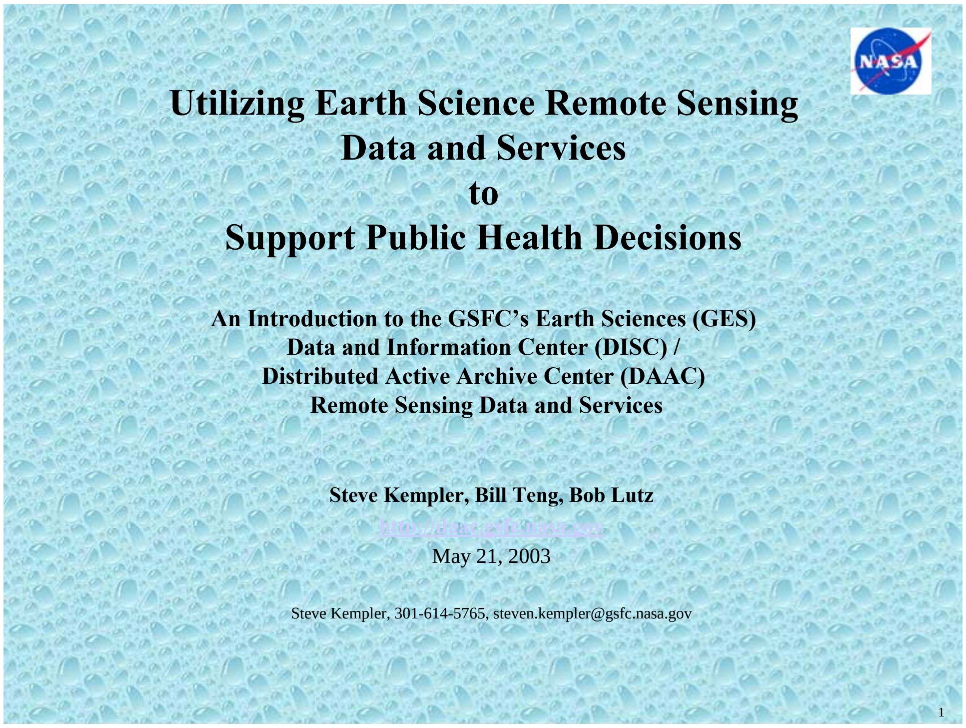
4-D Numerical atmospheric-climate simulation models

Temperature, precipitation, humidity, vegetation state or condition

Biological and climate research

Disease studies

Steve Kempler
“Utilizing Earth Science Remote Sensing Data and Services to Support Human Health”

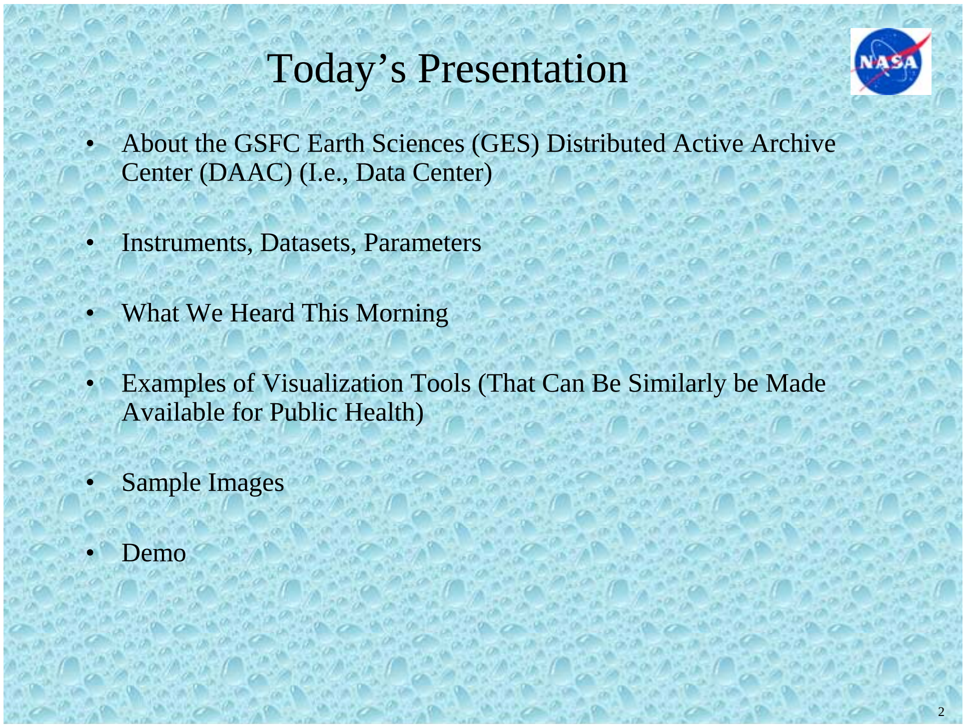


Utilizing Earth Science Remote Sensing Data and Services to Support Public Health Decisions

An Introduction to the GSFC’s Earth Sciences (GES)
Data and Information Center (DISC) /
Distributed Active Archive Center (DAAC)
Remote Sensing Data and Services

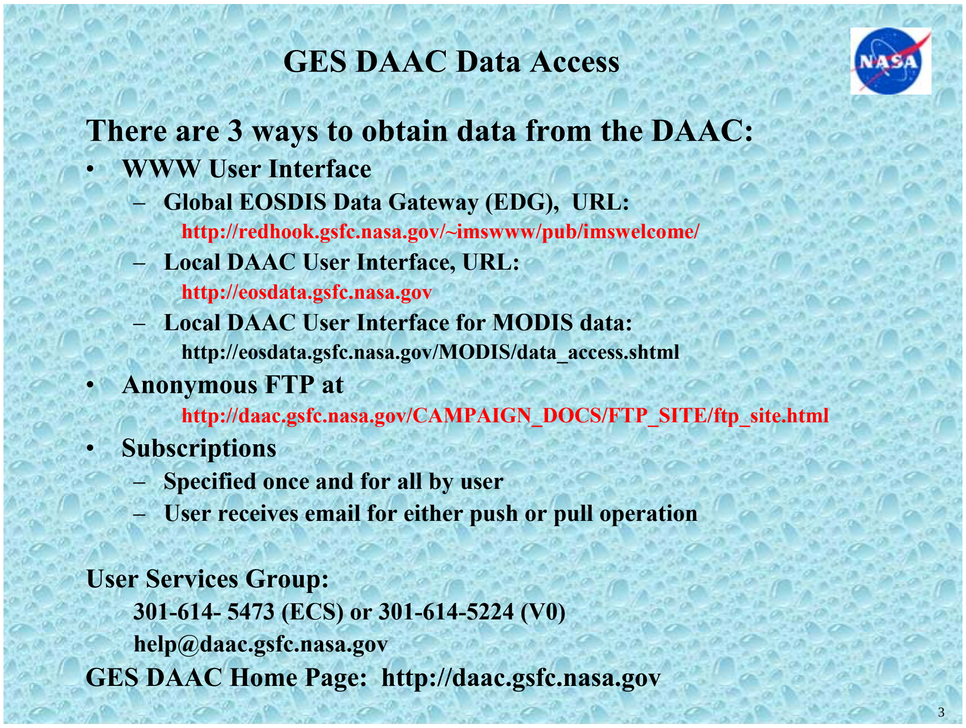
Steve Kempler, Bill Teng, Bob Lutz
http://daac.gsfc.nasa.gov
May 21, 2003

Steve Kempler, 301-614-5765, steven.kempler@gsfc.nasa.gov



Today’s Presentation

- About the GSFC Earth Sciences (GES) Distributed Active Archive Center (DAAC) (I.e., Data Center)
- Instruments, Datasets, Parameters
- What We Heard This Morning
- Examples of Visualization Tools (That Can Be Similarly be Made Available for Public Health)
- Sample Images
- Demo

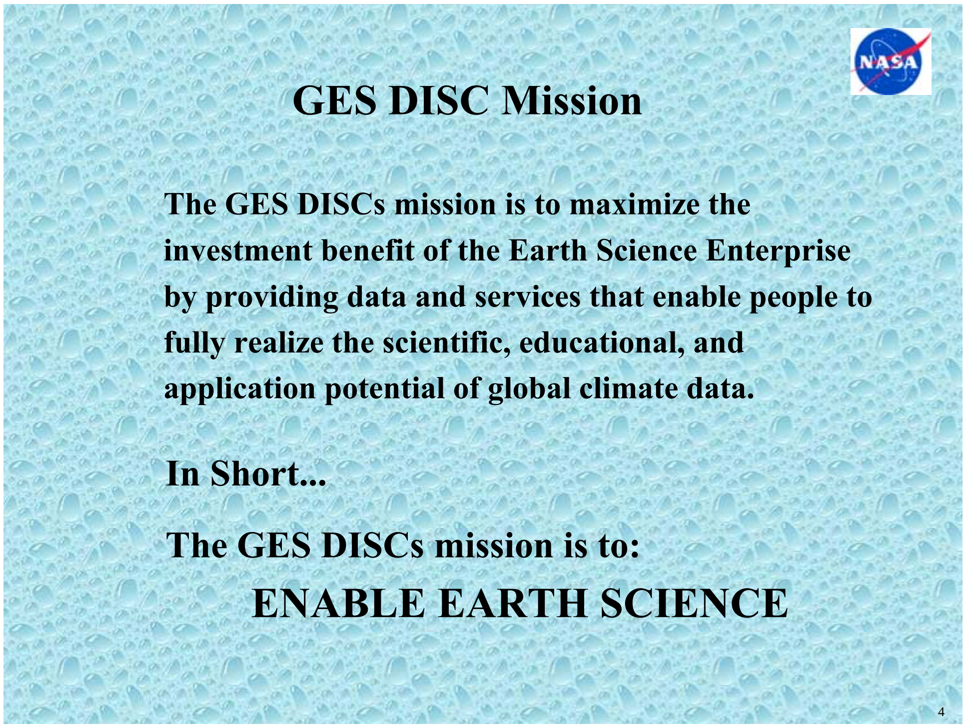


GES DAAC Data Access

There are 3 ways to obtain data from the DAAC:

- **WWW User Interface**
  - **Global EOSDIS Data Gateway (EDG), URL:** **http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/**
  - **Local DAAC User Interface, URL:** **http://eosdata.gsfc.nasa.gov**
  - **Local DAAC User Interface for MODIS data:** **http://eosdata.gsfc.nasa.gov/MODIS/data_access.shtml**
- **Anonymous FTP at** **http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/FTP_SITE/ftp_site.html**
- **Subscriptions**
  - **Specified once and for all by user**
  - **User receives email for either push or pull operation**

User Services Group:
301-614- 5473 (ECS) or 301-614-5224 (V0)
help@daac.gsfc.nasa.gov
GES DAAC Home Page: http://daac.gsfc.nasa.gov



GES DISC Mission

The GES DISCs mission is to maximize the investment benefit of the Earth Science Enterprise by providing data and services that enable people to fully realize the scientific, educational, and application potential of global climate data.

In Short...

The GES DISCs mission is to:

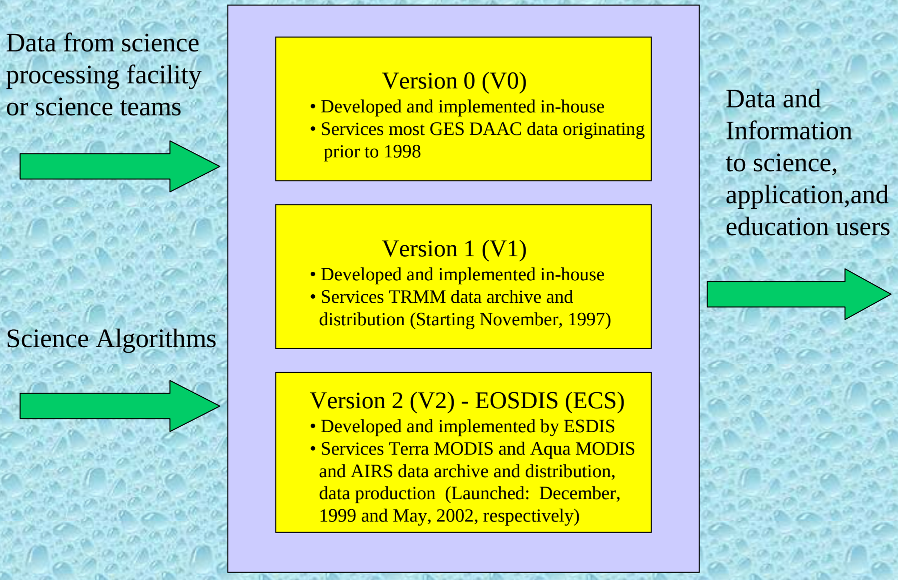
ENABLE EARTH SCIENCE

GSFC Earth Sciences Organizations

Code 900 - Earth Sciences Directorate

- Code 902 - Global Change Data Center
- Code 903 - Administration and Resources Management Office
- Code 910 - Laboratory for Atmospheres
- Code 920 - Laboratory for Terrestrial Physics
- Code 930 - Earth and Space Data Computing Division
- Code 940 - Goddard Institute for Space Studies
- Code 970 - Laboratory for Hydrospheric Processes

GES DAAC Data Flow



Data from science processing facility or science teams

Science Algorithms

Version 0 (V0)
- Developed and implemented in-house
- Services most GES DAAC data originating prior to 1998

Version 1 (V1)
- Developed and implemented in-house
- Services TRMM data archive and distribution (Starting November, 1997)

Version 2 (V2) - EOSDIS (ECS)
- Developed and implemented by ESDIS
- Services Terra MODIS and Aqua MODIS and AIRS data archive and distribution, data production (Launched: December, 1999 and May, 2002, respectively)

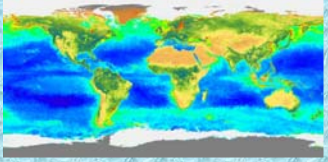
Data and Information to science, application,and education users

The GES DISC is NASAs Earth Science Data and Information Services Center for Specific Disciplines

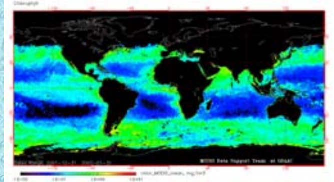
- **Atmospheric Chemistry**
- **Atmospheric Dynamics**
- **Hydrology**
- **Ocean Color**
- **Land Biosphere**

GES DAAC Science Disciplines

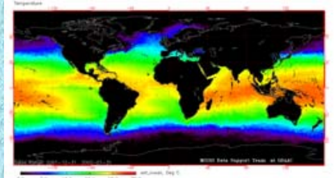
Global Biosphere



Monthly ocean chlorophyll and NDVI from SeaWiFS



Monthly ocean chlorophyll from MODIS

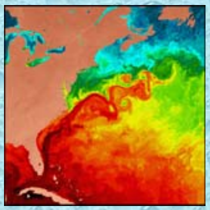


Monthly ocean sea surface temperature from MODIS

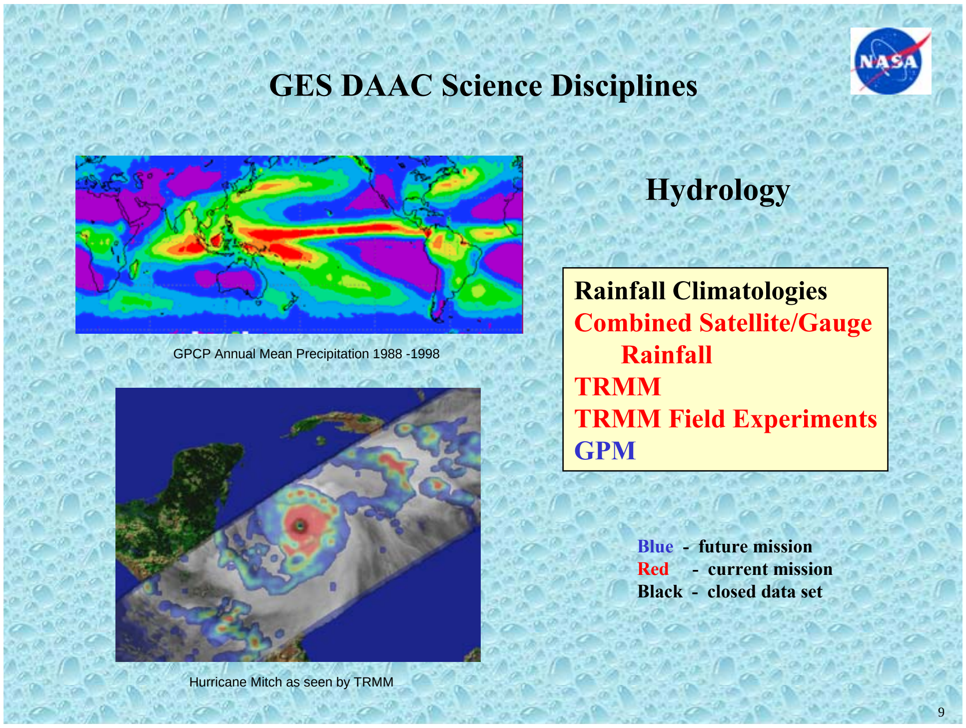
Ocean Color
- **CZCS**
- **SeaWiFS**
- **MODIS**
- **NPP**

Land Biosphere
- **AVHRR Pathfinder**
- **Triana**

Blue - future mission
Red - current mission
Black - closed data set



Gulf Stream as seen by CZCS sensor



GES DAAC Science Disciplines

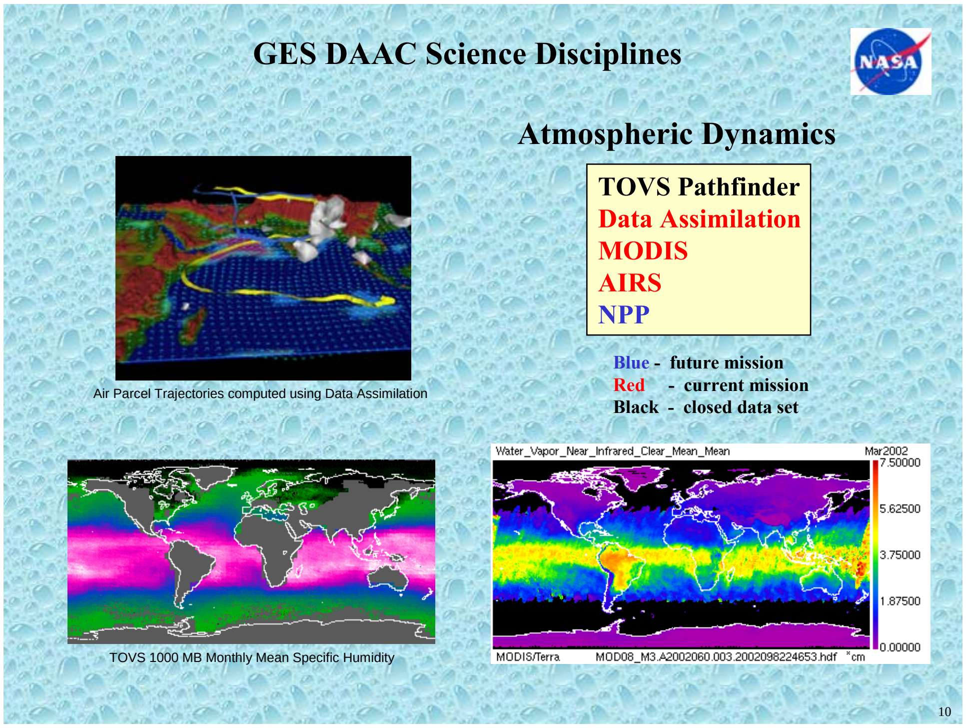
Hydrology

GPCP Annual Mean Precipitation 1988 -1998

Hurricane Mitch as seen by TRMM

Rainfall Climatologies
Combined Satellite/Gauge Rainfall
TRMM
TRMM Field Experiments
GPM

Blue - future mission
Red - current mission
Black - closed data set



GES DAAC Science Disciplines

Atmospheric Dynamics

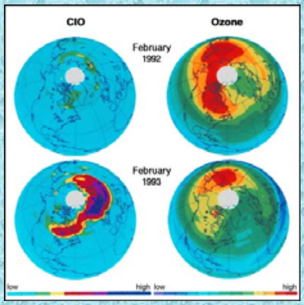
TOVS Pathfinder
Data Assimilation
MODIS
AIRS
NPP

Blue - future mission
Red - current mission
Black - closed data set

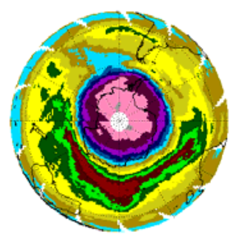
Air Parcel Trajectories computed using Data Assimilation

TOVS 1000 MB Monthly Mean Specific Humidity

GES DAAC Science Disciplines



Relationship between stratospheric Chlorine Monoxide and Ozone



Antarctic Ozone Hole 9/25/99 as seen by TOMS

Atmospheric Chemistry

Heritage TOMS
Heritage SBUV
EP-TOMS
UARS
Triana
SORCE
HIRDLS (AURA)
MLS (AURA)
OMI (AURA)

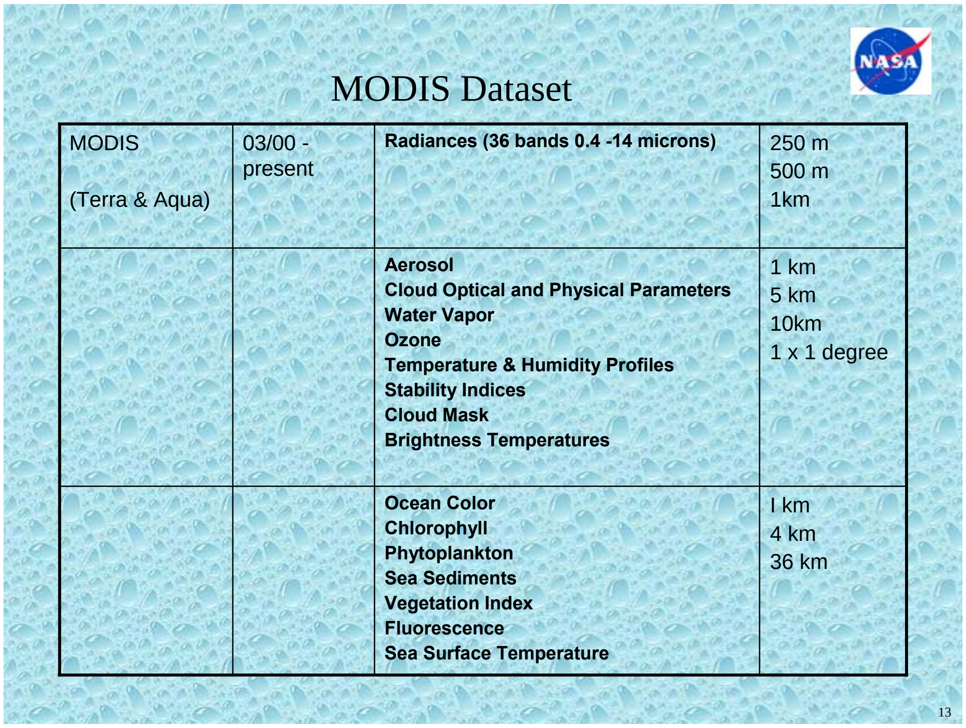
Blue - future mission
Red - current mission
Black - closed data set

Datasets Containing Sample Parameters Applicable to Public Health

AVHRR Advanced Very High Resolution Radiometer	- Vegetation Index
TOVS TIROS Operational Vertical Sounder	- Temperature and Humidity Profiles; Rainfall Rate
TRMM Tropical Rainfall Measuring Mission	- Rainfall Rate, Profile, and Type; Drop size Distribution
MODIS Moderate Resolution Imaging Spectro-radiometer	- Temperature and Humidity Profiles; Water Vapor; Stability Indices
AIRS Atmospheric Infrared Sounder	- Temperature and Humidity Profiles

- See “Climate Datasets at GES DAAC” handout for greater detail

  (including atmospheric products such as ozone, aerosol, radiation, and oceans products such as phytoplankton and chlorophyll)



MODIS Dataset

MODIS (Terra & Aqua)	03/00 - present	**Radiances (36 bands 0.4 -14 microns)**	250 m 500 m 1km
		Aerosol **Cloud Optical and Physical Parameters** **Water Vapor** **Ozone** **Temperature & Humidity Profiles** **Stability Indices** **Cloud Mask** **Brightness Temperatures**	1 km 5 km 10km 1 x 1 degree
		Ocean Color **Chlorophyll** **Phytoplankton** **Sea Sediments** **Vegetation Index** **Fluorescence** **Sea Surface Temperature**	I km 4 km 36 km

Other Earth Sciences DAACs

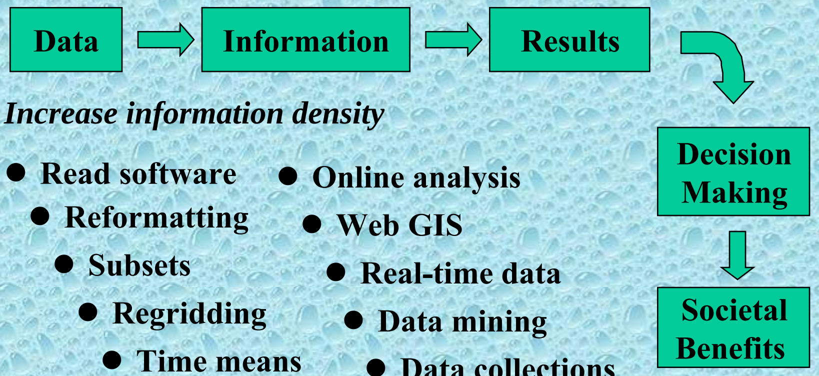
- Alaska SAR Facility (ASF) - SAR, Sea Ice, Polar Processes, Geophysics
- Global Hydrology Resource Center (GHRC) - Hydrologic Cycle, Severe Weather Interactions, Lightning, Convection
- Langley Atmospheric Sciences Data Center (ASDC) - Radiation Budget, Clouds, Aerosols, Tropospheric Chemistry
- Land Processes (LP) DAAC - Land Process Data
- National Snow and Ice Data Center (NSIDC) - Snow and Ice, Cryosphere, Climate
- Oak Ridge National Laboratory (ORNL) - Biogeochemical Dynamics, Ecological Data for studying Environmental Processes
- Physical Oceanography (PO) DAAC - Oceanic Processes and Air-Sea Interactions
- Socio-economic Data and Applications Center (SEDAC) - Population, Sustainability, Geospatial Data, Multilateral Environmental Agreements

GES DAAC Data Services

GES DAAC services include:

- Providing EOS and non-EOS ancillary data for science research, applied research, and applications users (e.g., education, policy makers, etc.)
- Distribution data products electronically or via media (e.g., 8mm tape, DLT and CD ROM)
- Online data search/browse/order (see slide after next)
- Full suite of documentation (detailed guide, summary guide, readme)
- User support via dedicated Data Support Teams (data access, HDF-EOS, documentation, data usage, etc)
- Subsetting, On-demand Subsetting, Subsampling, and Data Mining tools
- Data Visualization and Analysis Tools
- Making data available in GIS and binary formats
- Full suite of user services and outreach

Consumption Chain



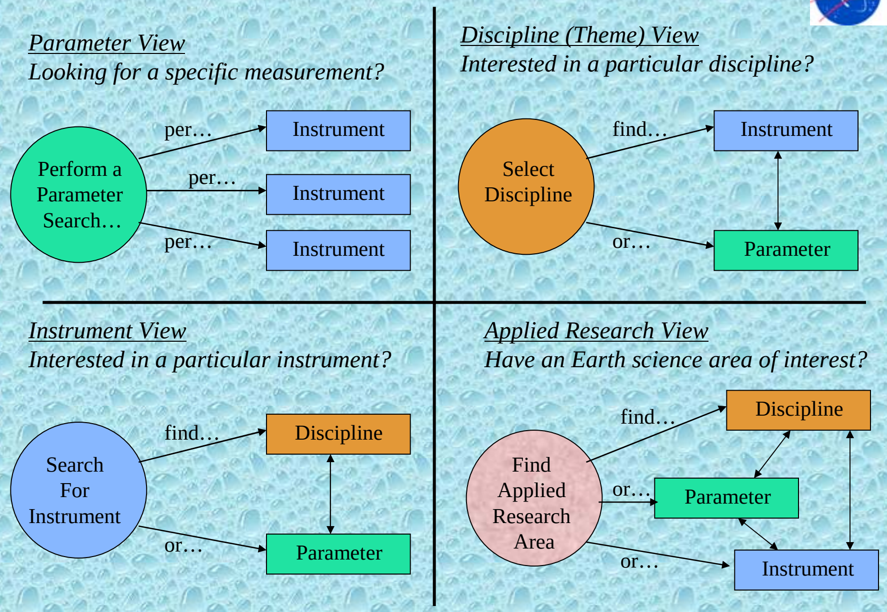
Data → **Information** → **Results** → **Decision Making** → **Societal Benefits**

Increase information density

- **Read software**
  - **Reformatting**
    - **Subsets**
      - **Regridding**
        - **Time means**
          - **Time series**
            - **Basic statistics**

- **Online analysis**
  - **Web GIS**
    - **Real-time data**
      - **Data mining**
        - **Data collections**
          - **Derived parameters**

Views of GES DAAC Data



Parameter View
Looking for a specific measurement?

Perform a Parameter Search…
per… Instrument
per… Instrument
per… Instrument

Discipline (Theme) View
Interested in a particular discipline?

Select Discipline
find… Instrument
or… Parameter

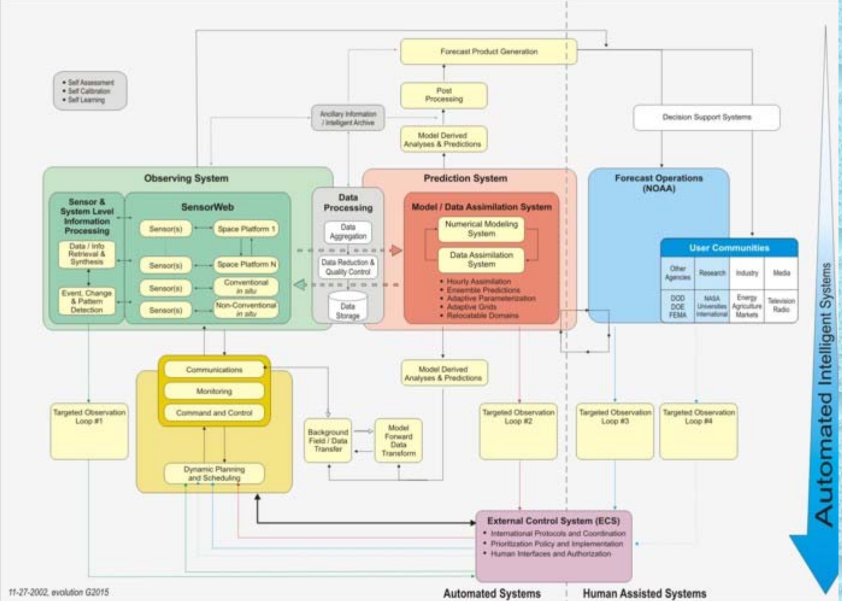
Instrument View
Interested in a particular instrument?

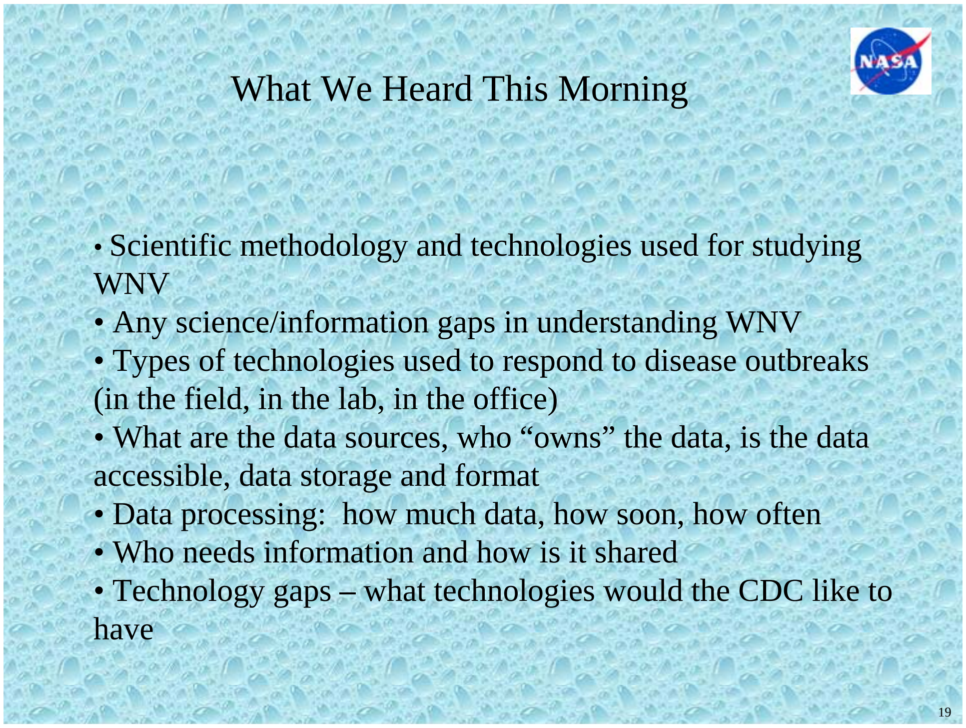
Search For Instrument
find… Discipline
or… Parameter

Applied Research View
Have an Earth science area of interest?

Find Applied Research Area
find… Discipline
or… Parameter
or… Instrument

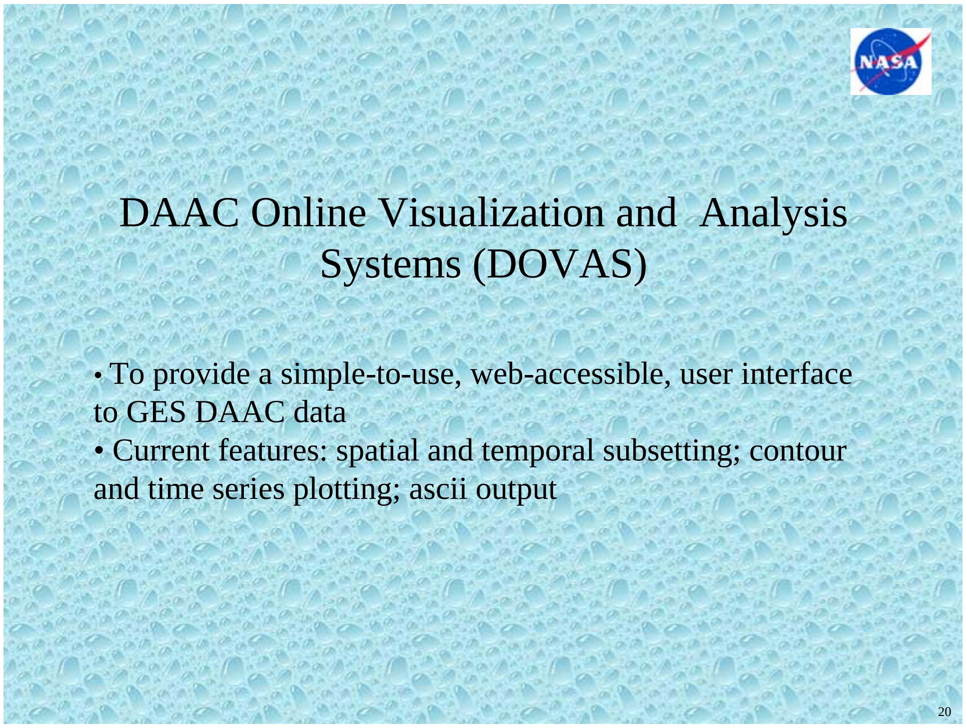
Sensor-Web Study





What We Heard This Morning

- Scientific methodology and technologies used for studying WNV
- Any science/information gaps in understanding WNV
- Types of technologies used to respond to disease outbreaks (in the field, in the lab, in the office)
- What are the data sources, who “owns” the data, is the data accessible, data storage and format
- Data processing: how much data, how soon, how often
- Who needs information and how is it shared
- Technology gaps – what technologies would the CDC like to have



DAAC Online Visualization and Analysis Systems (DOVAS)

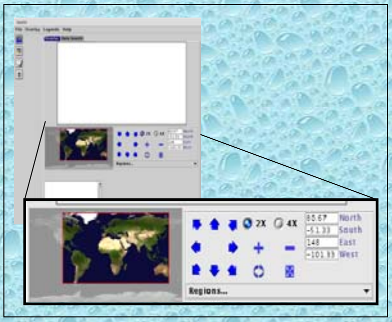
- To provide a simple-to-use, web-accessible, user interface to GES DAAC data
- Current features: spatial and temporal subsetting; contour and time series plotting; ascii output

Interoperable Web Mapping Application at the GES DAAC – Web GIS

- To allow users to visualize GES DAAC and external data with a web browser
- Current features: spatial and temporal subsetting; panning and zooming, multiple images display; remote access to distributed data

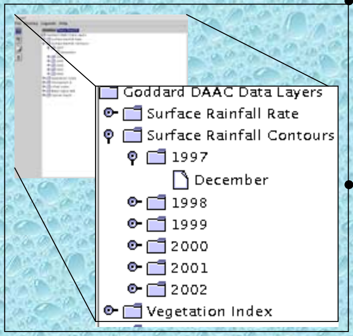
Web GIS - User Interface

- Interactive map to select a desired geographic subset
- Ability to click & drag or type in specific coordinates
- Also pre-defined subsets available



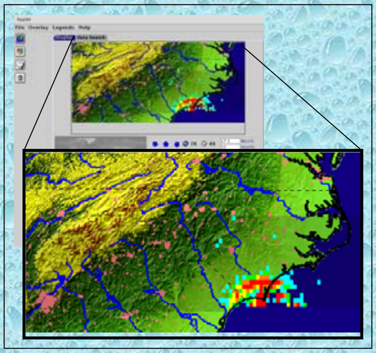
85.67 North
-51.33 South
148 East
-101.33 West

Web GIS - User Interface



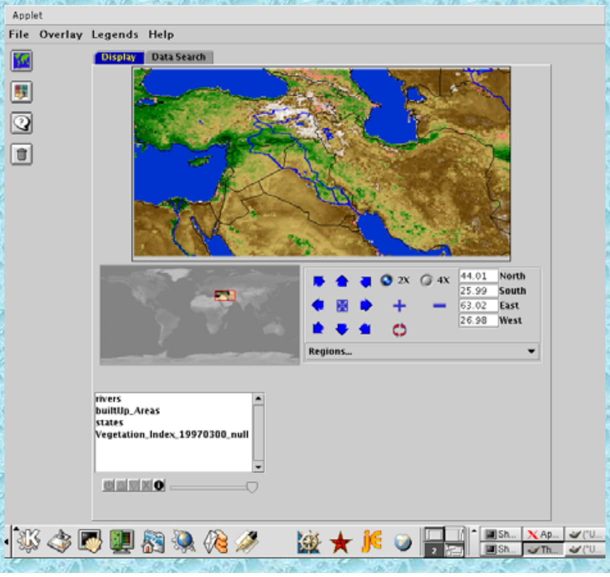
- Search available:
  - Environmental parameters
  - Time
- Unified search for data various platforms/sensors

Map Display



- Display multiple superimposed images
- User can specify the order to draw layers
- Adjust the transparency level of individual layers

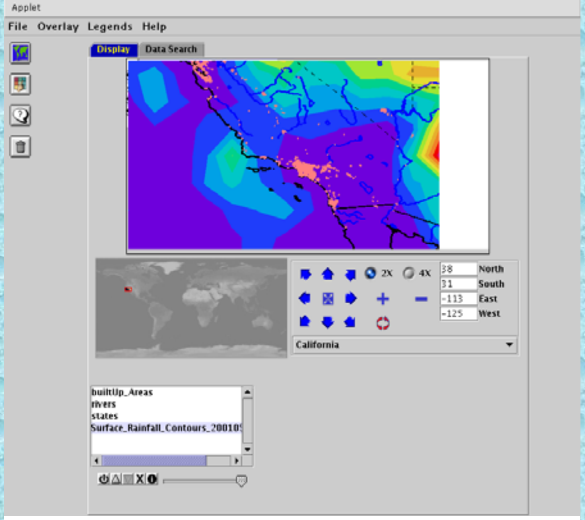
Map Display



North: 44.01
South: 25.99
East: 63.02
West: 26.98
Regions...

rivers
builtUp_Areas
states
Vegetation_Index_19970300_null

Map Display

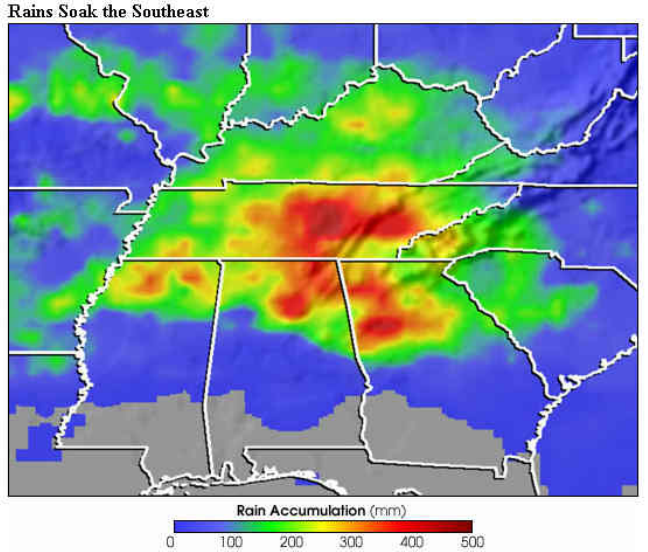


North: 38
South: 31
East: -113
West: -125
California

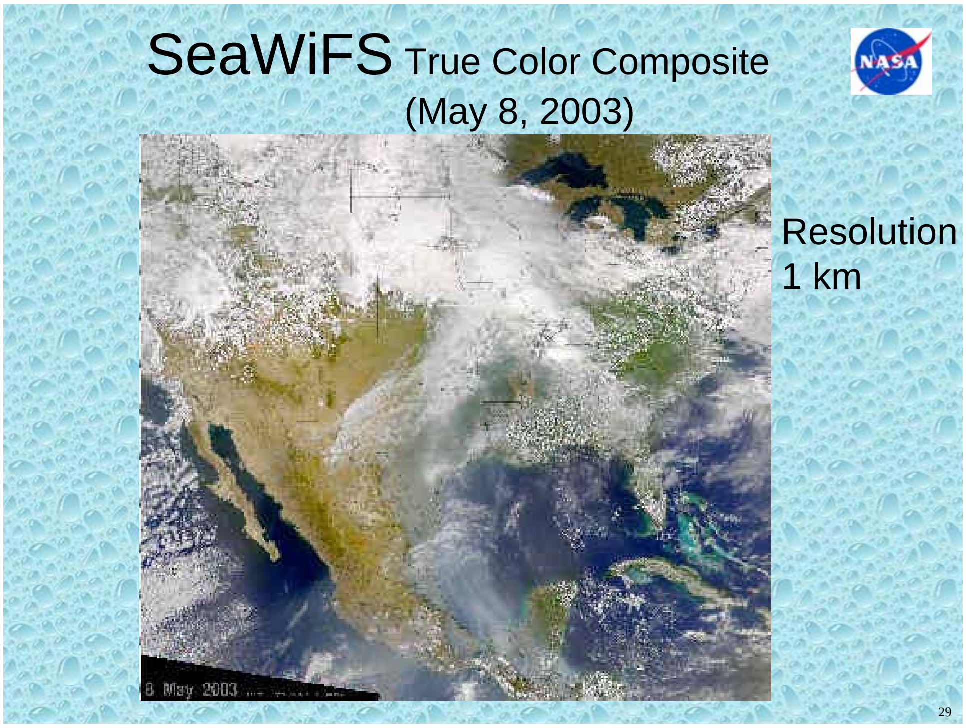
builtUp_Areas
rivers
states
Surface_Rainfall_Contours_20010

GES DAAC Data - Image Examples

TRMM Real-time Multi-satellite Precipitation (May 4-9, 2003)

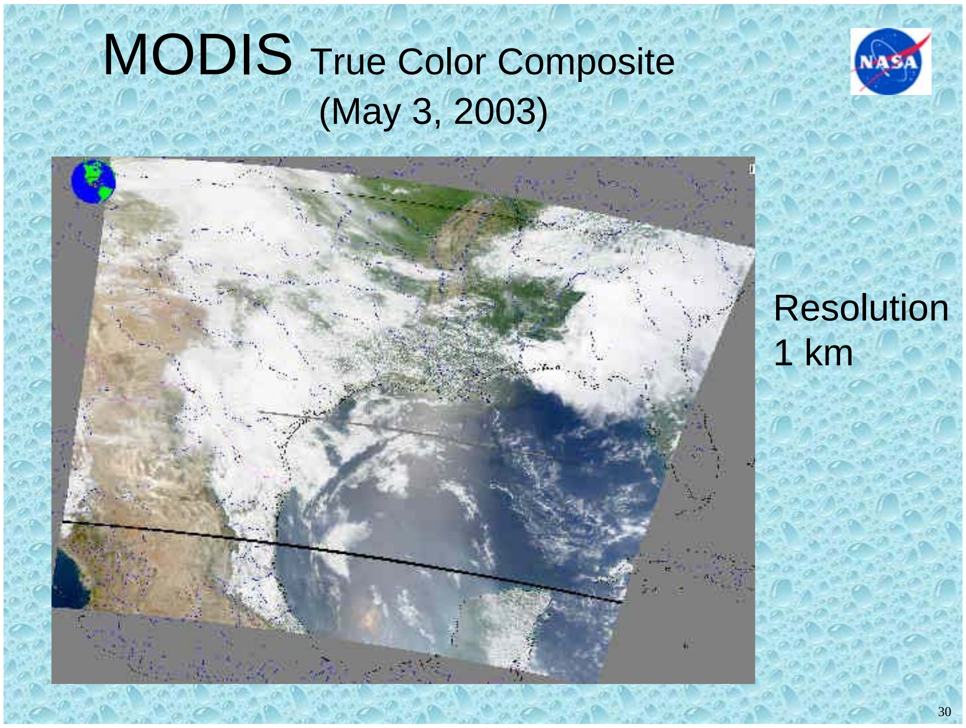


Resolution
0.25 deg



SeaWiFS True Color Composite
(May 8, 2003)

Resolution
1 km



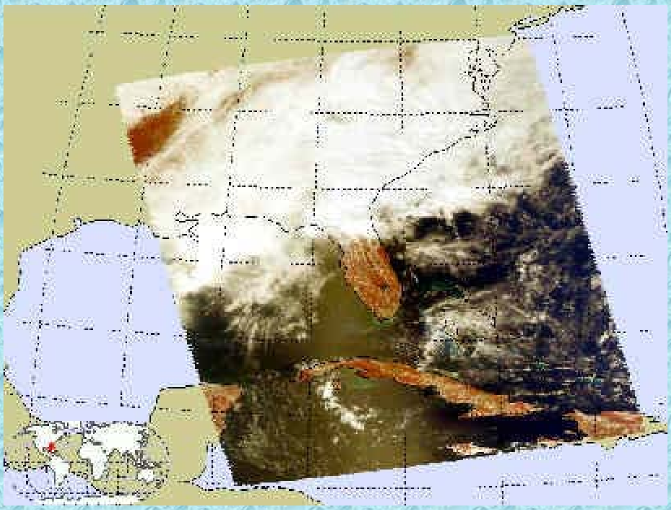
MODIS True Color Composite
(May 3, 2003)

Resolution
1 km

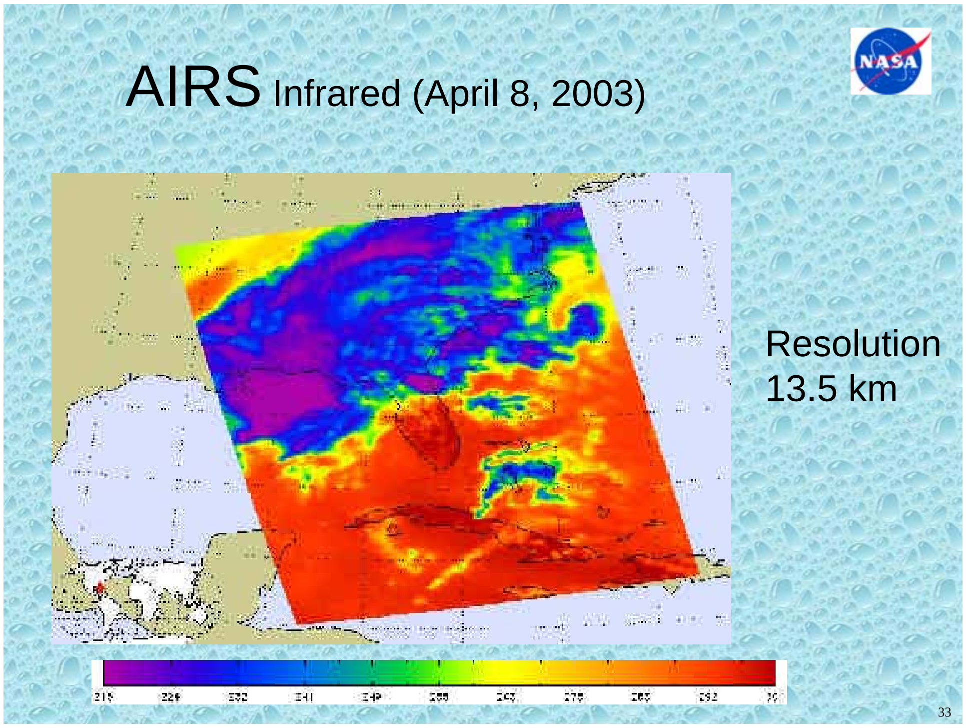
MODIS True Color Composite (May 3, 2003)

Resolution
250 m

AIRS Visible/Near Infrared, False-color Composite (April 8, 2003)



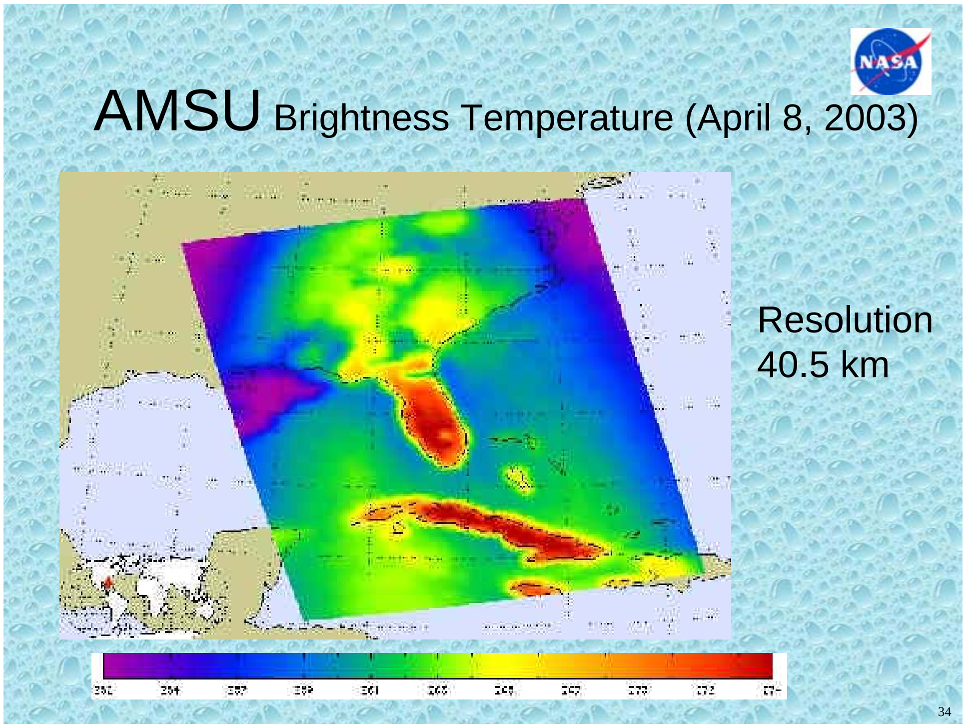
Resolution
2.3 km



AIRS Infrared (April 8, 2003)

Resolution
13.5 km

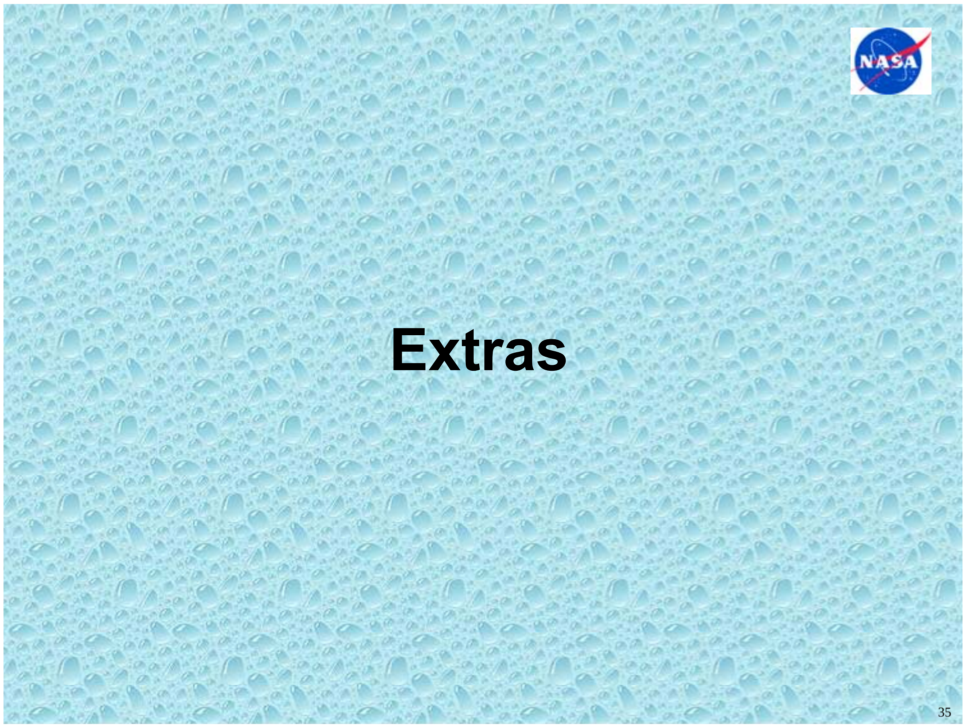
33



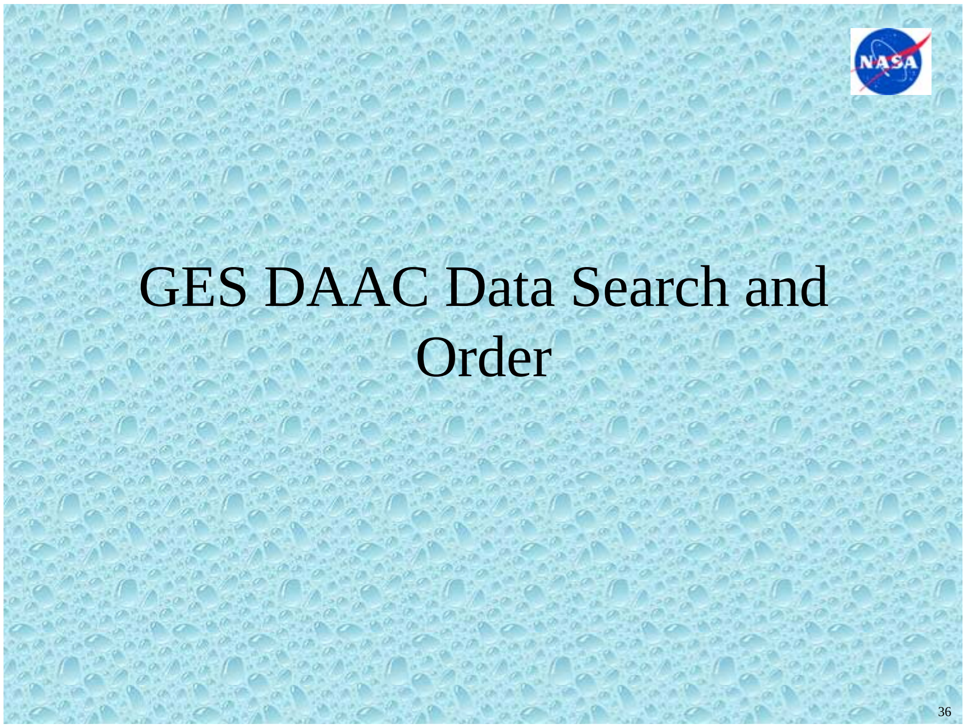
AMSU Brightness Temperature (April 8, 2003)

Resolution
40.5 km

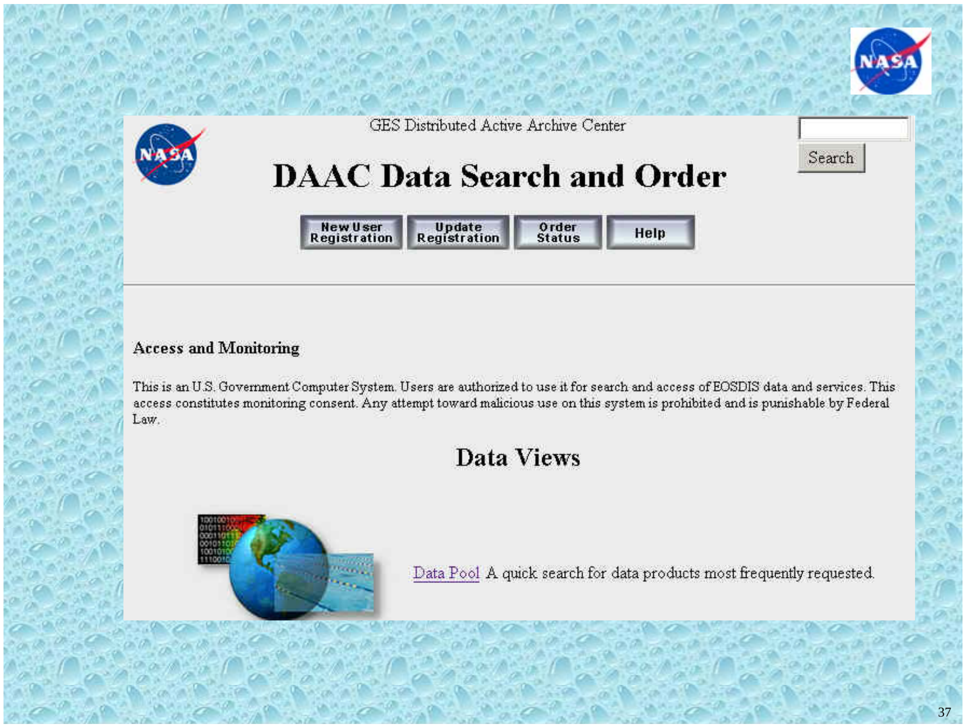
34



Extras



GES DAAC Data Search and Order



GES Distributed Active Archive Center

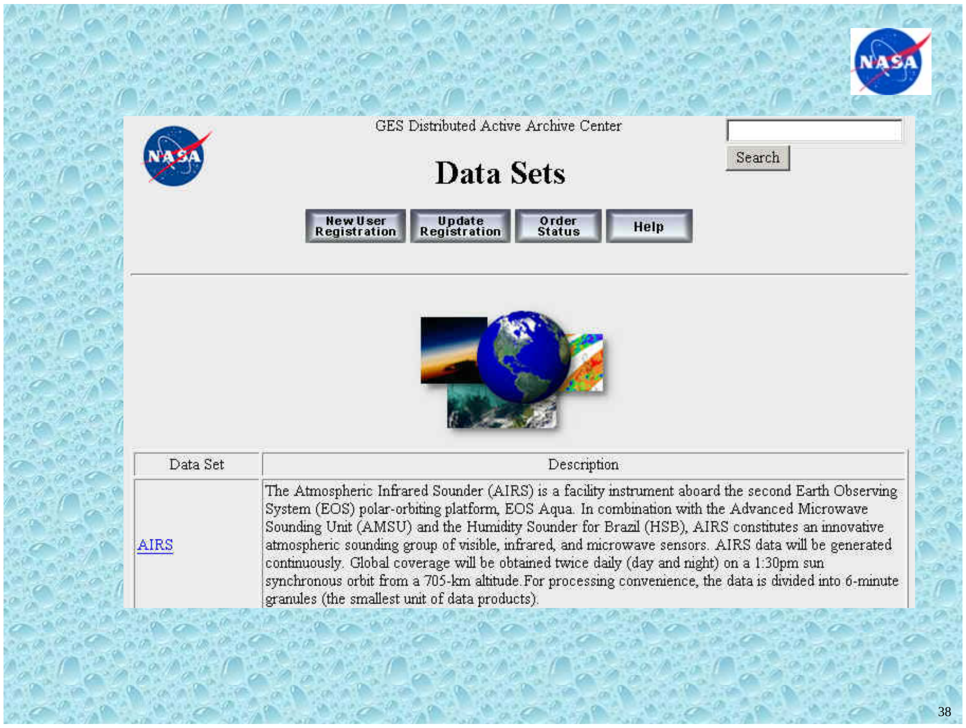
DAAC Data Search and Order

Access and Monitoring

This is an U.S. Government Computer System. Users are authorized to use it for search and access of EOSDIS data and services. This access constitutes monitoring consent. Any attempt toward malicious use on this system is prohibited and is punishable by Federal Law.

Data Views

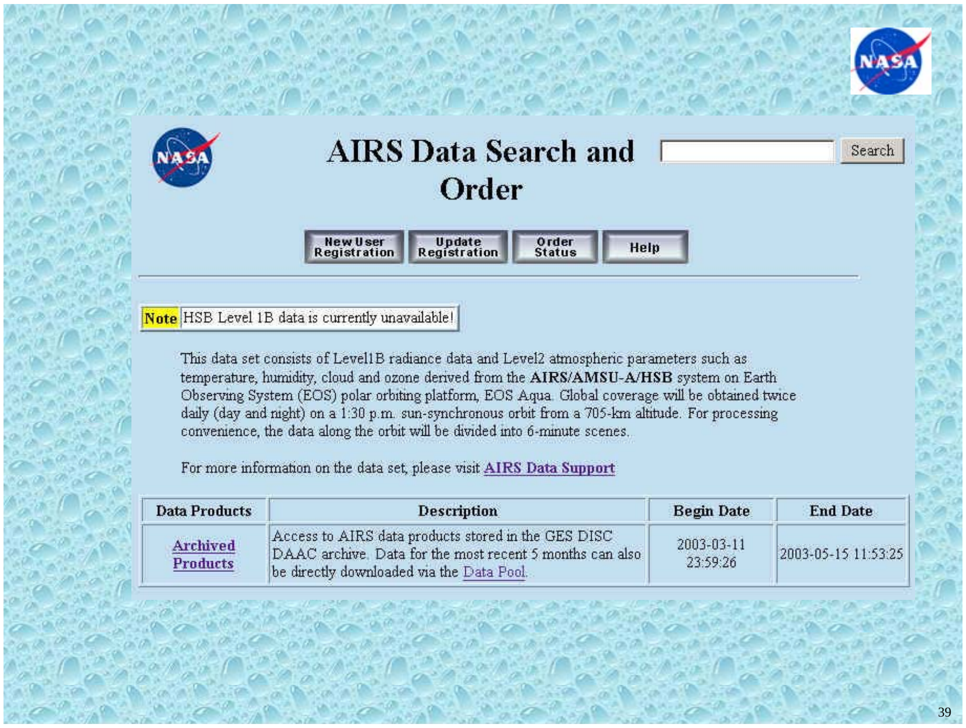
Data Pool A quick search for data products most frequently requested.



GES Distributed Active Archive Center

Data Sets

Data Set	Description
AIRS	The Atmospheric Infrared Sounder (AIRS) is a facility instrument aboard the second Earth Observing System (EOS) polar-orbiting platform, EOS Aqua. In combination with the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB), AIRS constitutes an innovative atmospheric sounding group of visible, infrared, and microwave sensors. AIRS data will be generated continuously. Global coverage will be obtained twice daily (day and night) on a 1:30pm sun synchronous orbit from a 705-km altitude. For processing convenience, the data is divided into 6-minute granules (the smallest unit of data products).

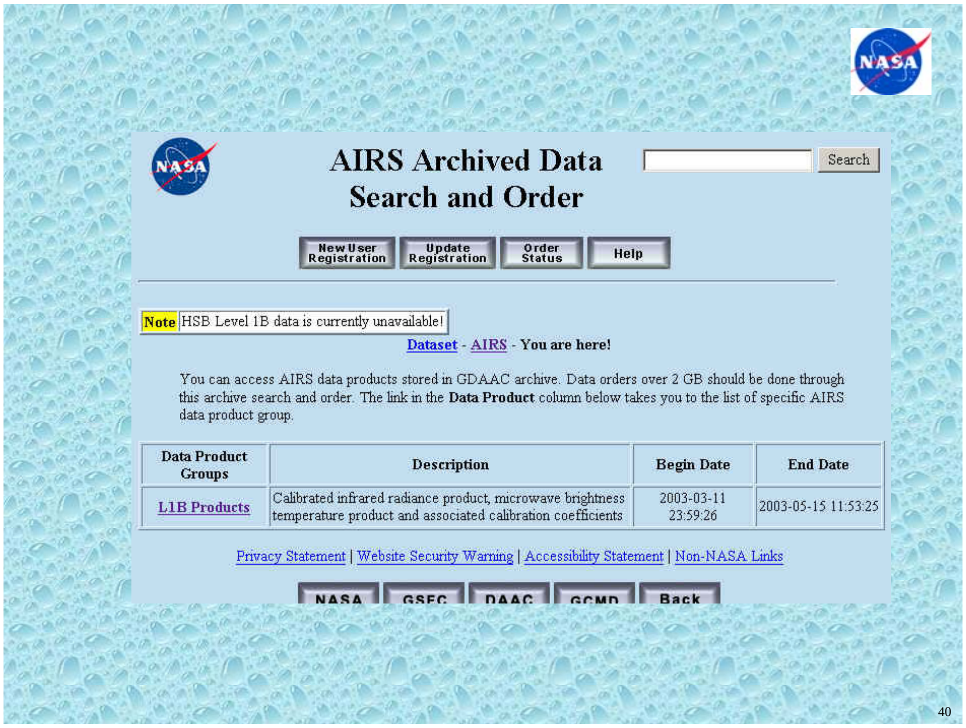


Note HSB Level 1B data is currently unavailable!

This data set consists of Level1B radiance data and Level2 atmospheric parameters such as temperature, humidity, cloud and ozone derived from the **AIRS/AMSU-A/HSB** system on Earth Observing System (EOS) polar orbiting platform, EOS Aqua. Global coverage will be obtained twice daily (day and night) on a 1:30 p.m. sun-synchronous orbit from a 705-km altitude. For processing convenience, the data along the orbit will be divided into 6-minute scenes.

For more information on the data set, please visit **AIRS Data Support**

Data Products	Description	Begin Date	End Date
Archived Products	Access to AIRS data products stored in the GES DISC DAAC archive. Data for the most recent 5 months can also be directly downloaded via the Data Pool.	2003-03-11 23:59:26	2003-05-15 11:53:25



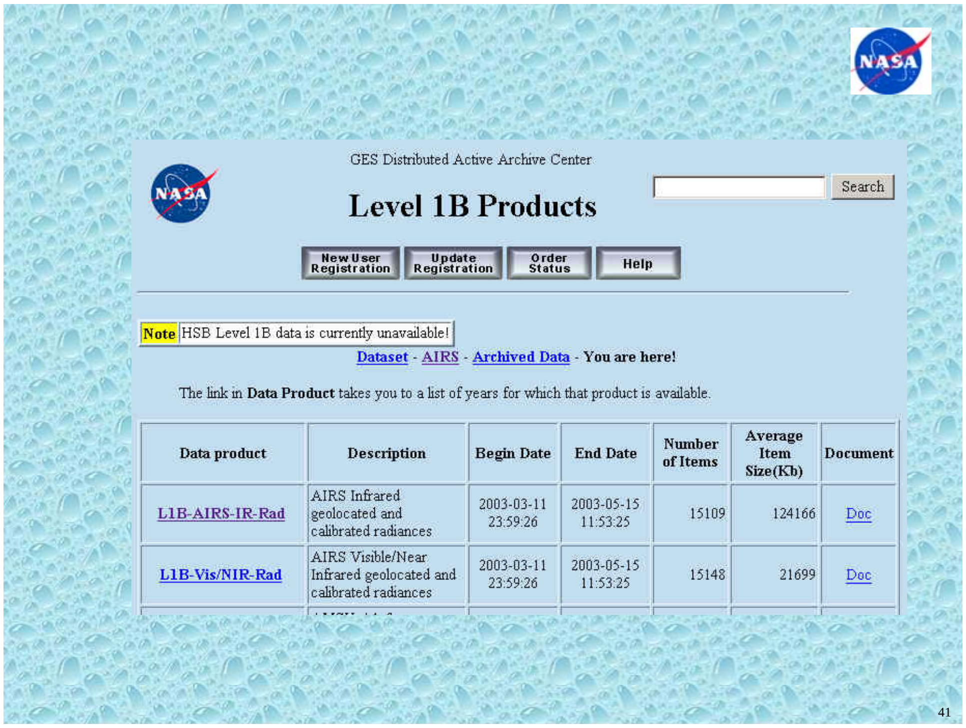
Note HSB Level 1B data is currently unavailable!

Dataset - AIRS - **You are here!**

You can access AIRS data products stored in GDAAC archive. Data orders over 2 GB should be done through this archive search and order. The link in the **Data Product** column below takes you to the list of specific AIRS data product group.

Data Product Groups	Description	Begin Date	End Date
L1B Products	Calibrated infrared radiance product, microwave brightness temperature product and associated calibration coefficients	2003-03-11 23:59:26	2003-05-15 11:53:25

Privacy Statement | Website Security Warning | Accessibility Statement | Non-NASA Links



GES Distributed Active Archive Center

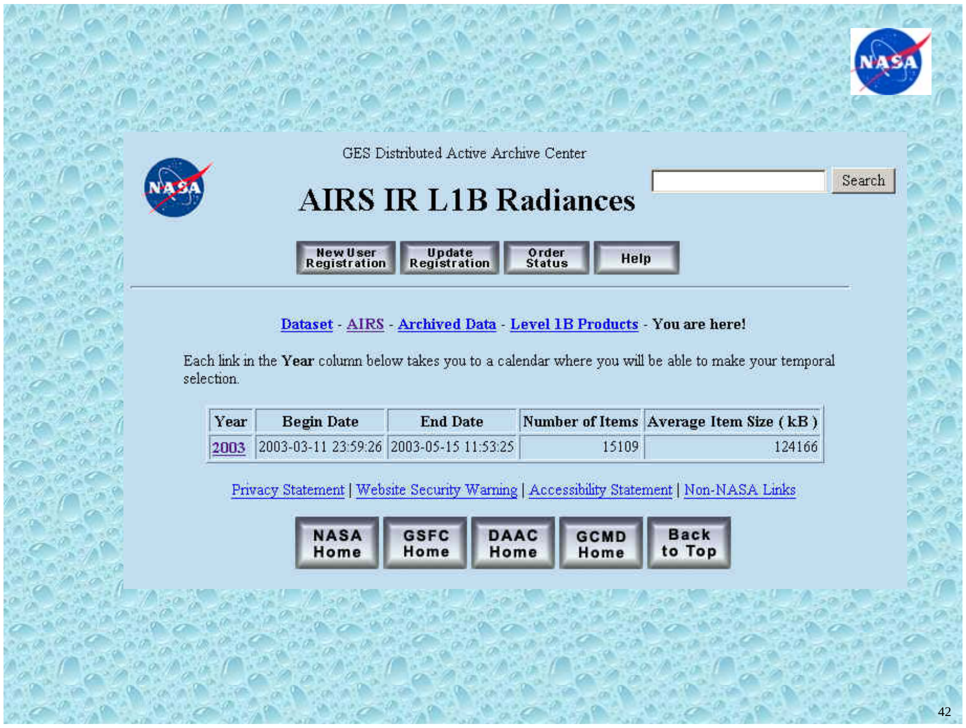
Level 1B Products

Note HSB Level 1B data is currently unavailable!

Dataset - AIRS - Archived Data - **You are here!**

The link in **Data Product** takes you to a list of years for which that product is available.

Data product	Description	Begin Date	End Date	Number of Items	Average Item Size(Kb)	Document
L1B-AIRS-IR-Rad	AIRS Infrared geolocated and calibrated radiances	2003-03-11 23:59:26	2003-05-15 11:53:25	15109	124166	Doc
L1B-Vis/NIR-Rad	AIRS Visible/Near Infrared geolocated and calibrated radiances	2003-03-11 23:59:26	2003-05-15 11:53:25	15148	21699	Doc



GES Distributed Active Archive Center

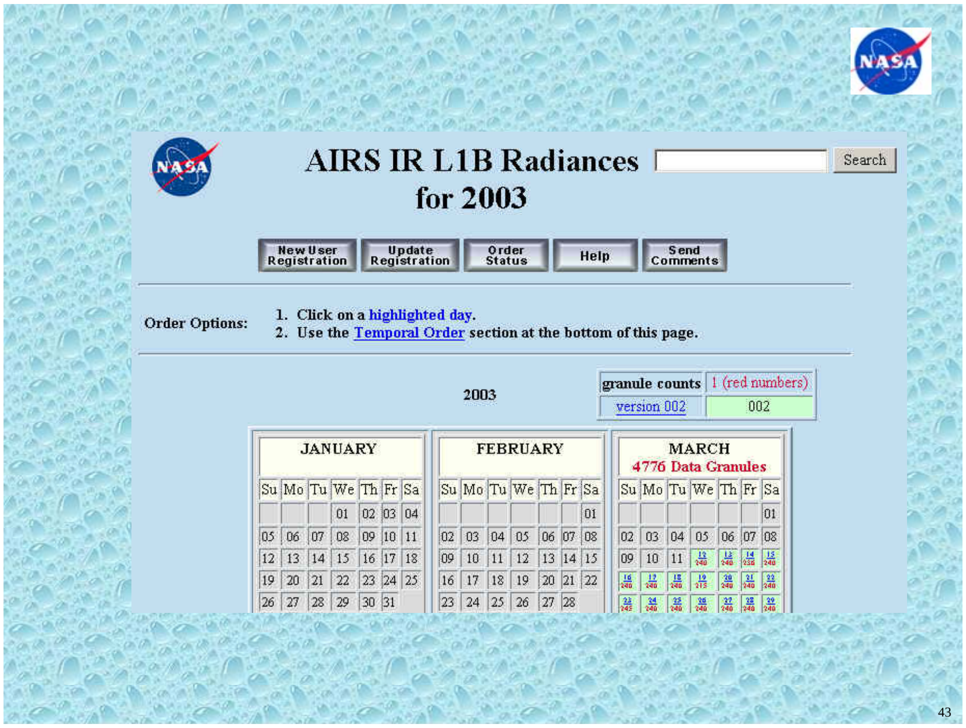
AIRS IR L1B Radiances

Dataset - AIRS - Archived Data - Level 1B Products - **You are here!**

Each link in the **Year** column below takes you to a calendar where you will be able to make your temporal selection.

Year	Begin Date	End Date	Number of Items	Average Item Size (kB)
2003	2003-03-11 23:59:26	2003-05-15 11:53:25	15109	124166

Privacy Statement | Website Security Warning | Accessibility Statement | Non-NASA Links



AIRS IR L1B Radiances for 2003

Order Options:

1. Click on a highlighted day.
2. Use the Temporal Order section at the bottom of this page.

2003

granule counts	1 (red numbers)
version 002	002

JANUARY

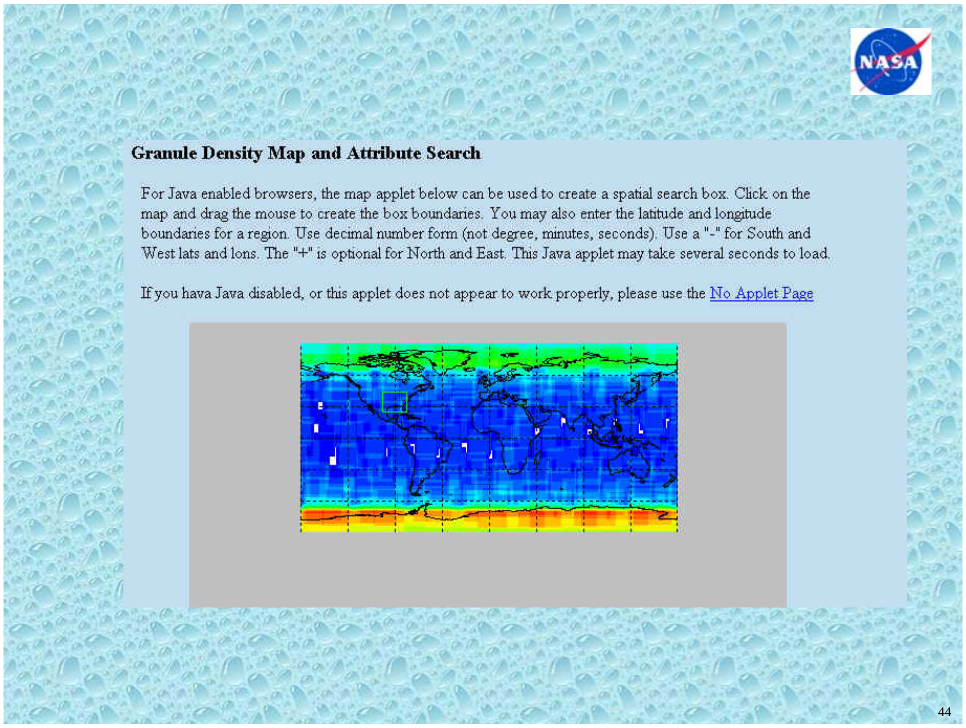
Su	Mo	Tu	We	Th	Fr	Sa
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

FEBRUARY

Su	Mo	Tu	We	Th	Fr	Sa
						01
02	03	04	05	06	07	08
09	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

MARCH
4776 Data Granules

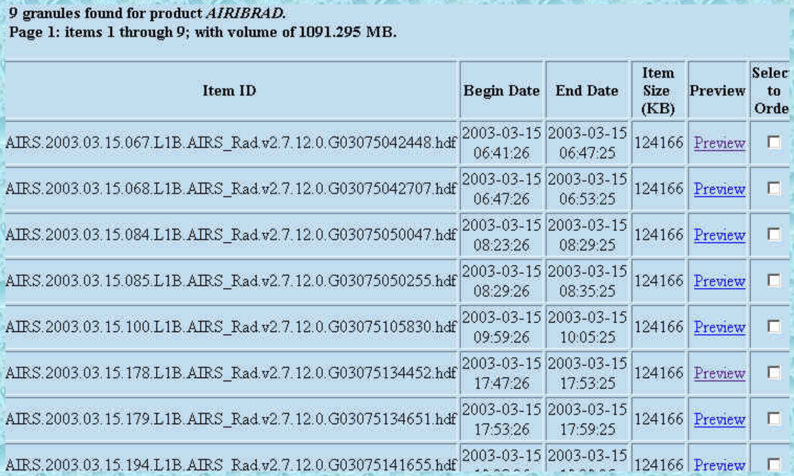
Su	Mo	Tu	We	Th	Fr	Sa
						01
02	03	04	05	06	07	08
09	10	11	12 240	13 240	14 236	15 240
16 240	17 240	18 240	19 215	20 240	21 240	22 240
23 243	24 240	25 240	26 240	27 240	28 240	29 240



Granule Density Map and Attribute Search

For Java enabled browsers, the map applet below can be used to create a spatial search box. Click on the map and drag the mouse to create the box boundaries. You may also enter the latitude and longitude boundaries for a region. Use decimal number form (not degree, minutes, seconds). Use a "-" for South and West lats and lons. The "+" is optional for North and East. This Java applet may take several seconds to load.

If you hava Java disabled, or this applet does not appear to work properly, please use the No Applet Page

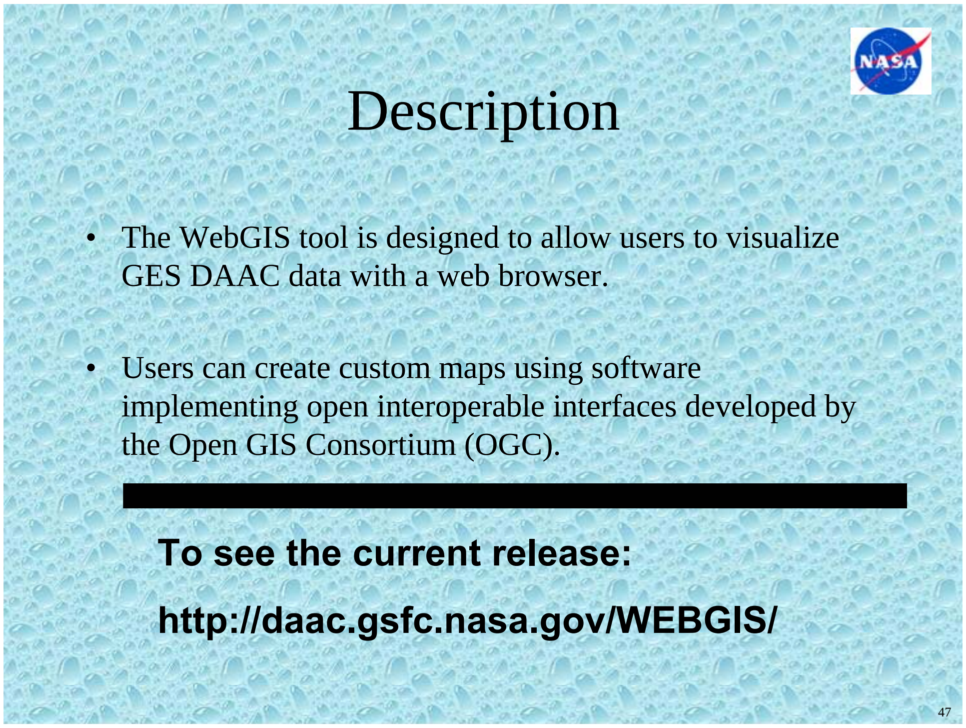


9 granules found for product *AIRIBRAD*.
Page 1: items 1 through 9; with volume of 1091.295 MB.

Item ID	Begin Date	End Date	Item Size (KB)	Preview	Selec to Orde
AIRS.2003.03.15.067.L1B.AIRS_Rad.v2.7.12.0.G03075042448.hdf	2003-03-15 06:41:26	2003-03-15 06:47:25	124166	Preview	☐
AIRS.2003.03.15.068.L1B.AIRS_Rad.v2.7.12.0.G03075042707.hdf	2003-03-15 06:47:26	2003-03-15 06:53:25	124166	Preview	☐
AIRS.2003.03.15.084.L1B.AIRS_Rad.v2.7.12.0.G03075050047.hdf	2003-03-15 08:23:26	2003-03-15 08:29:25	124166	Preview	☐
AIRS.2003.03.15.085.L1B.AIRS_Rad.v2.7.12.0.G03075050255.hdf	2003-03-15 08:29:26	2003-03-15 08:35:25	124166	Preview	☐
AIRS.2003.03.15.100.L1B.AIRS_Rad.v2.7.12.0.G03075105830.hdf	2003-03-15 09:59:26	2003-03-15 10:05:25	124166	Preview	☐
AIRS.2003.03.15.178.L1B.AIRS_Rad.v2.7.12.0.G03075134452.hdf	2003-03-15 17:47:26	2003-03-15 17:53:25	124166	Preview	☐
AIRS.2003.03.15.179.L1B.AIRS_Rad.v2.7.12.0.G03075134651.hdf	2003-03-15 17:53:26	2003-03-15 17:59:25	124166	Preview	☐
AIRS.2003.03.15.194.L1B.AIRS_Rad.v2.7.12.0.G03075141655.hdf	2003-03-15	2003-03-15	124166	Preview	☐

Project Background

- WebGIS tool developed to assist GIS users to access GES DAAC data
- Evolved from our work in creating automated production of GIS data sets, and implementation of internet map server software
- Initial release March 2002, incremental releases planned as functionality increases

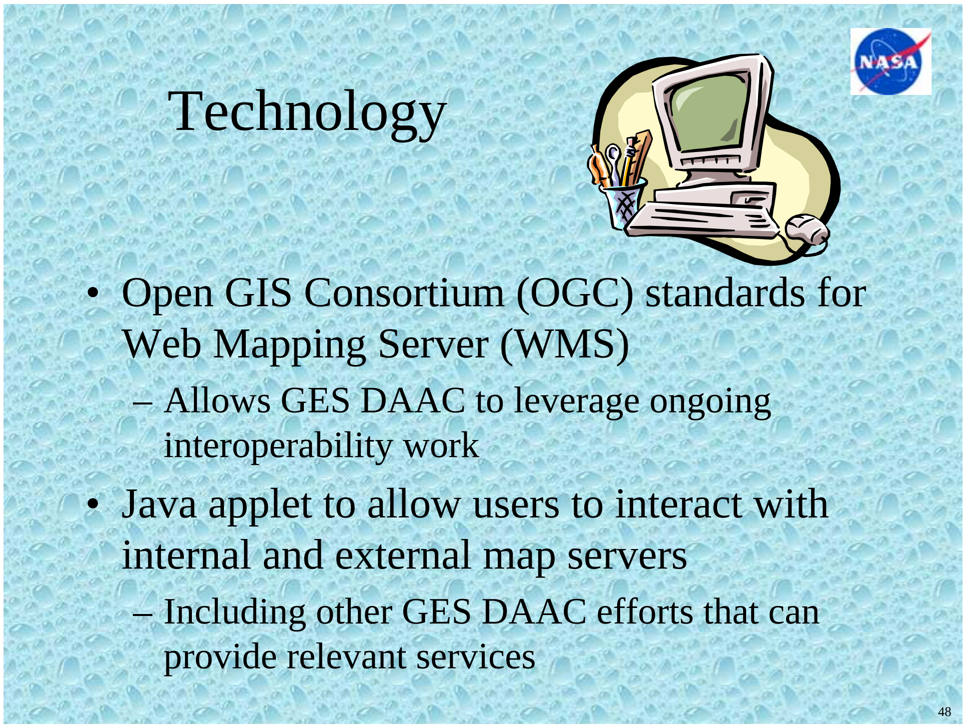


Description

- The WebGIS tool is designed to allow users to visualize GES DAAC data with a web browser.
- Users can create custom maps using software implementing open interoperable interfaces developed by the Open GIS Consortium (OGC).

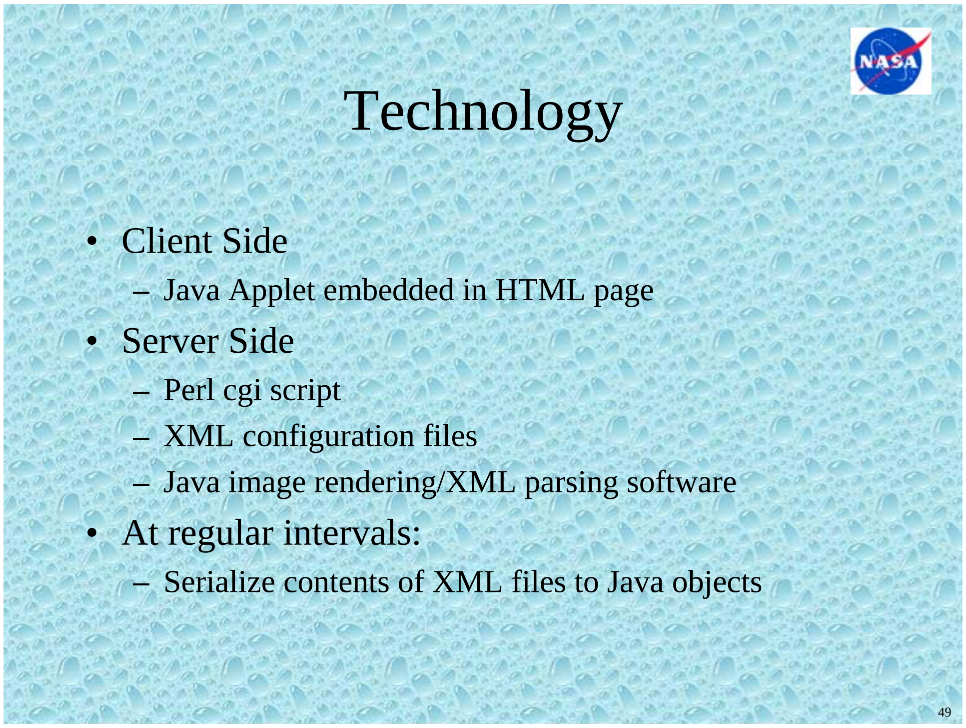
To see the current release:

http://daac.gsfc.nasa.gov/WEBGIS/



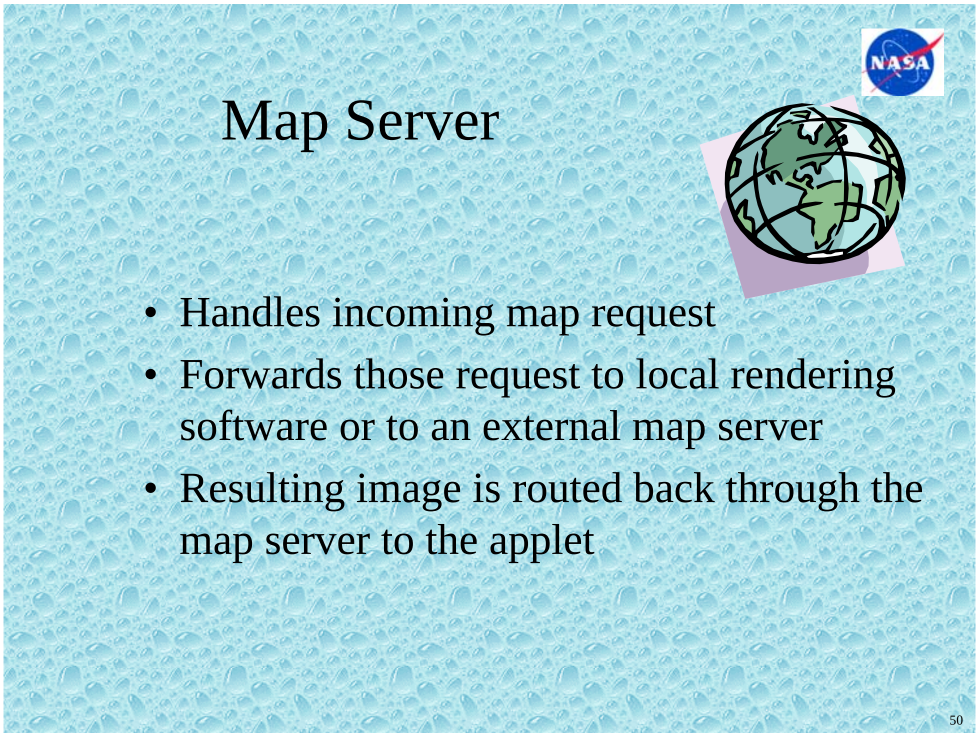
Technology

- Open GIS Consortium (OGC) standards for Web Mapping Server (WMS)
  - Allows GES DAAC to leverage ongoing interoperability work
- Java applet to allow users to interact with internal and external map servers
  - Including other GES DAAC efforts that can provide relevant services



Technology

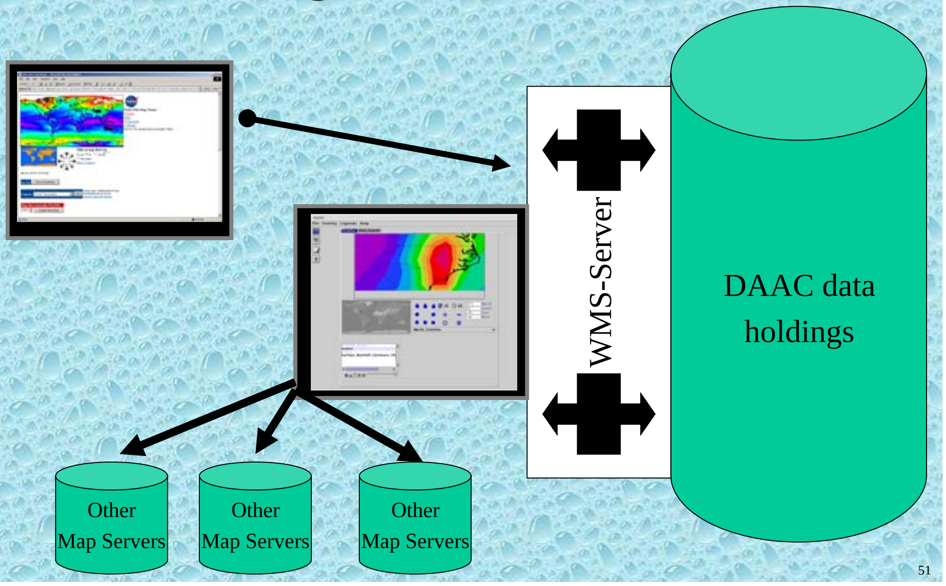
- Client Side
  - Java Applet embedded in HTML page
- Server Side
  - Perl cgi script
  - XML configuration files
  - Java image rendering/XML parsing software
- At regular intervals:
  - Serialize contents of XML files to Java objects



Map Server

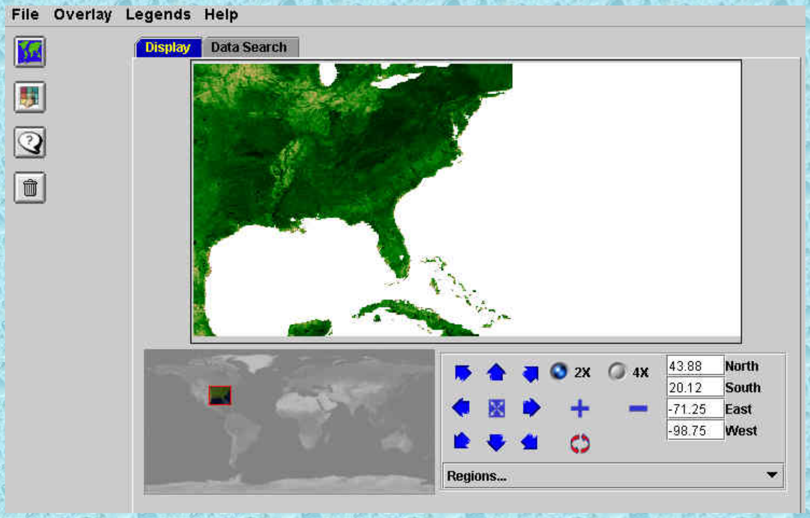
- Handles incoming map request
- Forwards those request to local rendering software or to an external map server
- Resulting image is routed back through the map server to the applet

Diagram of WebGIS

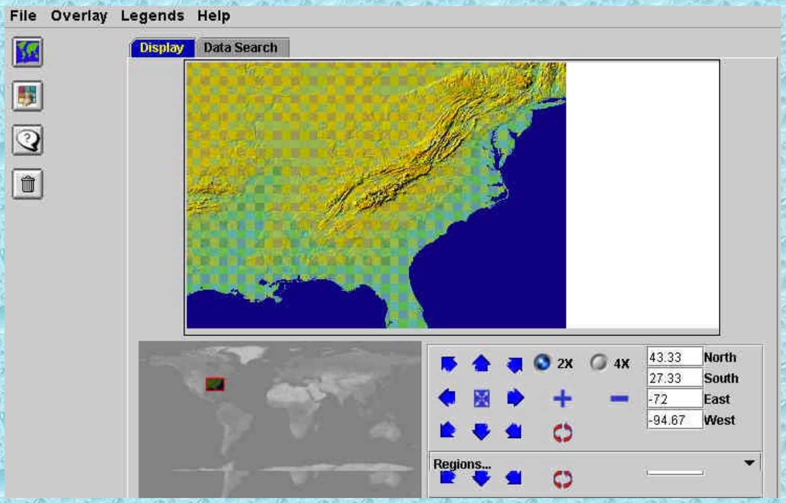


Another example of Web GIS follows

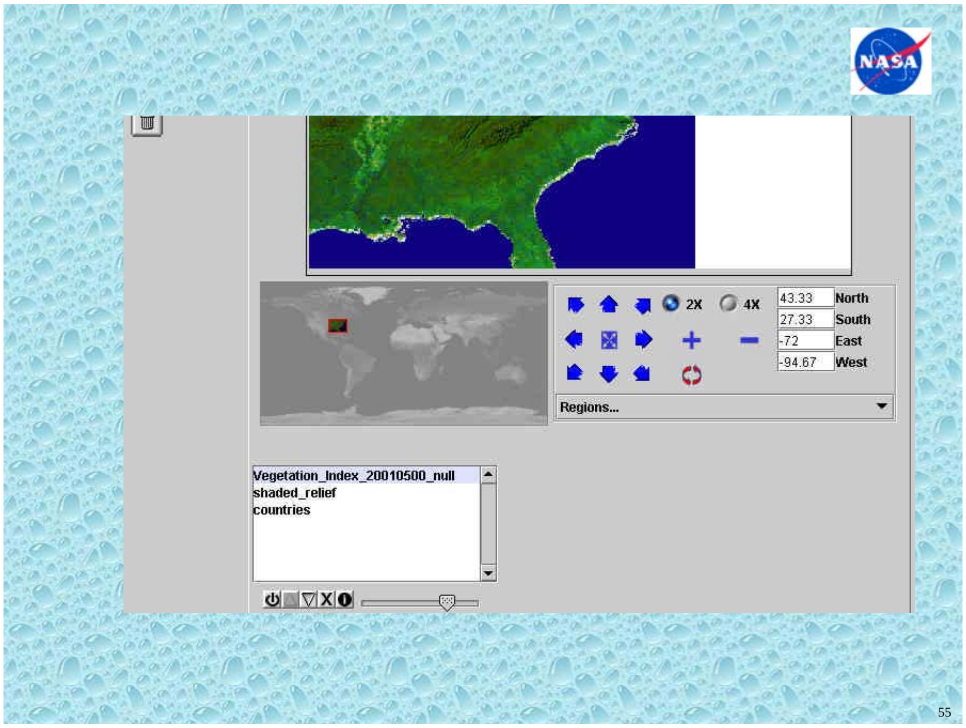
User Interface



43.88 North
20.12 South
-71.25 East
-98.75 West

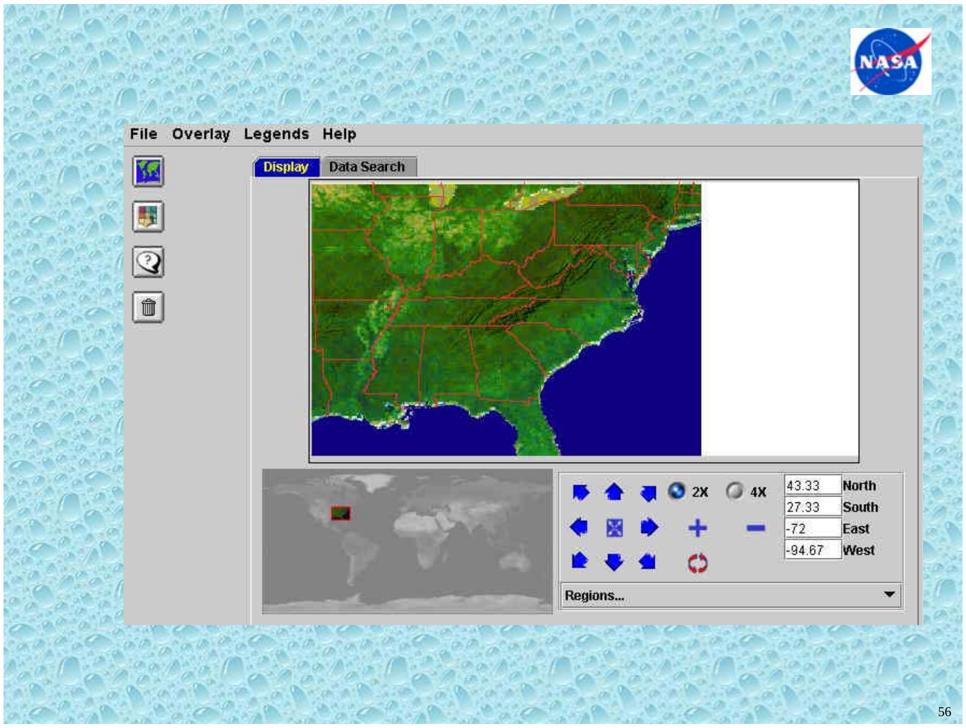


43.33 North
27.33 South
-72 East
-94.67 West

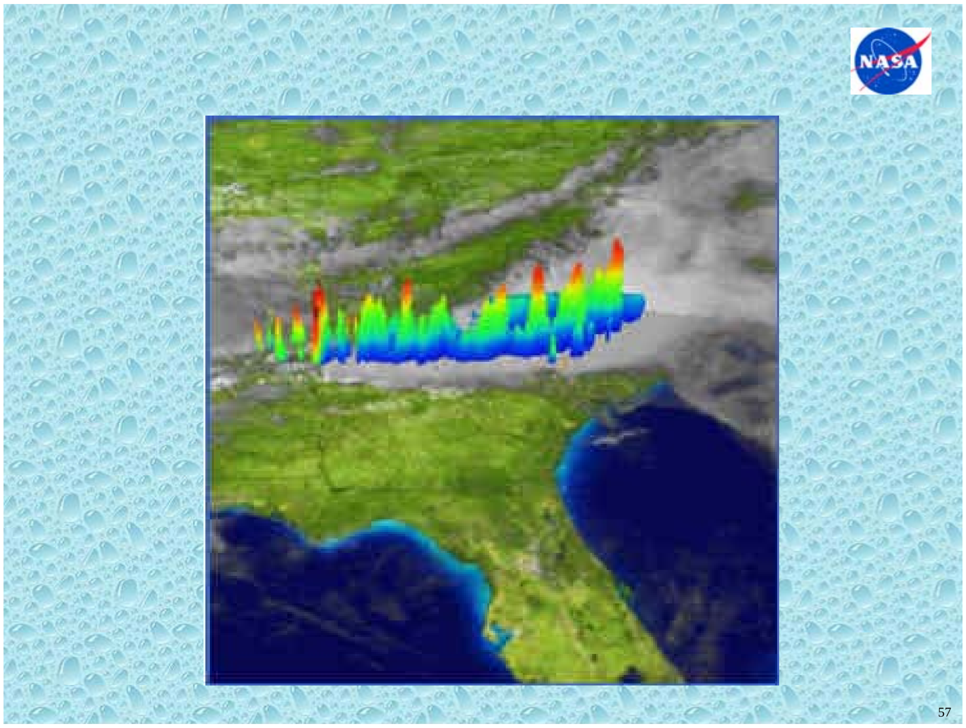


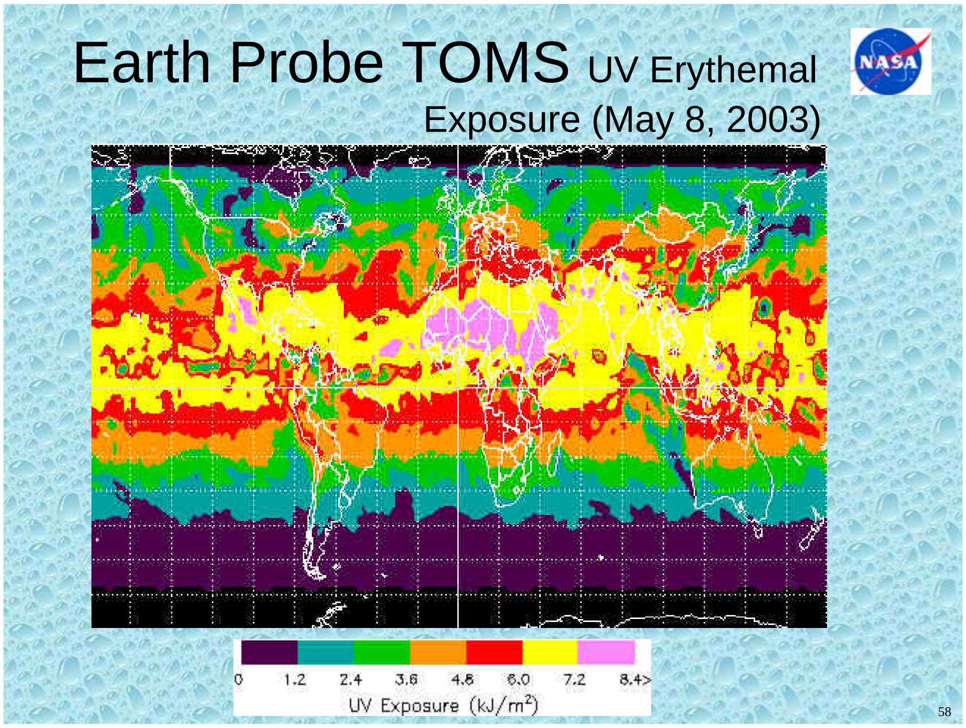
43.33 North
27.33 South
-72 East
-94.67 West

Vegetation_Index_20010500_null
shaded_relief
countries

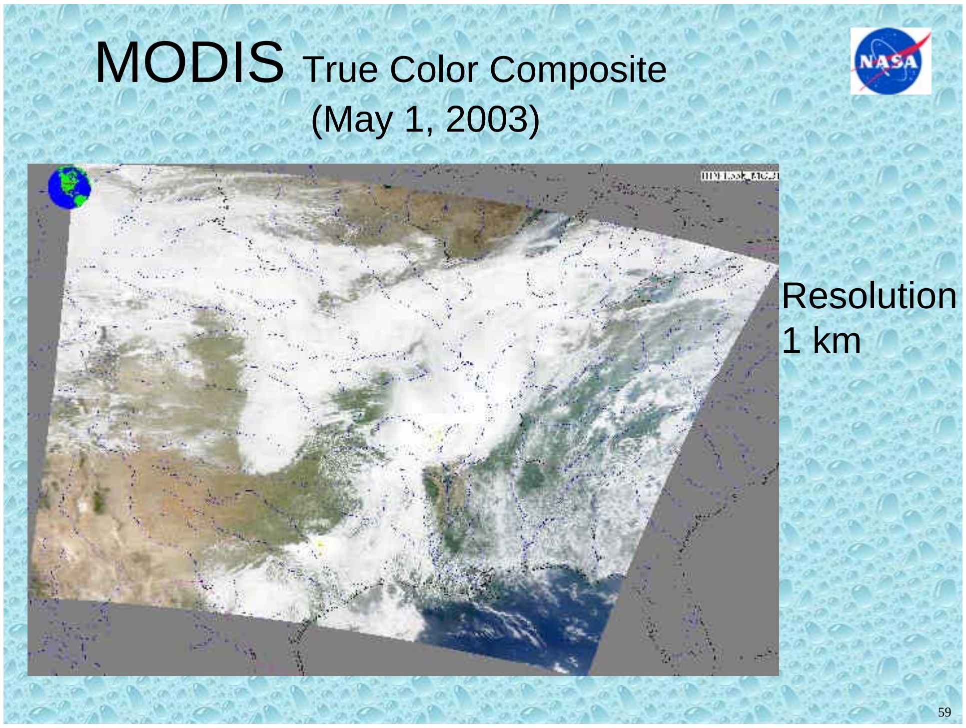


43.33 North
27.33 South
-72 East
-94.67 West



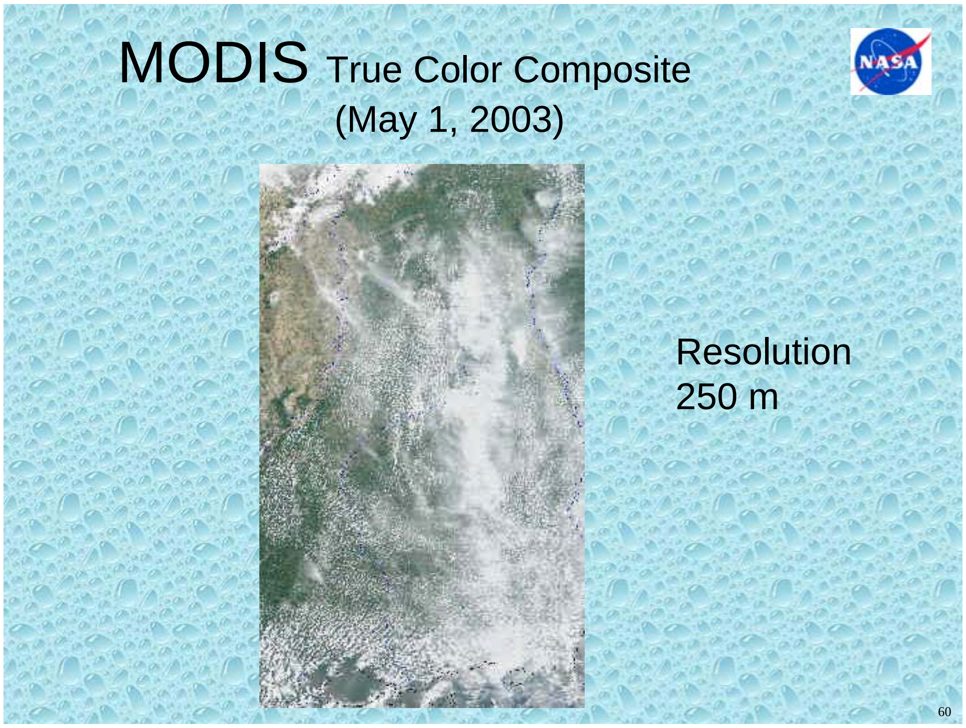


Earth Probe TOMS UV Erythemal Exposure (May 8, 2003)



MODIS True Color Composite (May 1, 2003)

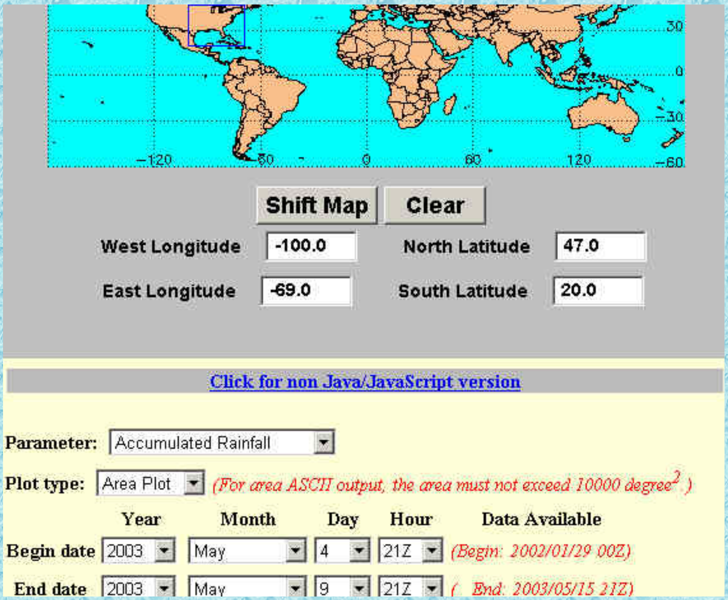
Resolution
1 km



MODIS True Color Composite (May 1, 2003)

Resolution
250 m

DAAC Online Visualization and Analysis Systems (DOVAS)



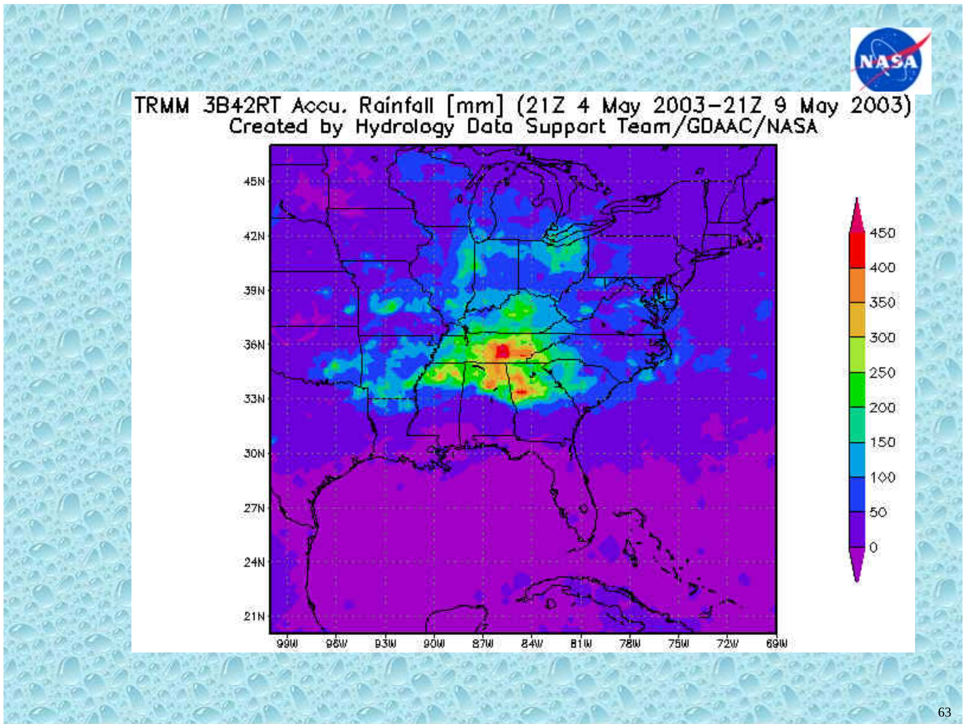
West Longitude: -100.0
North Latitude: 47.0
East Longitude: -69.0
South Latitude: 20.0

Click for non Java/JavaScript version

Parameter: Accumulated Rainfall

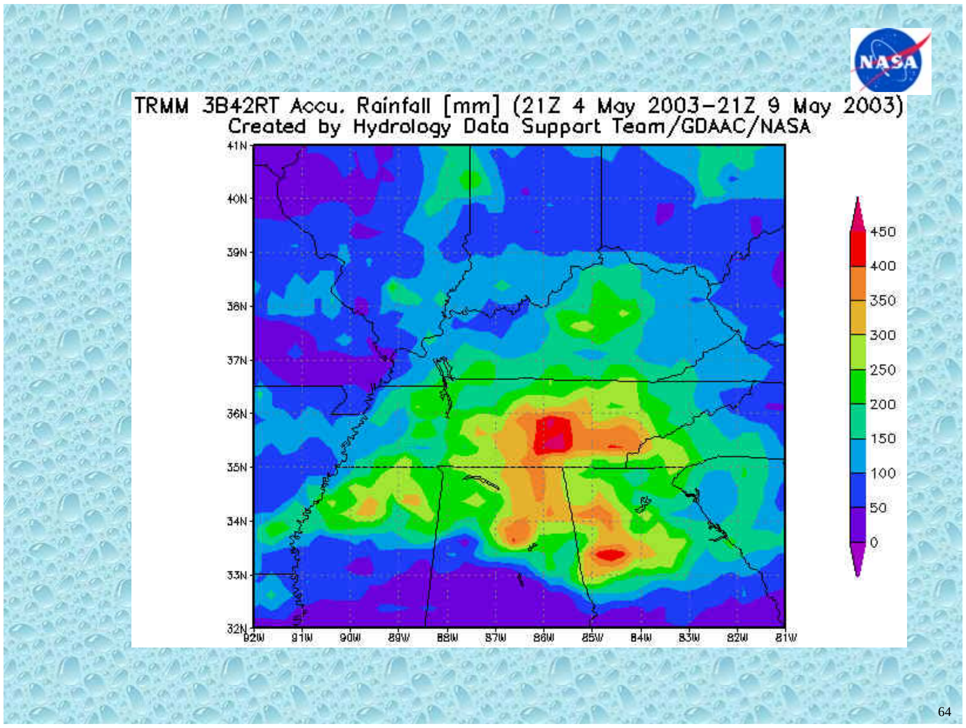
Plot type: Area Plot *(For area ASCII output, the area must not exceed 10000 degree^2)*

	Year	Month	Day	Hour	Data Available
Begin date	2003	May	4	21Z	*(Begin: 2002/01/29 00Z)*
End date	2003	May	9	21Z	*(End: 2003/05/15 21Z)*



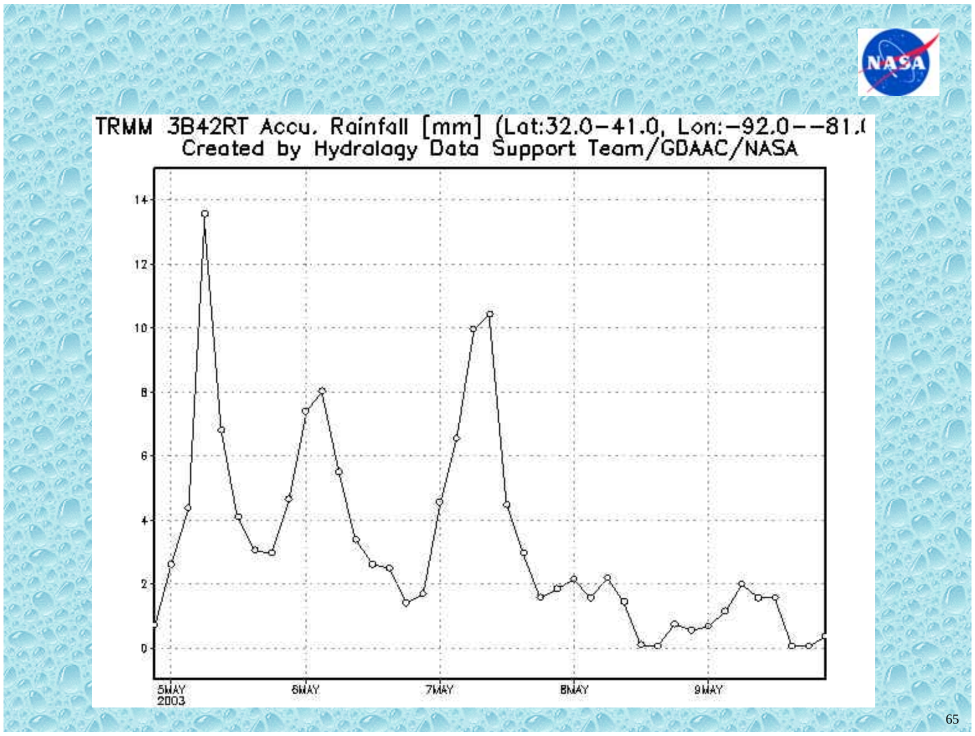
TRMM 3B42RT Accu. Rainfall [mm] (21Z 4 May 2003–21Z 9 May 2003)
Created by Hydrology Data Support Team/GDAAC/NASA

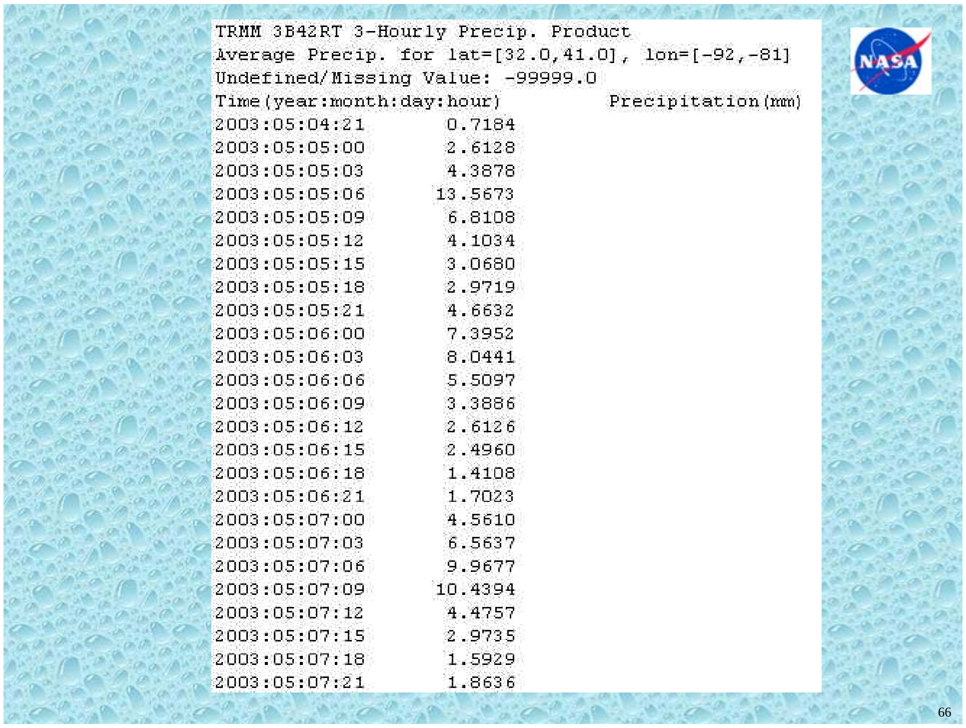
63



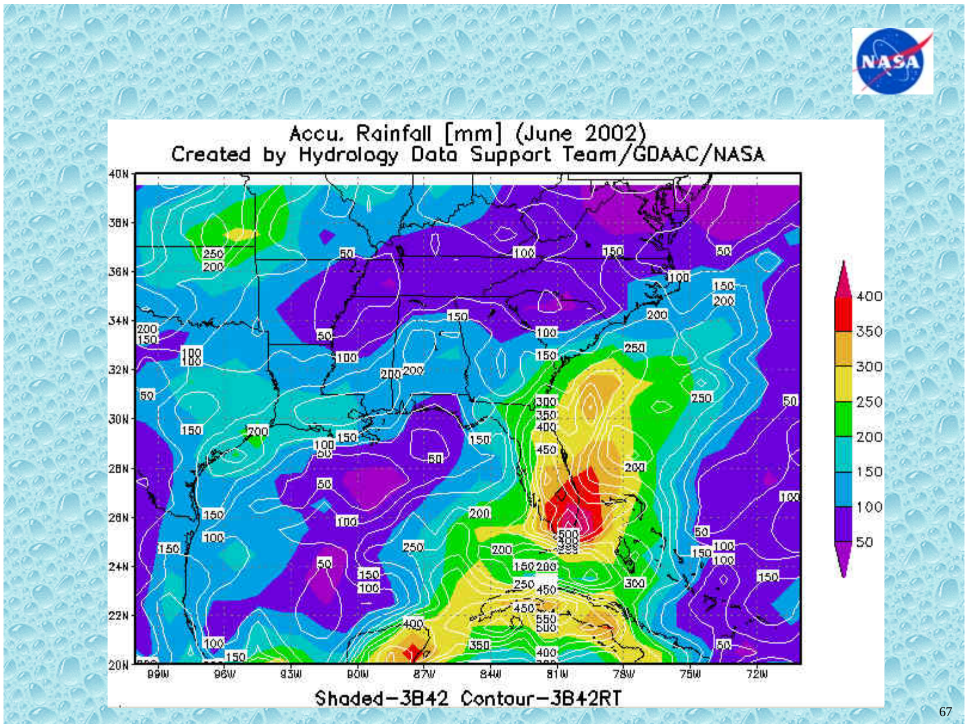
TRMM 3B42RT Accu. Rainfall [mm] (21Z 4 May 2003–21Z 9 May 2003)
Created by Hydrology Data Support Team/GDAAC/NASA

64



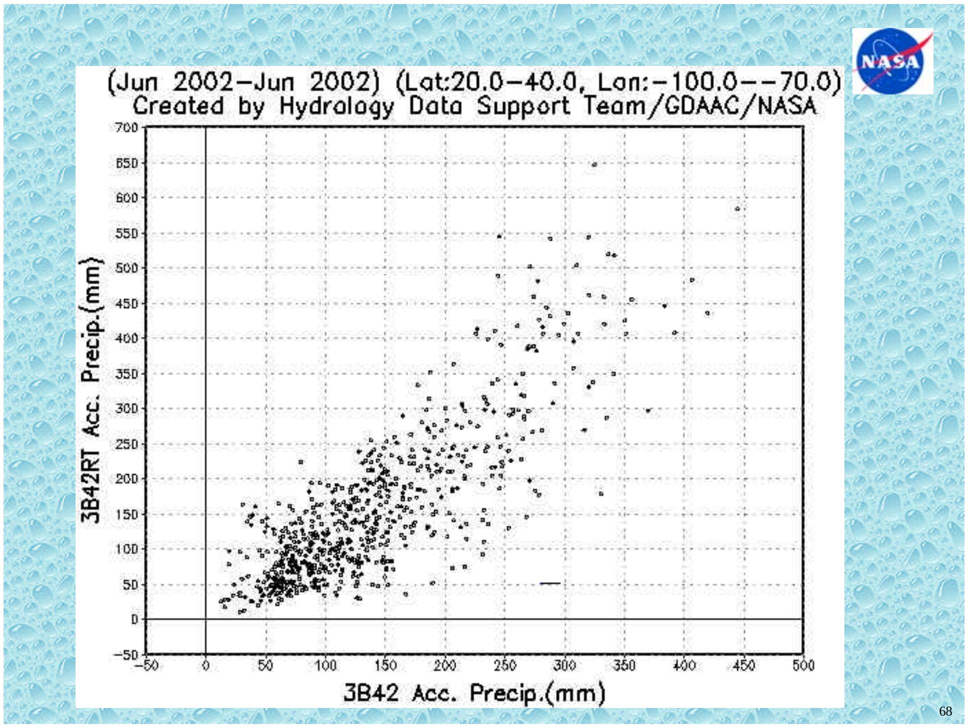


```
TRMM 3B42RT 3-Hourly Precip. Product
Average Precip. for lat=[32.0,41.0], lon=[-92,-81]
Undefined/Missing Value: -99999.0
Time(year:month:day:hour)           Precipitation(mm)
2003:05:04:21        0.7184
2003:05:05:00        2.6128
2003:05:05:03        4.3878
2003:05:05:06       13.5673
2003:05:05:09        6.8108
2003:05:05:12        4.1034
2003:05:05:15        3.0680
2003:05:05:18        2.9719
2003:05:05:21        4.6632
2003:05:06:00        7.3952
2003:05:06:03        8.0441
2003:05:06:06        5.5097
2003:05:06:09        3.3886
2003:05:06:12        2.6126
2003:05:06:15        2.4960
2003:05:06:18        1.4108
2003:05:06:21        1.7023
2003:05:07:00        4.5610
2003:05:07:03        6.5637
2003:05:07:06        9.9677
2003:05:07:09       10.4394
2003:05:07:12        4.4757
2003:05:07:15        2.9735
2003:05:07:18        1.5929
2003:05:07:21        1.8636
```



Accu. Rainfall [mm] (June 2002)
Created by Hydrology Data Support Team/GDAAC/NASA

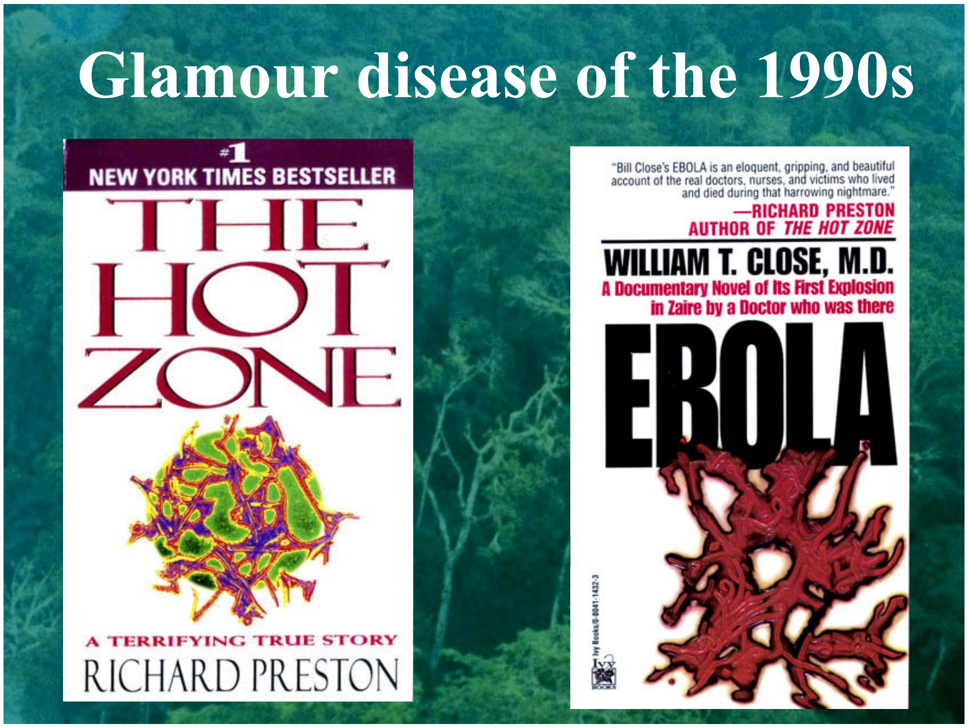
Shaded-3B42 Contour-3B42RT



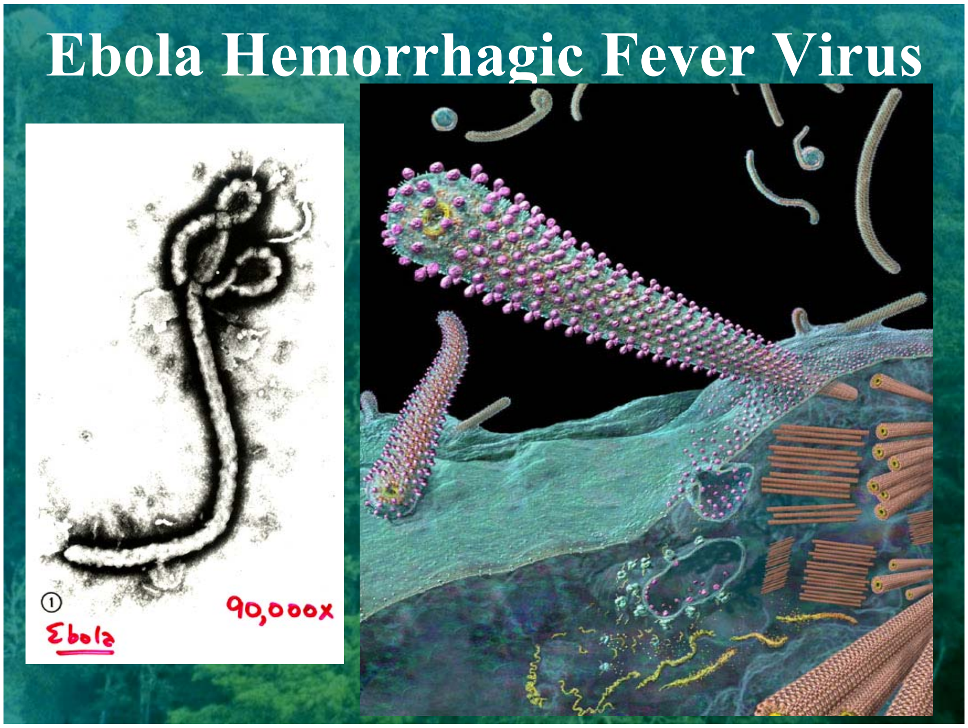
(Jun 2002–Jun 2002) (Lat:20.0–40.0, Lon:–100.0––70.0)
Created by Hydrology Data Support Team/GDAAC/NASA

Ebola River Hemorrhagic Fever

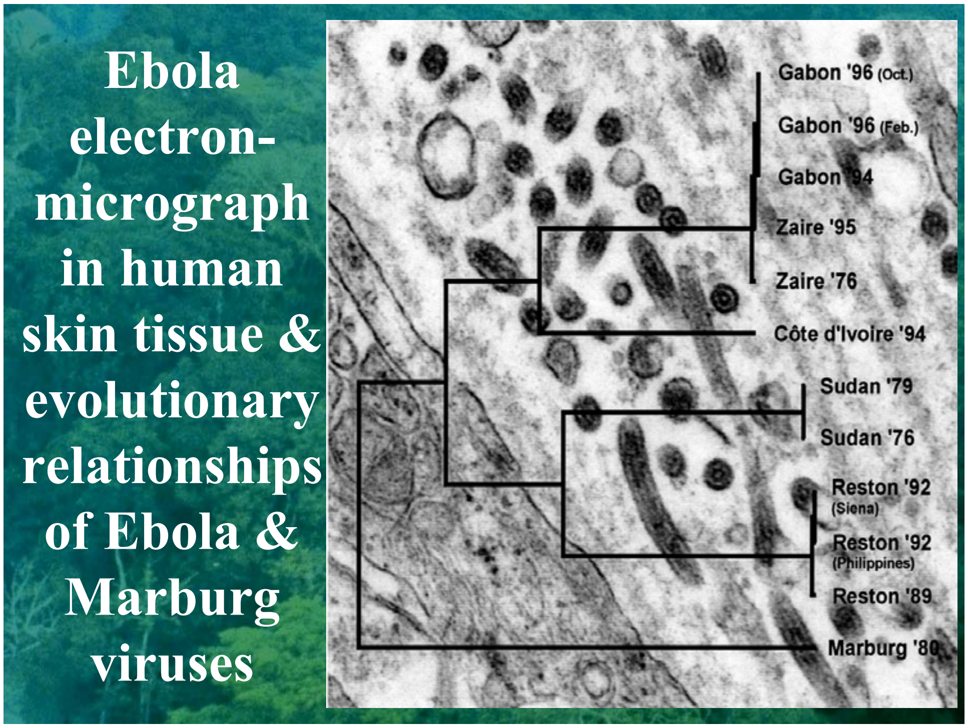
Ebola hemorrhagic fever outbreaks have occurred in African tropical rain forest or in gallery tropical forest



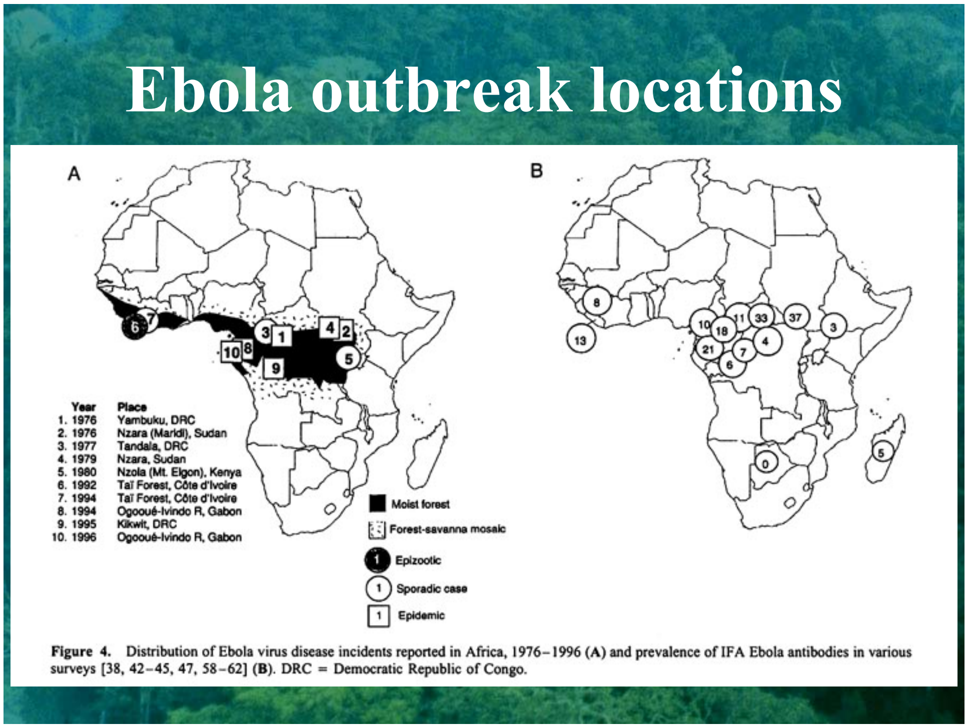
Glamour disease of the 1990s



Ebola Hemorrhagic Fever Virus



Ebola electron-micrograph in human skin tissue & evolutionary relationships of Ebola & Marburg viruses

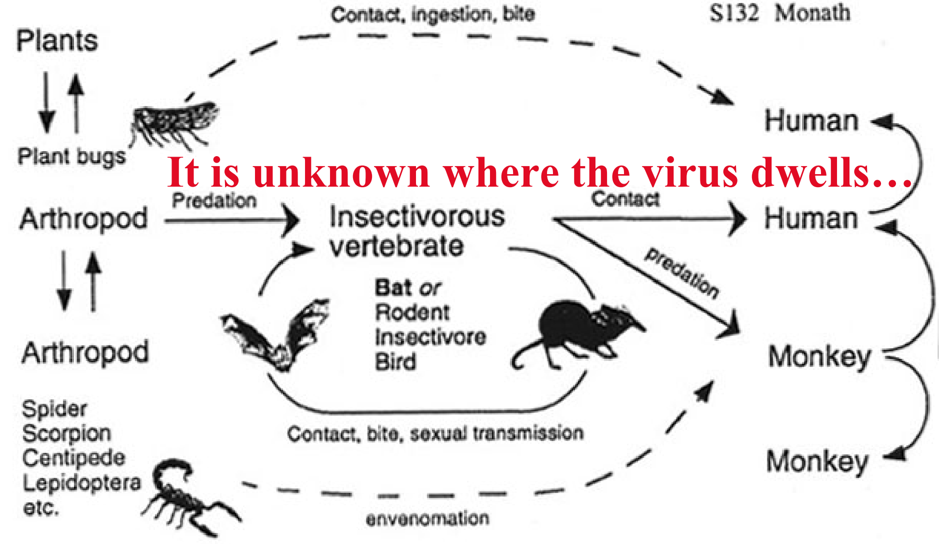


Ebola outbreak locations

	Year	Place
1.	1976	Yambuku, DRC
2.	1976	Nzara (Maridi), Sudan
3.	1977	Tandala, DRC
4.	1979	Nzara, Sudan
5.	1980	Nzola (Mt. Elgon), Kenya
6.	1992	Taï Forest, Côte d'Ivoire
7.	1994	Taï Forest, Côte d'Ivoire
8.	1994	Ogooué-Ivindo R, Gabon
9.	1995	Kikwit, DRC
10.	1996	Ogooué-Ivindo R, Gabon

Figure 4. Distribution of Ebola virus disease incidents reported in Africa, 1976–1996 (**A**) and prevalence of IFA Ebola antibodies in various surveys [38, 42–45, 47, 58–62] (**B**). DRC = Democratic Republic of Congo.

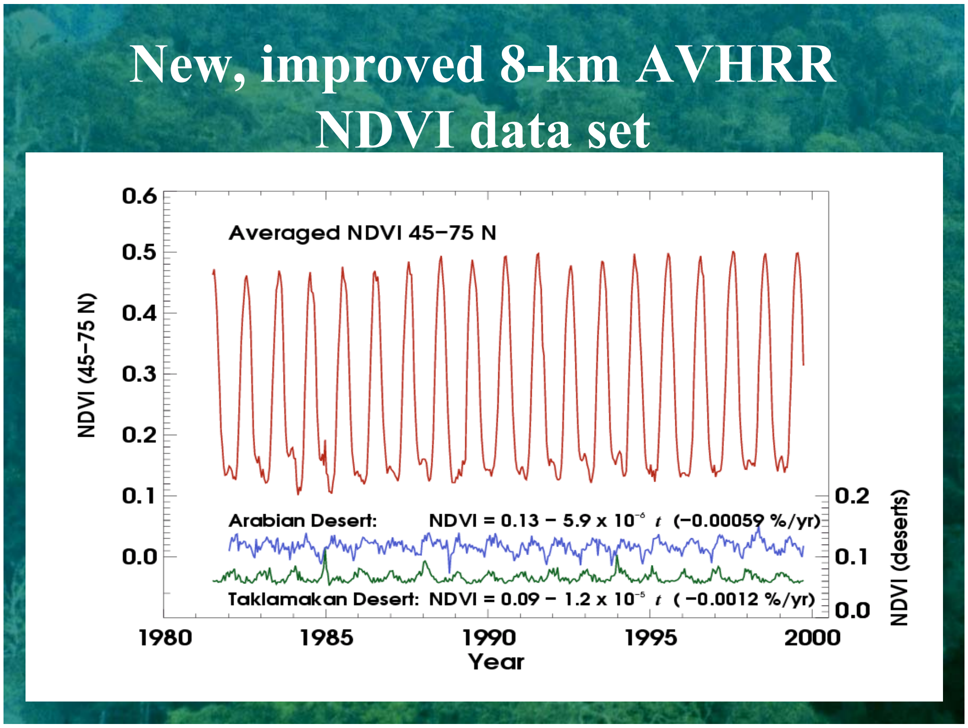
Possible Ebola Transmission(s) no usual suspects!



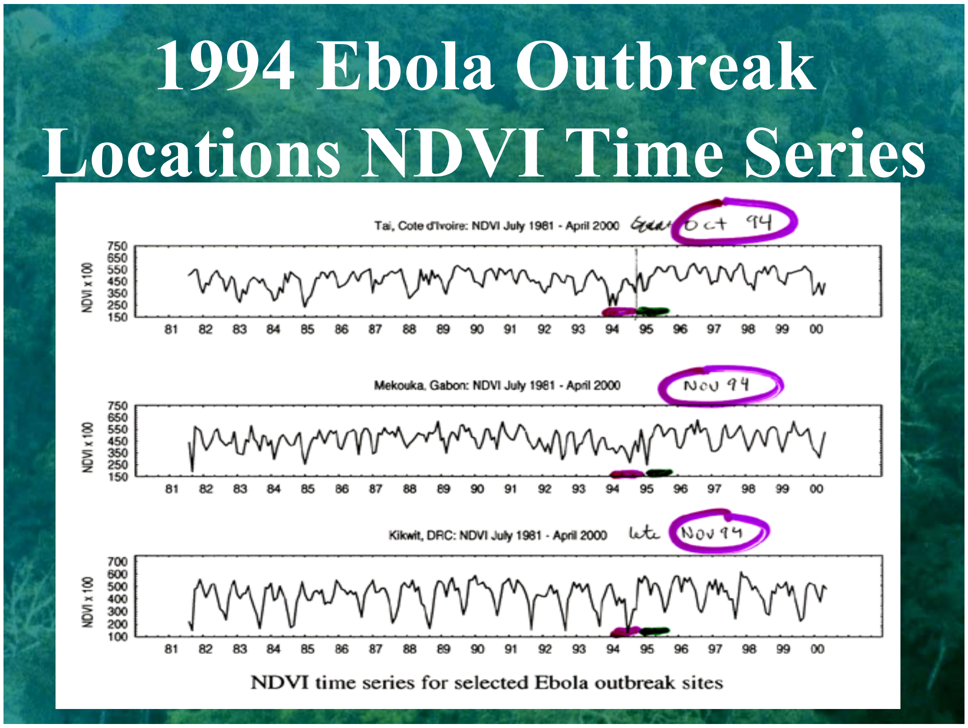
It is unknown where the virus dwells…

Ebola Outbreaks

Epidemic Site	Date of Index Case Clinical Presentation	cases	fatalities
Narza and Maridi, Sudan	June 1974	284	151
Yambuku, Congo	September 1976	318	280
Tandala, Congo	June 1977	1	1
Narza, Sudan	July 1979	34	22
Tai, Cote d'Ivoire	October 1994	12/1	12/0
Mekouka, Andock, Minkebe, Gabon	November 1994	49	29
Kikwit, DRC	November 1994	315	242
Mayibout II, Gabon	January 1996	31	21
Booue, Gabon	July 1996	60	40
Gulu, Uganda	August 2000		
Ogooue-Ivindo, Gabon	December 2001		



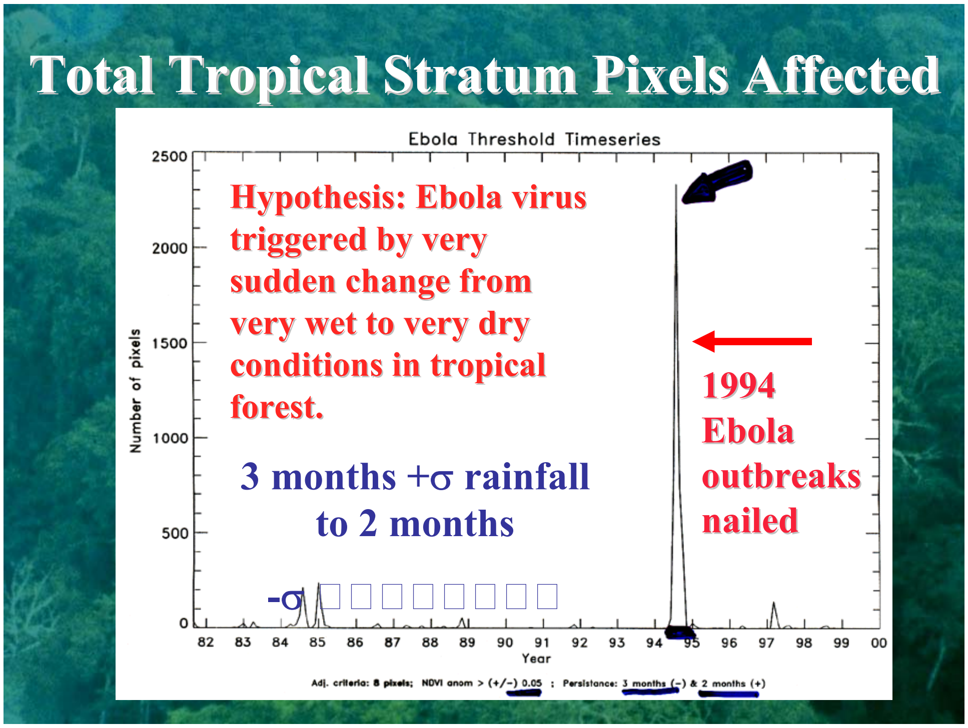
New, improved 8-km AVHRR NDVI data set



1994 Ebola Outbreak Locations NDVI Time Series

NDVI time series for selected Ebola outbreak sites

Total Tropical Stratum Pixels Affected



Hypothesis: Ebola virus triggered by very sudden change from very wet to very dry conditions in tropical forest.

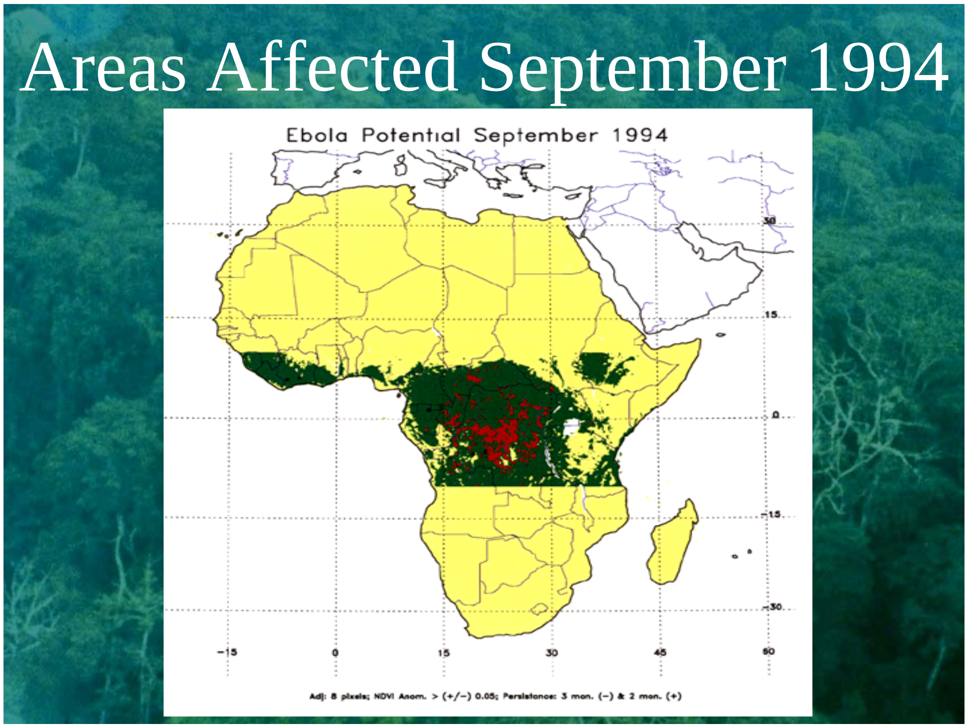
3 months +σ rainfall to 2 months

-σ □□□□□□□□

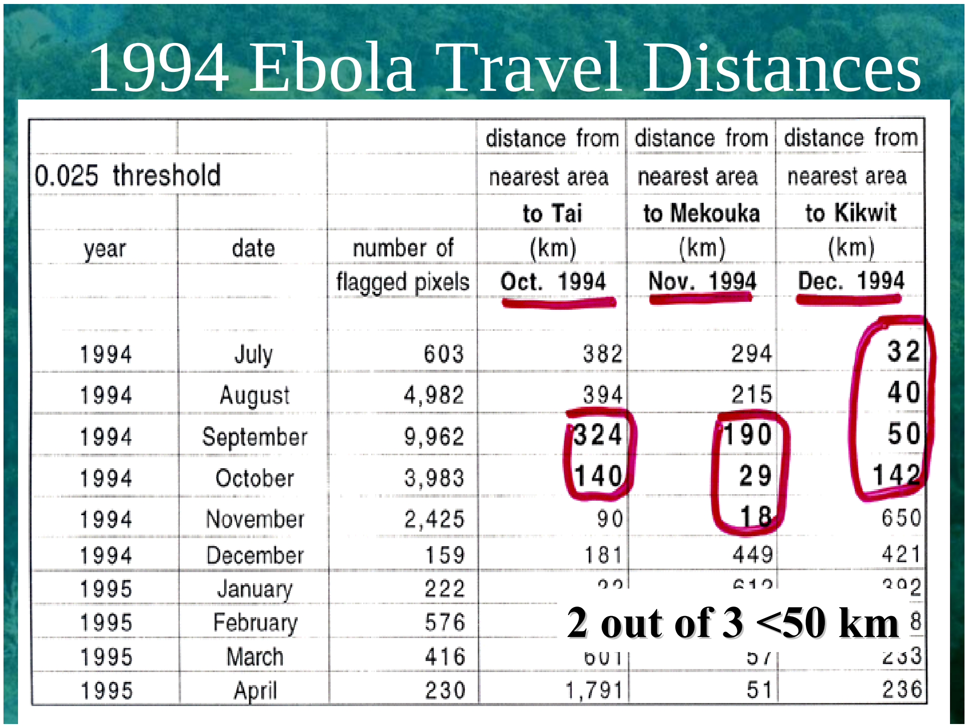
1994 Ebola outbreaks nailed

Adj. criteria: 8 pixels; NDVI anom > (+/−) 0.05 ; Persistance: 3 months (−) & 2 months (+)

Areas Affected September 1994



Adj: 8 pixels; NDVI Anom. > (+/−) 0.05; Persistance: 3 mon. (−) & 2 mon. (+)

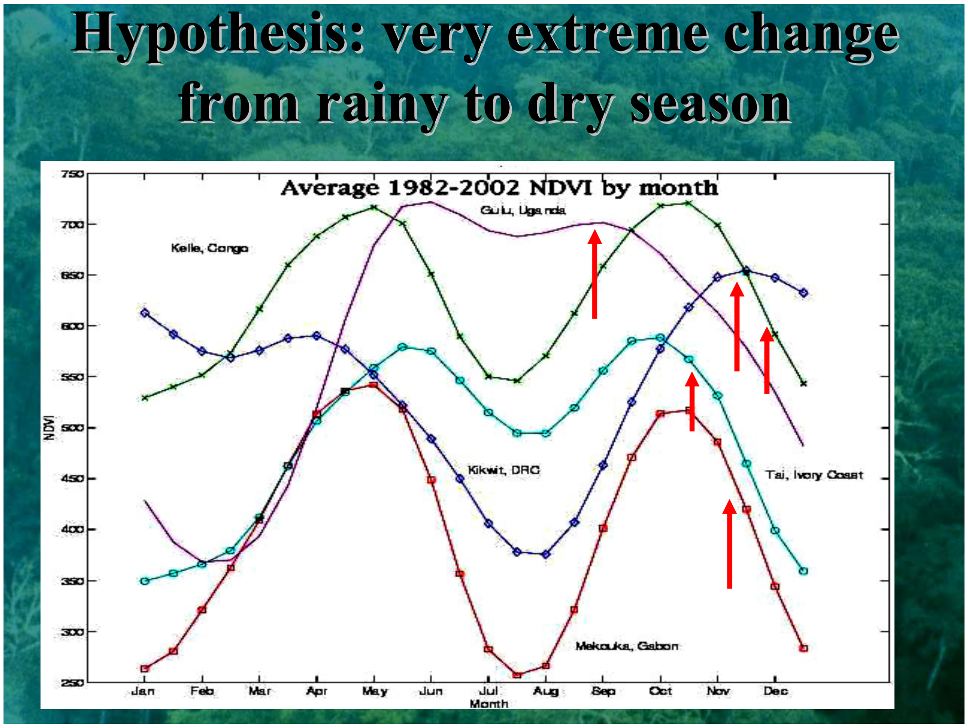


1994 Ebola Travel Distances

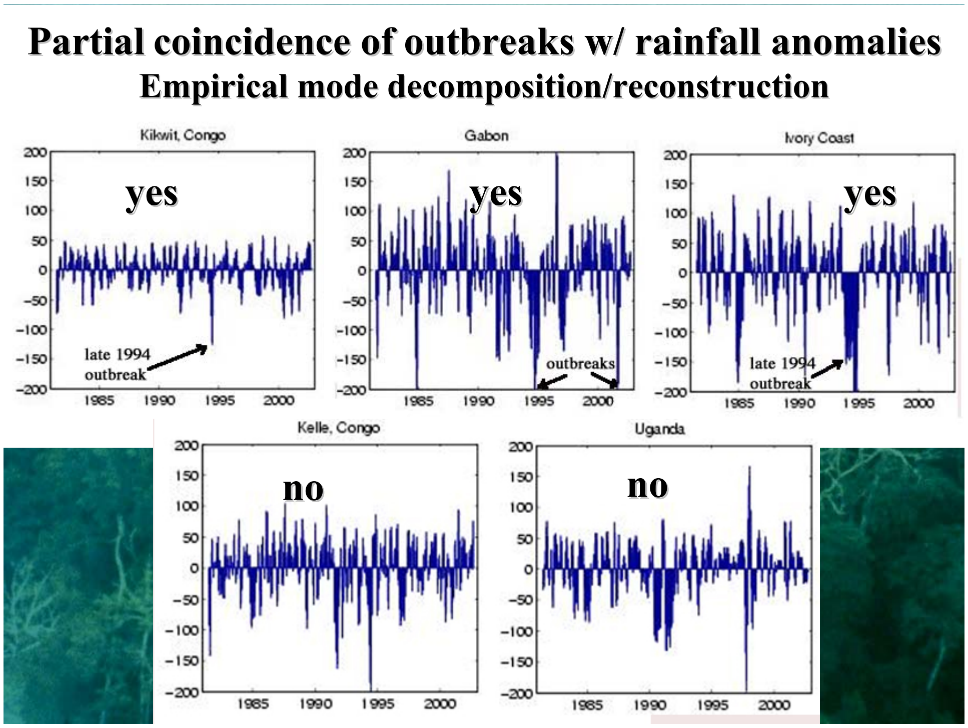
0.025 threshold

year	date	number of flagged pixels	distance from nearest area to Tai (km) Oct. 1994	distance from nearest area to Mekouka (km) Nov. 1994	distance from nearest area to Kikwit (km) Dec. 1994
1994	July	603	382	294	32
1994	August	4,982	394	215	40
1994	September	9,962	324	190	50
1994	October	3,983	140	29	142
1994	November	2,425	90	18	650
1994	December	159	181	449	421
1995	January	222	22	612	302
1995	February	576	[illegible]	[illegible]	8
1995	March	416	601	57	233
1995	April	230	1,791	51	236

2 out of 3 <50 km

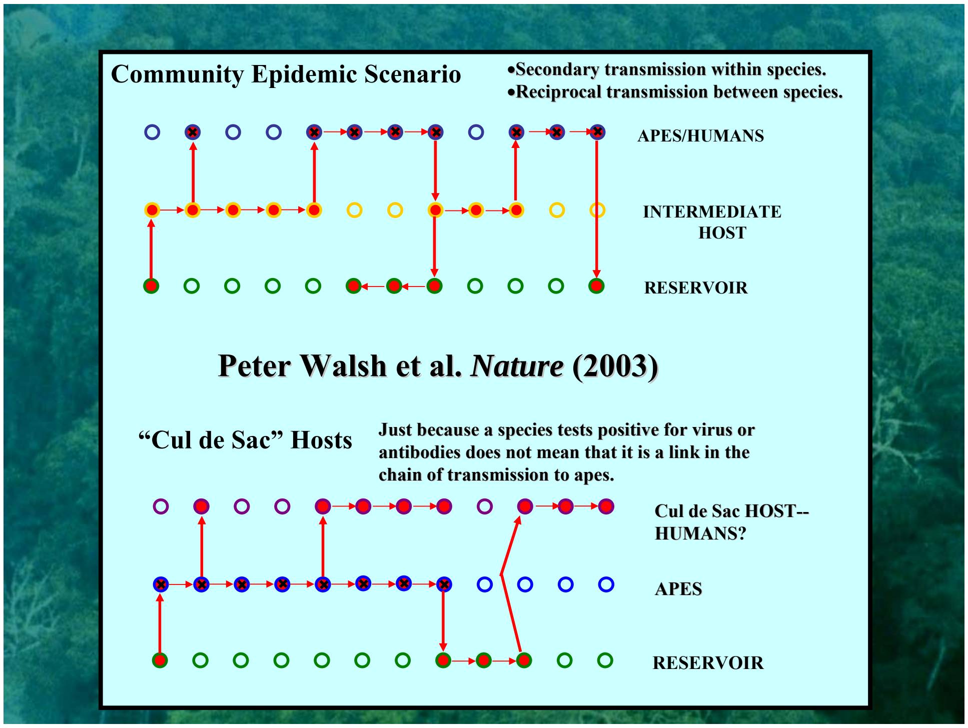


Hypothesis: very extreme change from rainy to dry season



Partial coincidence of outbreaks w/ rainfall anomalies

Empirical mode decomposition/reconstruction



Community Epidemic Scenario

- Secondary transmission within species.
- Reciprocal transmission between species.

Peter Walsh et al. *Nature* (2003)

“Cul de Sac” Hosts

Just because a species tests positive for virus or antibodies does not mean that it is a link in the chain of transmission to apes.

Ebola River Hemorrhagic Fever

???

Global Emerging Infections System

Yemen 2000 Rift Valley Fever Outbreak

NASA Remote Sensing, Human Health, National Security: Decision Support by the U.S. Army

NASA/GSFC-Walter Reed Project

Global Emerging Infections System

Yemen 2000 Rift Valley Fever Outbreak

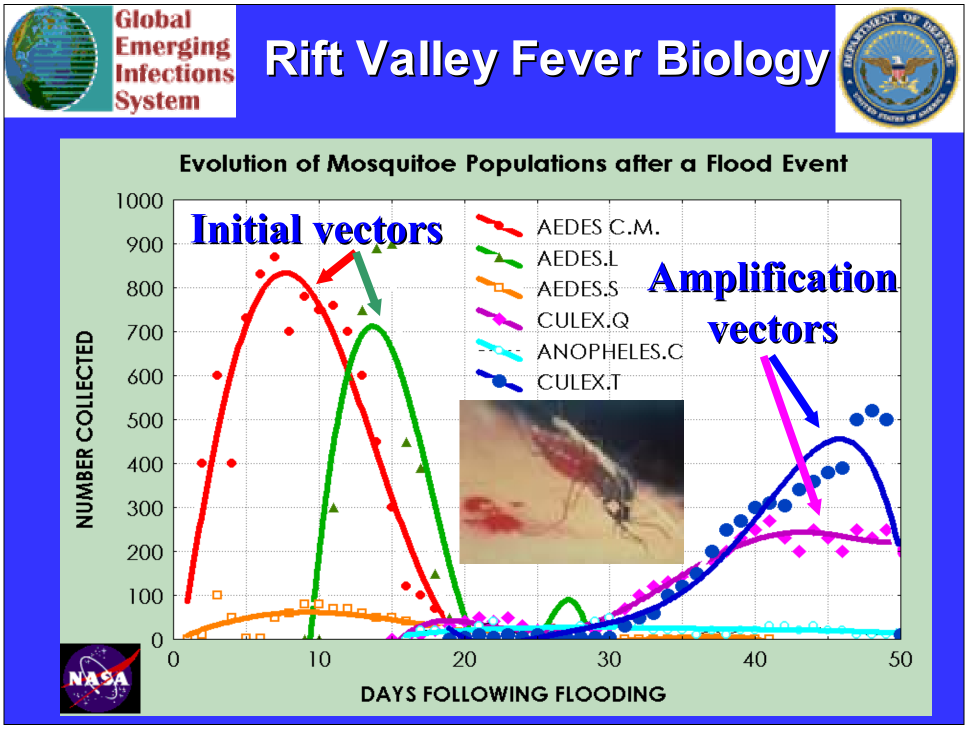
Rift Valley Fever was a USSR biowarfare agent

Viral hemorrhagic fever native to arid/semiarid Africa-Arabia

Yemen Outbreak in late 2000 (316 cases/66 dead)

Known site of virulent anti-American activity (e.g. USS Cole etc.)

QUESTION: natural or intentional-accidental release???



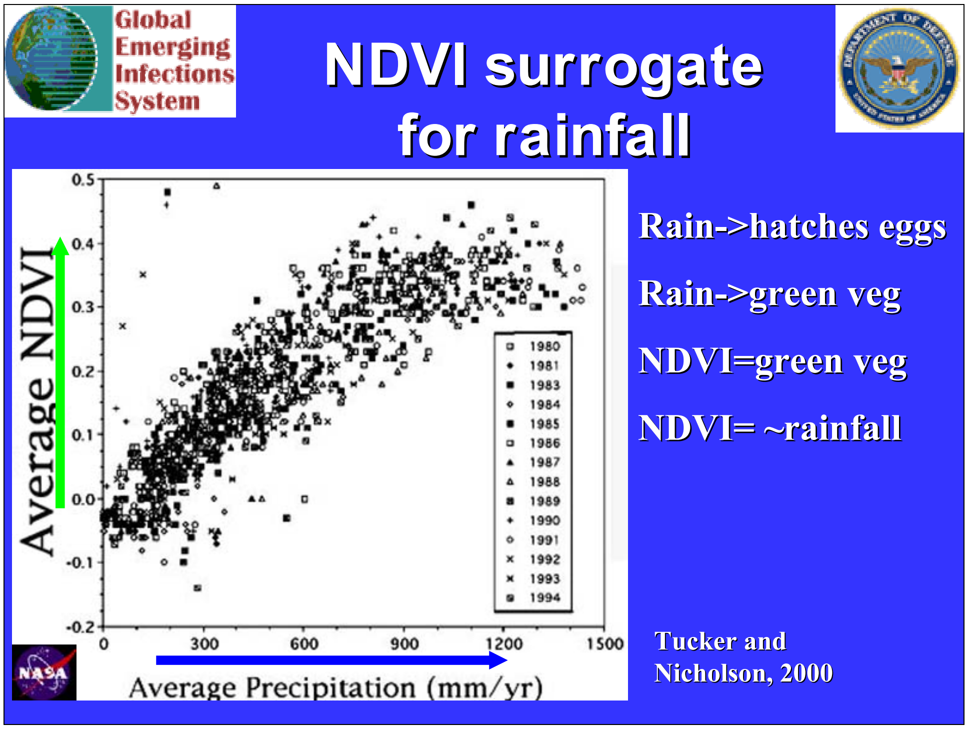
Global Emerging Infections System

Rift Valley Fever Biology

Evolution of Mosquitoe Populations after a Flood Event

Initial vectors

Amplification vectors



Global Emerging Infections System

NDVI surrogate for rainfall

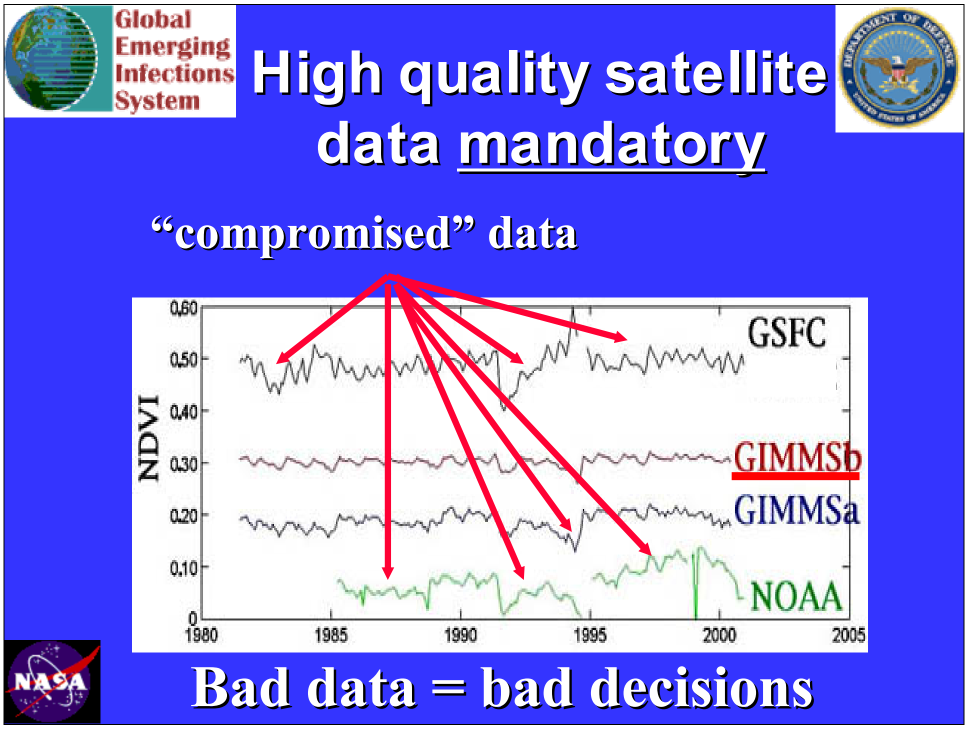
Rain->hatches eggs

Rain->green veg

NDVI=green veg

NDVI= ~rainfall

Tucker and Nicholson, 2000

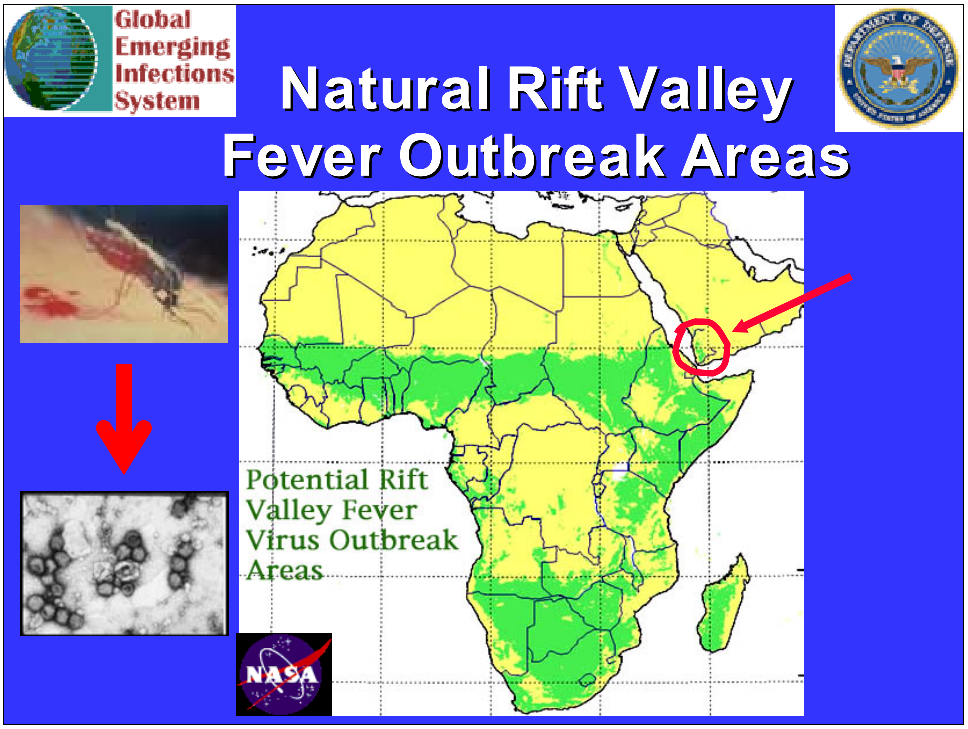


Global Emerging Infections System

High quality satellite data mandatory

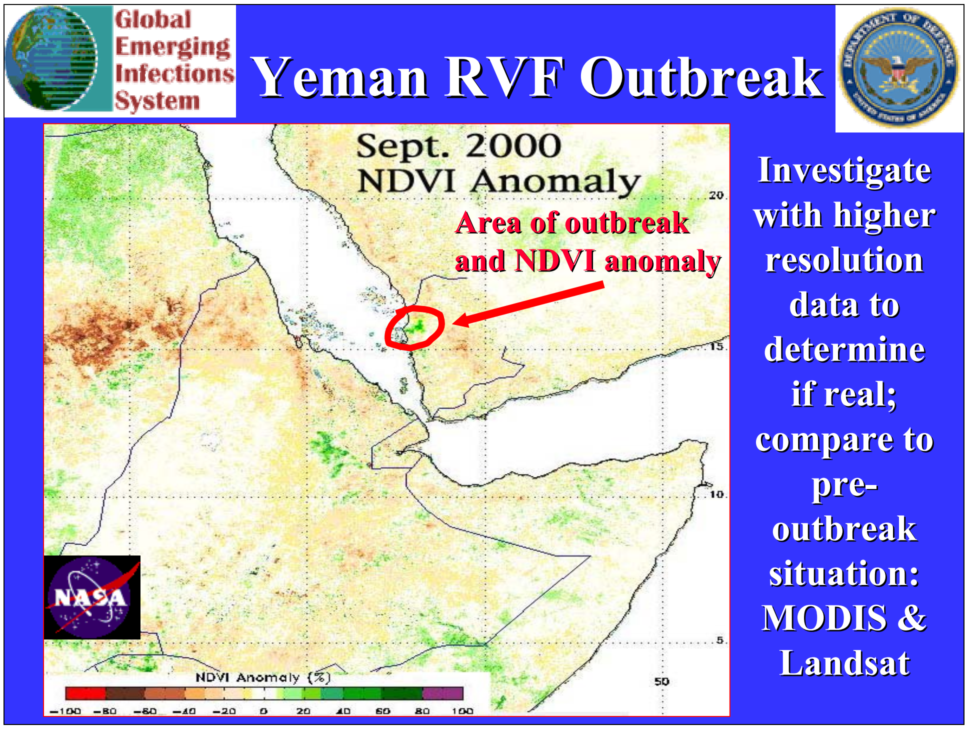
"compromised" data

Bad data = bad decisions



Global Emerging Infections System

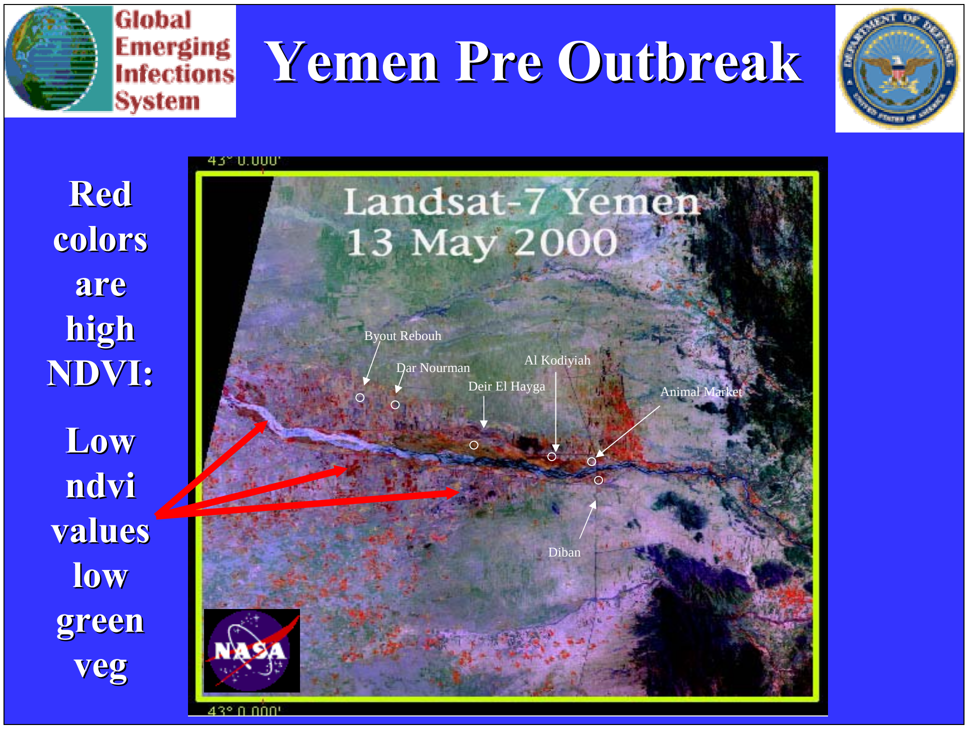
Natural Rift Valley Fever Outbreak Areas



Global Emerging Infections System

Yeman RVF Outbreak

Investigate with higher resolution data to determine if real; compare to pre-outbreak situation: MODIS & Landsat

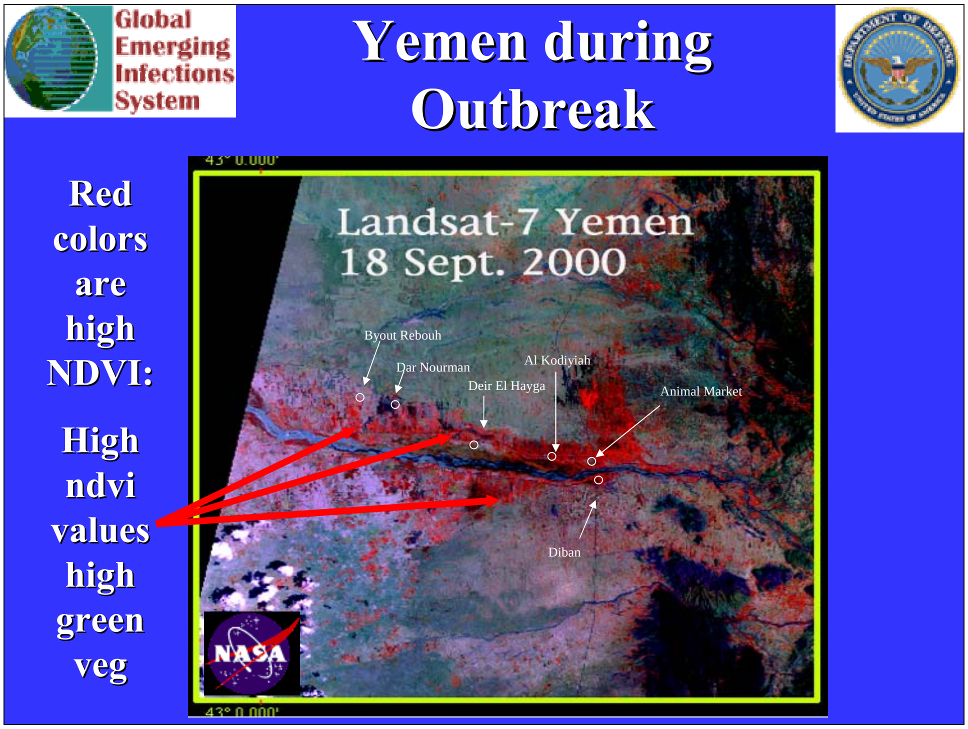


Global Emerging Infections System

Yemen Pre Outbreak

Red colors are high NDVI:

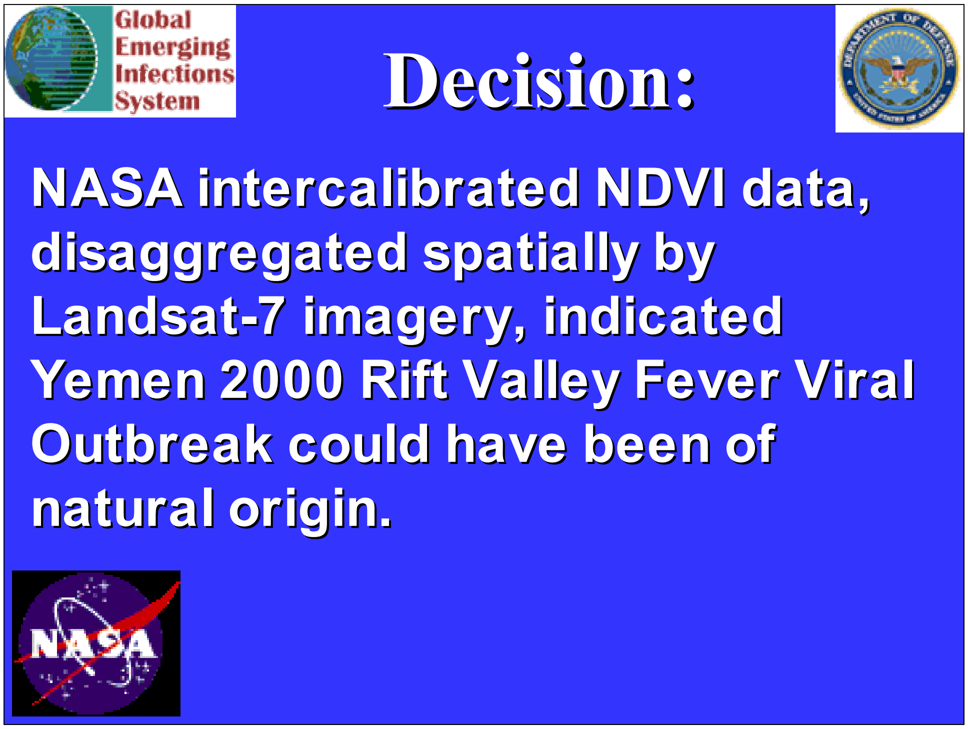
Low ndvi values low green veg



Yemen during Outbreak

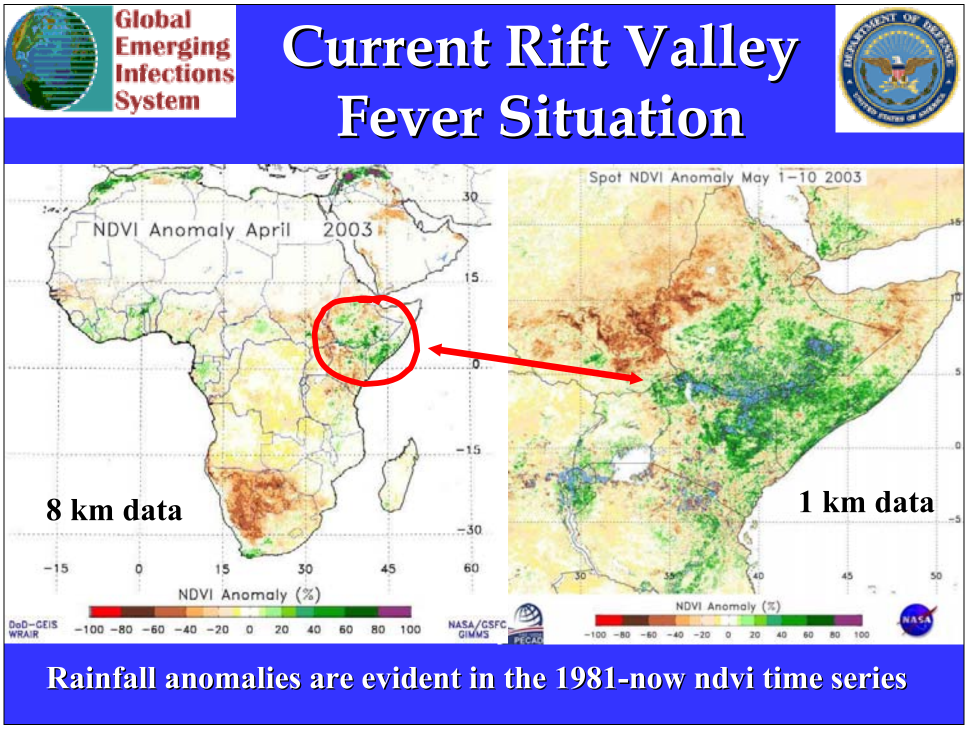
Red colors are high NDVI:

High ndvi values high green veg



Decision:

NASA intercalibrated NDVI data, disaggregated spatially by Landsat-7 imagery, indicated Yemen 2000 Rift Valley Fever Viral Outbreak could have been of natural origin.

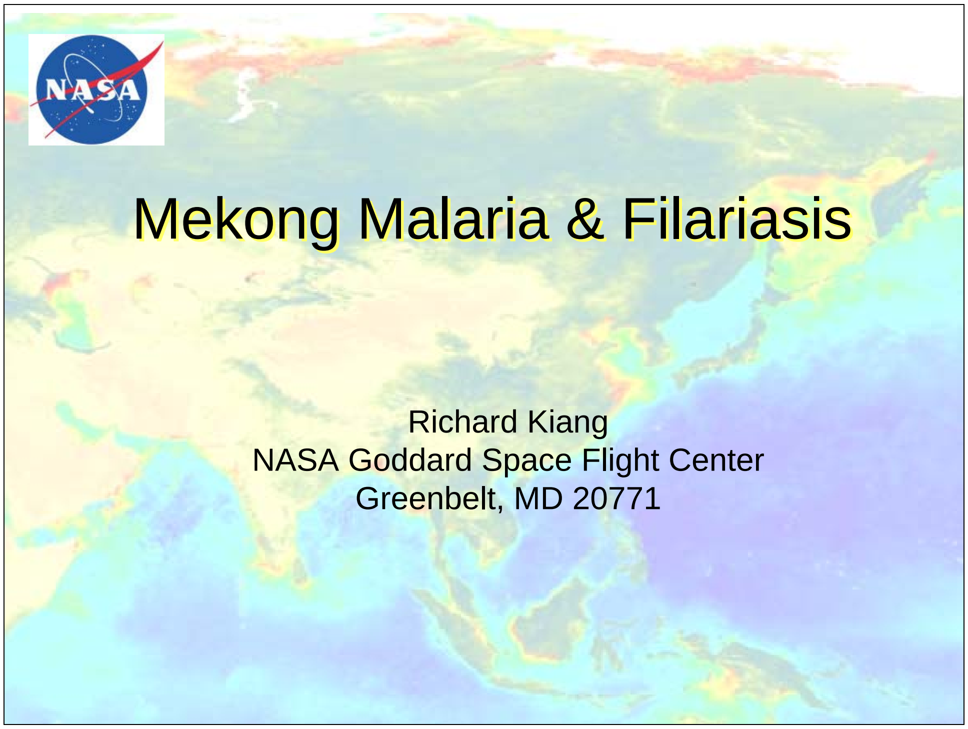


Global Emerging Infections System

Current Rift Valley Fever Situation

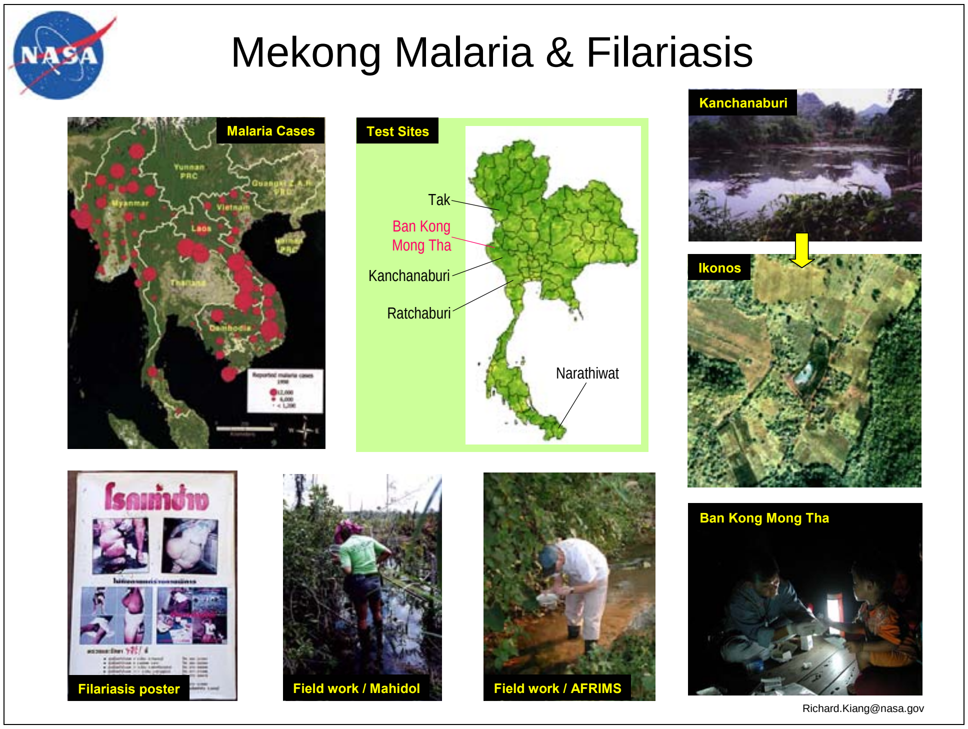
Rainfall anomalies are evident in the 1981-now ndvi time series

Richard Kiang, PhD
“Mekong Malaria and Filariasis”



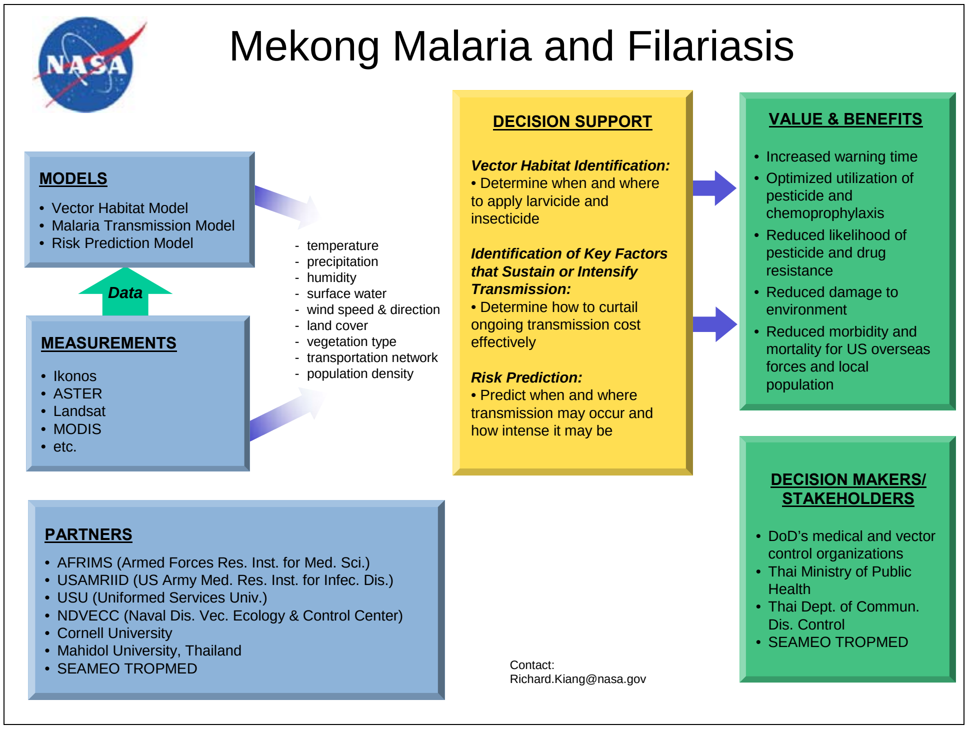
Mekong Malaria & Filariasis

Richard Kiang
NASA Goddard Space Flight Center
Greenbelt, MD 20771



Mekong Malaria & Filariasis

Richard.Kiang@nasa.gov



Mekong Malaria and Filariasis

MODELS

- Vector Habitat Model
- Malaria Transmission Model
- Risk Prediction Model

Data

MEASUREMENTS

- Ikonos
- ASTER
- Landsat
- MODIS
- etc.

- temperature
- precipitation
- humidity
- surface water
- wind speed & direction
- land cover
- vegetation type
- transportation network
- population density

DECISION SUPPORT

Vector Habitat Identification:
• Determine when and where to apply larvicide and insecticide

Identification of Key Factors that Sustain or Intensify Transmission:
• Determine how to curtail ongoing transmission cost effectively

Risk Prediction:
• Predict when and where transmission may occur and how intense it may be

VALUE & BENEFITS

- Increased warning time
- Optimized utilization of pesticide and chemoprophylaxis
- Reduced likelihood of pesticide and drug resistance
- Reduced damage to environment
- Reduced morbidity and mortality for US overseas forces and local population

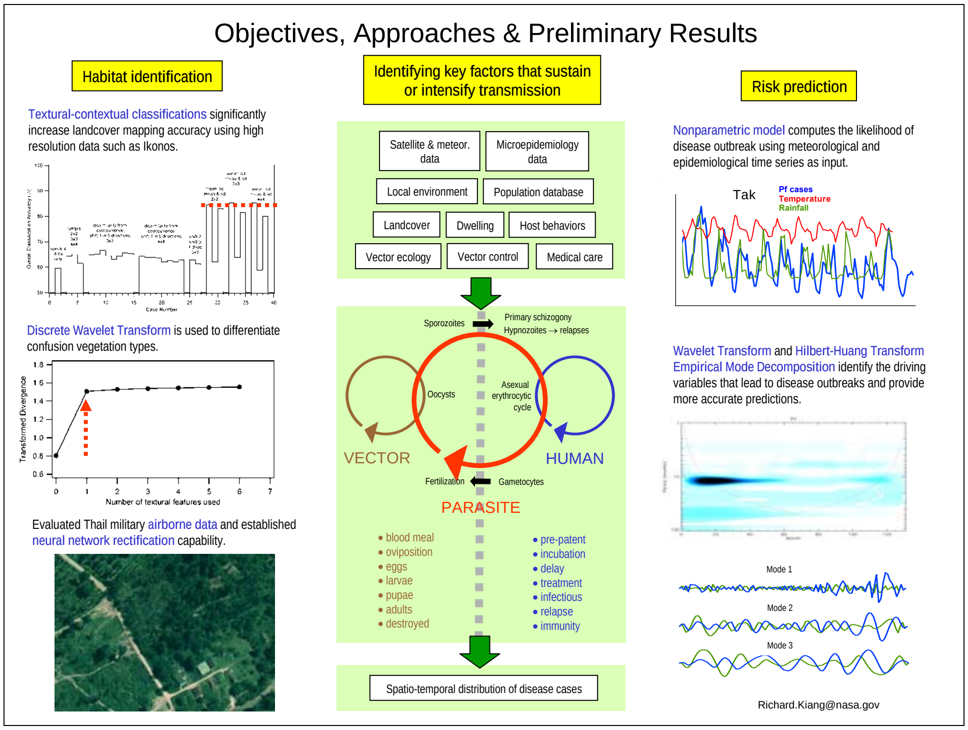
PARTNERS

- AFRIMS (Armed Forces Res. Inst. for Med. Sci.)
- USAMRIID (US Army Med. Res. Inst. for Infec. Dis.)
- USU (Uniformed Services Univ.)
- NDVECC (Naval Dis. Vec. Ecology & Control Center)
- Cornell University
- Mahidol University, Thailand
- SEAMEO TROPMED

DECISION MAKERS/ STAKEHOLDERS

- DoD's medical and vector control organizations
- Thai Ministry of Public Health
- Thai Dept. of Commun. Dis. Control
- SEAMEO TROPMED

Contact:
Richard.Kiang@nasa.gov



Objectives, Approaches & Preliminary Results

Habitat identification

Textural-contextual classifications significantly increase landcover mapping accuracy using high resolution data such as Ikonos.

Discrete Wavelet Transform is used to differentiate confusion vegetation types.

Evaluated Thail military airborne data and established neural network rectification capability.

Identifying key factors that sustain or intensify transmission

Satellite & meteor. data
Microepidemiology data
Local environment
Population database
Landcover
Dwelling
Host behaviors
Vector ecology
Vector control
Medical care

- blood meal
- oviposition
- eggs
- larvae
- pupae
- adults
- destroyed

- pre-patent
- incubation
- delay
- treatment
- infectious
- relapse
- immunity

Spatio-temporal distribution of disease cases

Risk prediction

Nonparametric model computes the likelihood of disease outbreak using meteorological and epidemiological time series as input.

Wavelet Transform and Hilbert-Huang Transform Empirical Mode Decomposition identify the driving variables that lead to disease outbreaks and provide more accurate predictions.

Richard.Kiang@nasa.gov

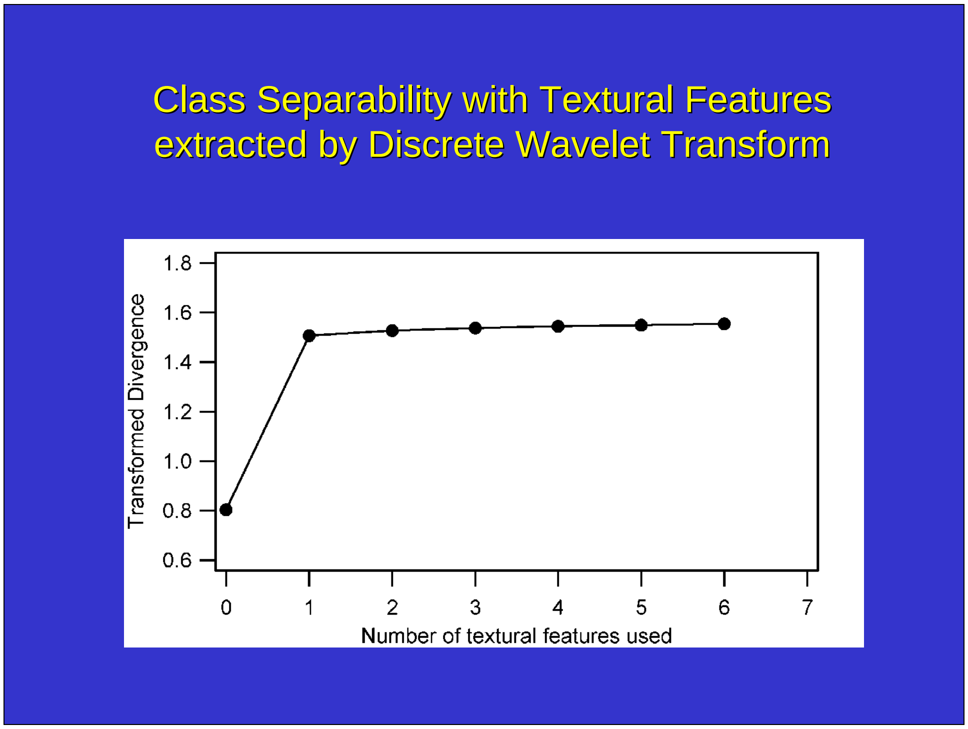
Anopheles dirus	forest; shaded pools; hoofprints in or at the edge of forests; with increasing deforestation, adapting to orchards, tea, rubber and other plantations.
An. minimus	forest fringe; flowing waters (foothill streams, springs, irrigation ditches, seepages, borrow pits, rice fields); shaded areas; grassy and shaded banks of stable, clear, slow moving streams.
An. maculatus	seepage waters; streams pools; pond edges; ditches and swamps with minimal vegetation; sunlit areas.

Bamboo Cups

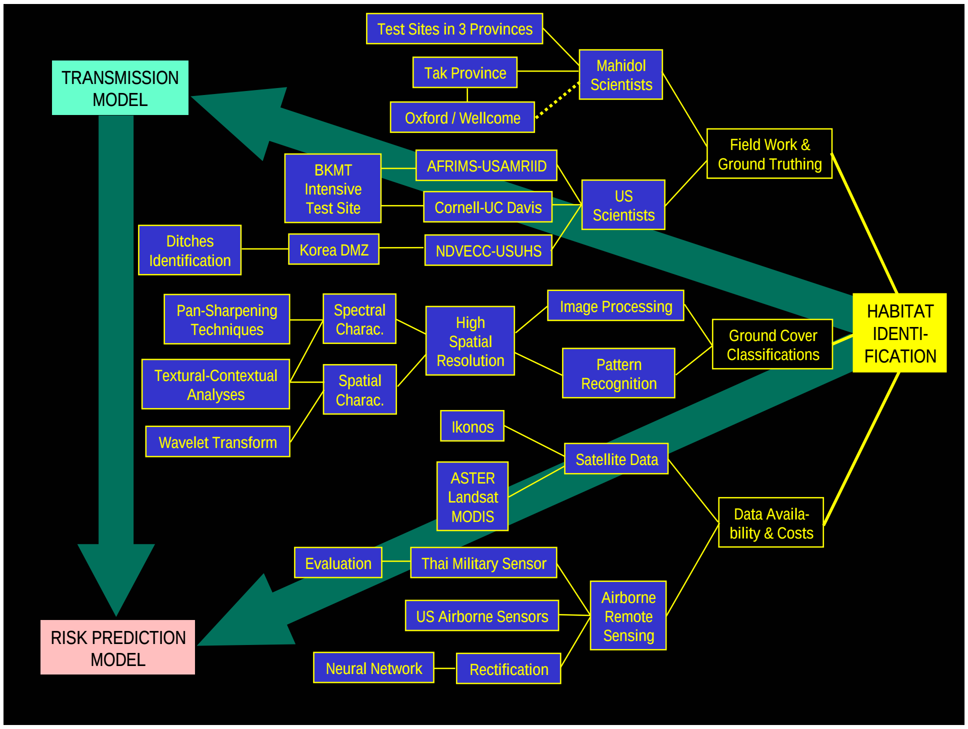
Kanchanaburi

Washington, D.C.

Space Imaging's Ikonos imagery



Class Separability with Textural Features extracted by Discrete Wavelet Transform



TRANSMISSION MODEL

Test Sites in 3 Provinces

Tak Province

Oxford / Wellcome

Mahidol Scientists

Field Work & Ground Truthing

BKMT Intensive Test Site

AFRIMS-USAMRIID

Cornell-UC Davis

NDVECC-USUHS

US Scientists

Ditches Identification

Korea DMZ

Pan-Sharpening Techniques

Textural-Contextual Analyses

Wavelet Transform

Spectral Charac.

Spatial Charac.

High Spatial Resolution

Image Processing

Pattern Recognition

Ground Cover Classifications

HABITAT IDENTI-FICATION

Ikonos

ASTER Landsat MODIS

Satellite Data

Data Availa-bility & Costs

Evaluation

Thai Military Sensor

US Airborne Sensors

Airborne Remote Sensing

Neural Network

Rectification

RISK PREDICTION MODEL

North Korea – Malaria Transmission

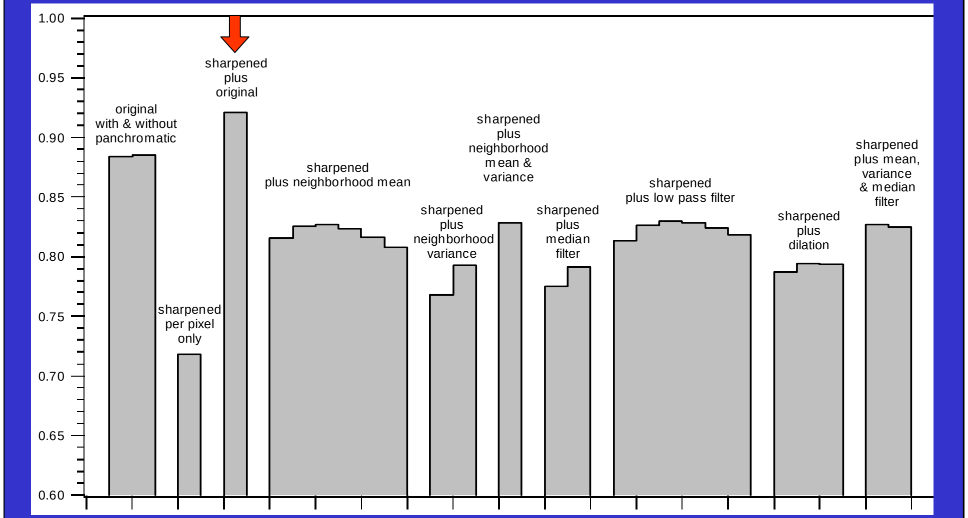
Camp Greaves and Surrounding Area

Kyunggi, South Korea

kr4_truecolor_brightened.jpg

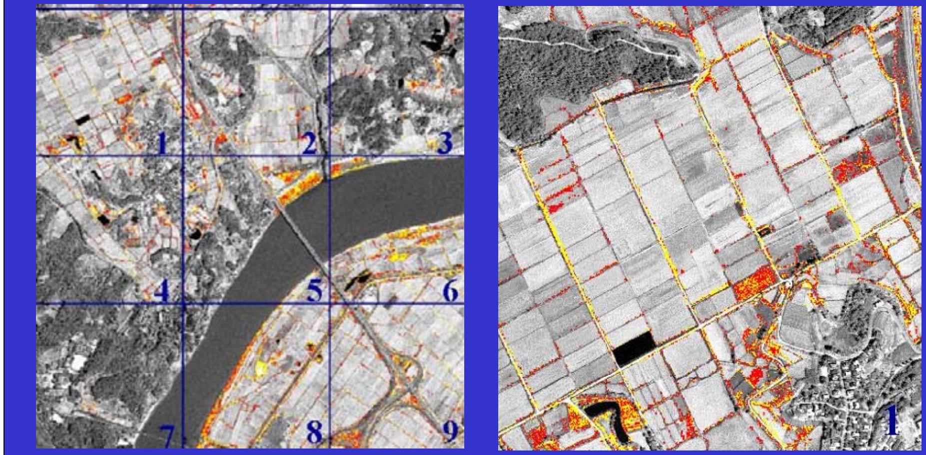
Space Imaging's Ikonos imagery

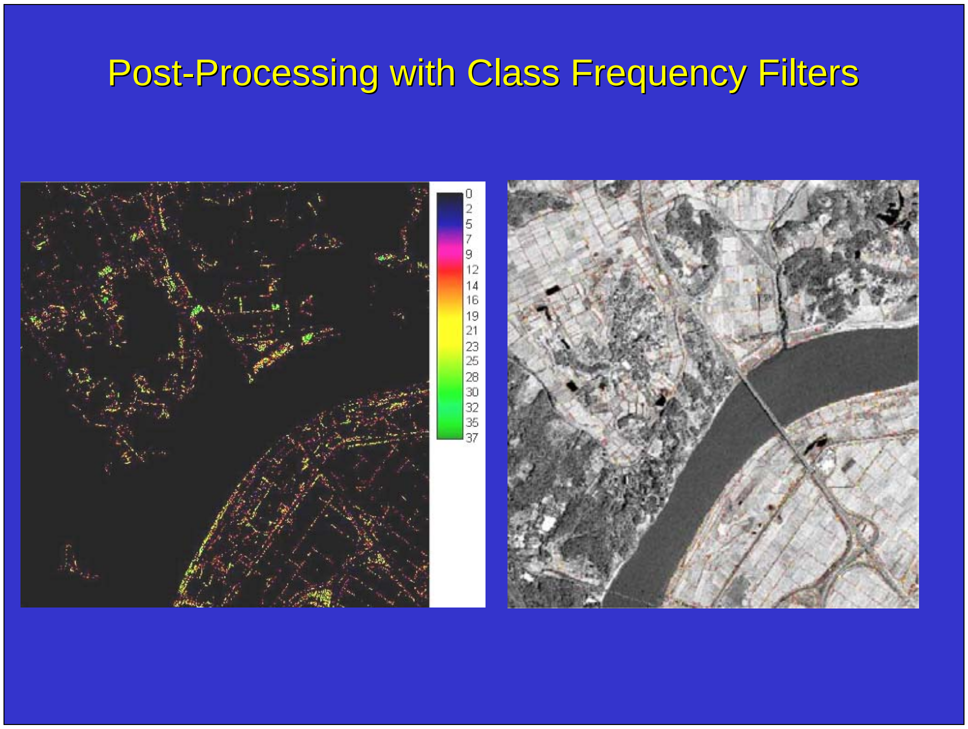
Classification Accuracy using Pan-Sharpened Ikonos Data (1 meter resolution)



Detection of Ditches using 1-meter Data

(Larval Habitats of *An. sinensis*)





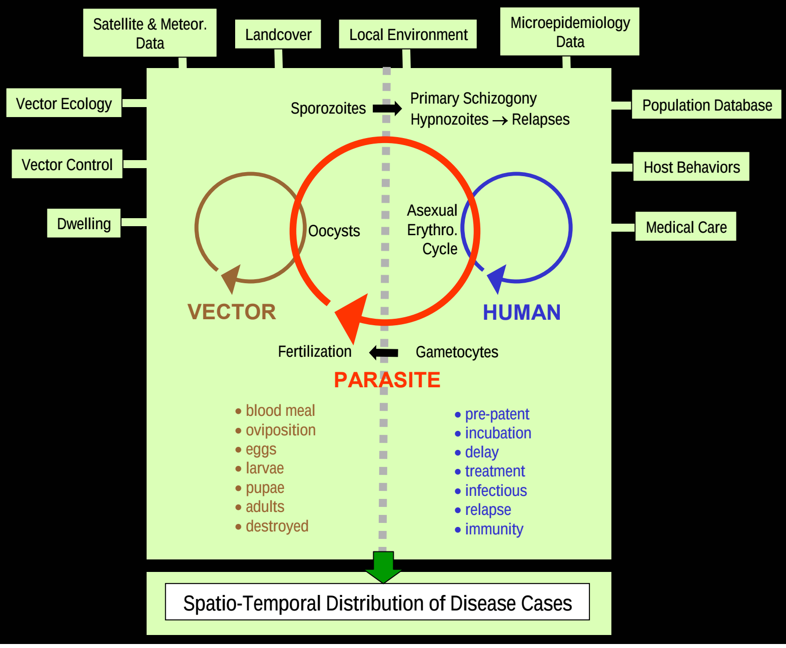
Post-Processing with Class Frequency Filters

Sources:
CDC DVBID
Rutgers Univ. Entomology Dept./NJMCA

Ban Kong Mong Tha

Ratchaburi, Thailand

TRANSMISSION MODEL



Satellite & Meteor. Data

Landcover

Local Environment

Microepidemiology Data

Vector Ecology

Vector Control

Dwelling

Population Database

Host Behaviors

Medical Care

Sporozoites → Primary Schizogony

Hypnozoites → Relapses

Oocysts

Asexual Erythro. Cycle

VECTOR

HUMAN

Fertilization ← Gametocytes

PARASITE

- blood meal
- oviposition
- eggs
- larvae
- pupae
- adults
- destroyed

- pre-patent
- incubation
- delay
- treatment
- infectious
- relapse
- immunity

Spatio-Temporal Distribution of Disease Cases hx, hy, hproof

rsex, rage, rimmune, revout, rgamet

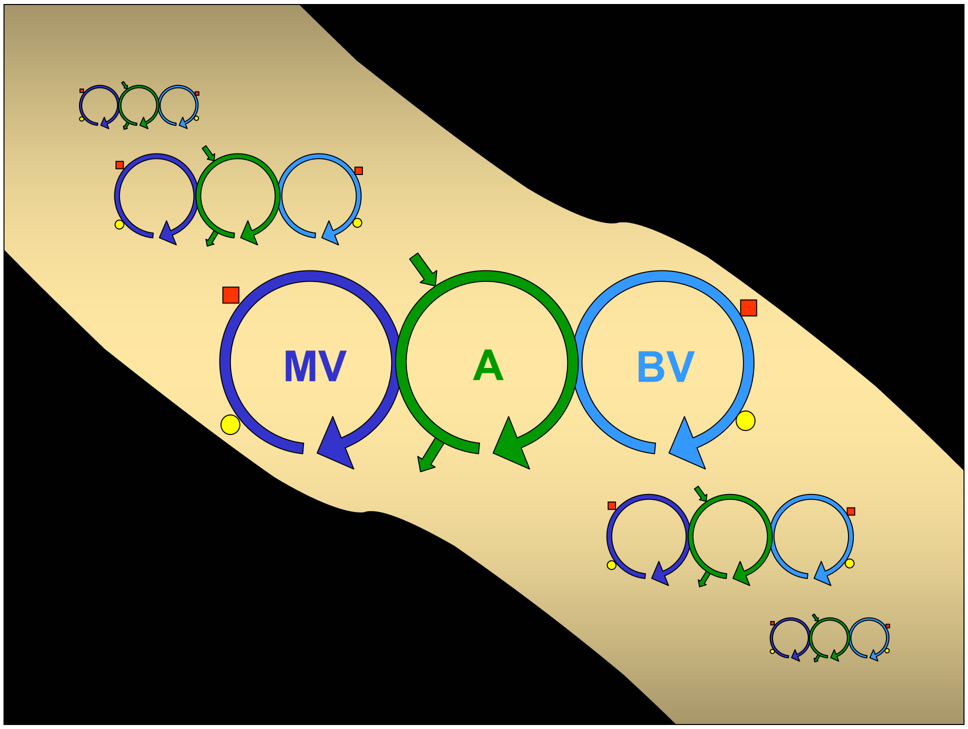
bx, by

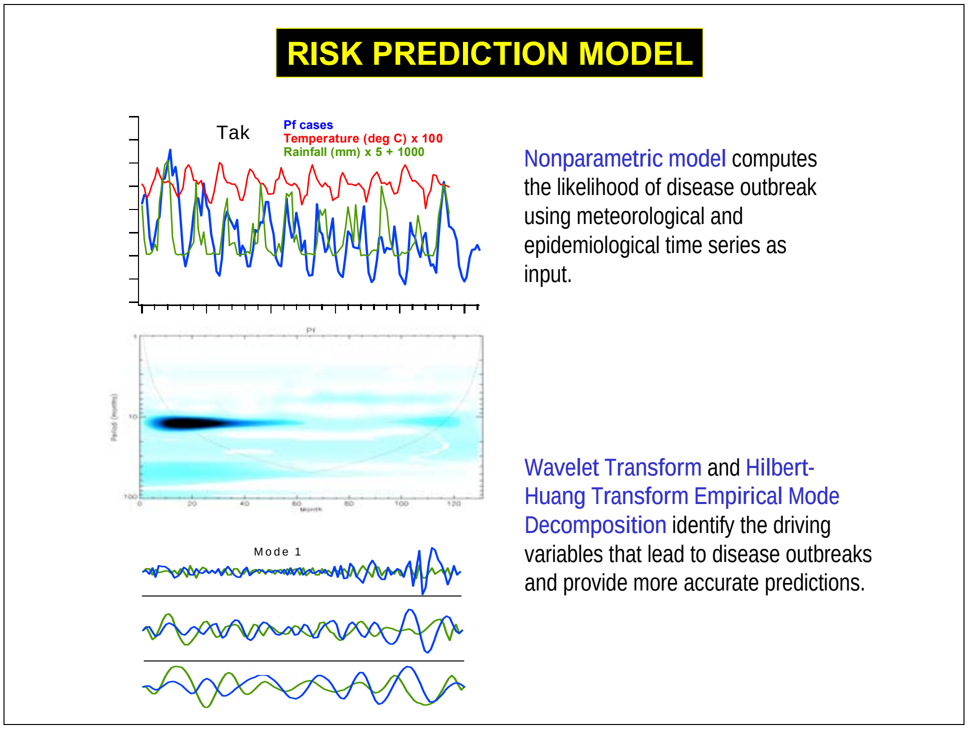
tegg, tlarva, tpupa, tmate, tovi, tspor

wbtoh, whtoh, whtob

mage, mspor

tincub, twait, tgamet, theal, tpost, trelapse

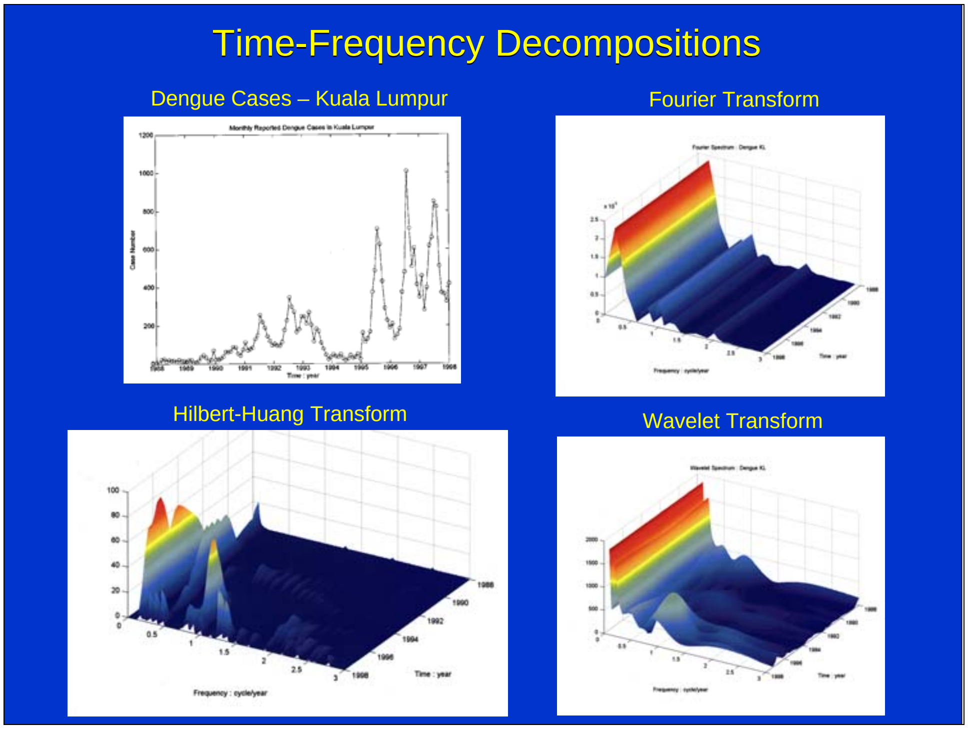




RISK PREDICTION MODEL

Nonparametric model computes the likelihood of disease outbreak using meteorological and epidemiological time series as input.

Wavelet Transform and Hilbert-Huang Transform Empirical Mode Decomposition identify the driving variables that lead to disease outbreaks and provide more accurate predictions.



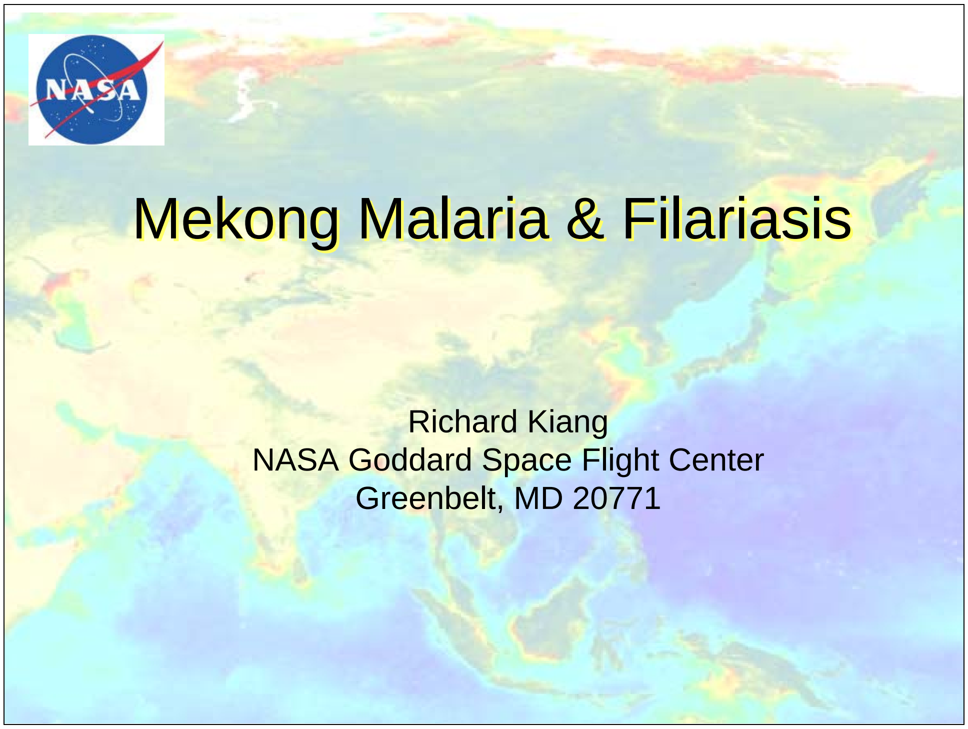
Time-Frequency Decompositions

Dengue Cases – Kuala Lumpur

Fourier Transform

Hilbert-Huang Transform

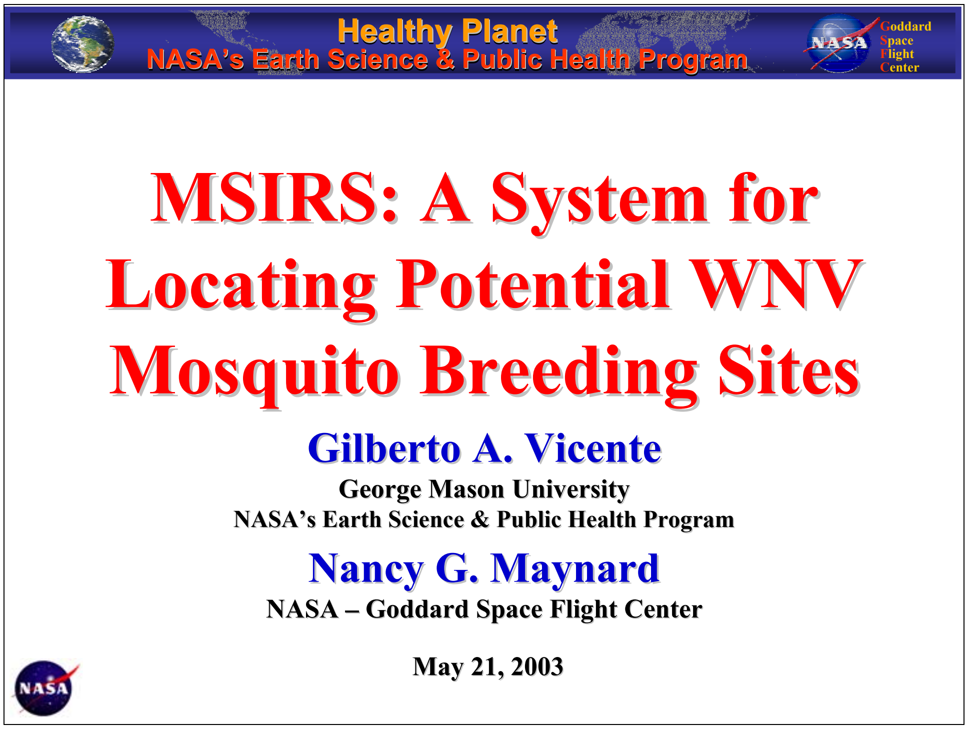
Wavelet Transform



Mekong Malaria & Filariasis

Richard Kiang
NASA Goddard Space Flight Center
Greenbelt, MD 20771

Gilberto Vincente, PhD
“MSIRS: A System for Locating Potential WNV Mosquito Breeding Sites”



Healthy Planet
NASA’s Earth Science & Public Health Program

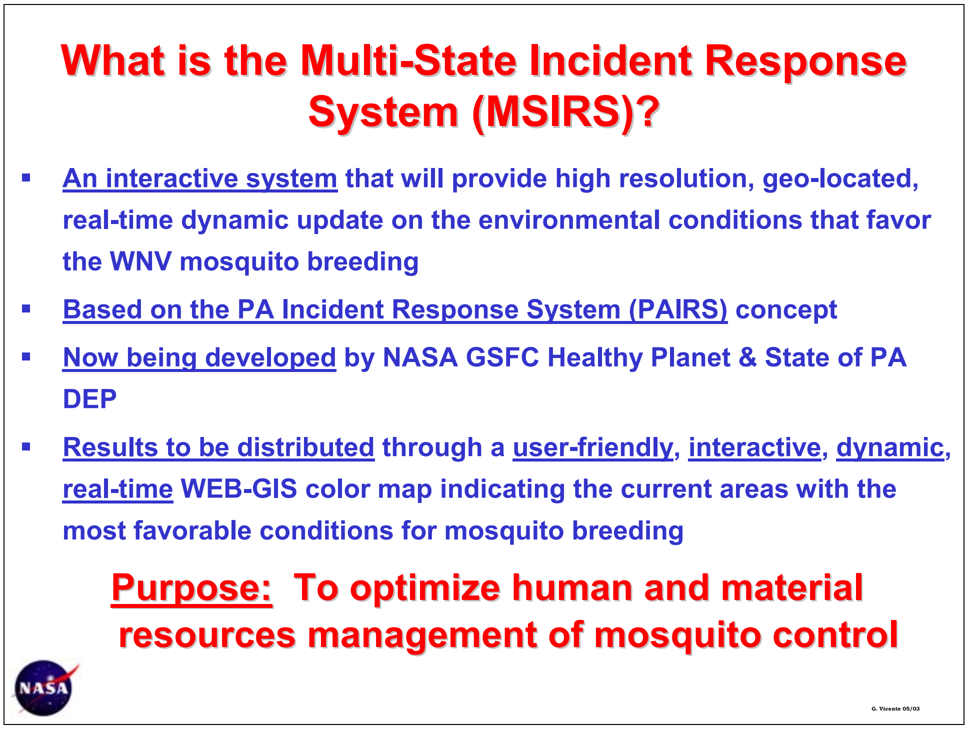
Goddard
Space
Flight
Center

MSIRS: A System for Locating Potential WNV Mosquito Breeding Sites

Gilberto A. Vicente
George Mason University
NASA’s Earth Science & Public Health Program

Nancy G. Maynard
NASA – Goddard Space Flight Center

May 21, 2003

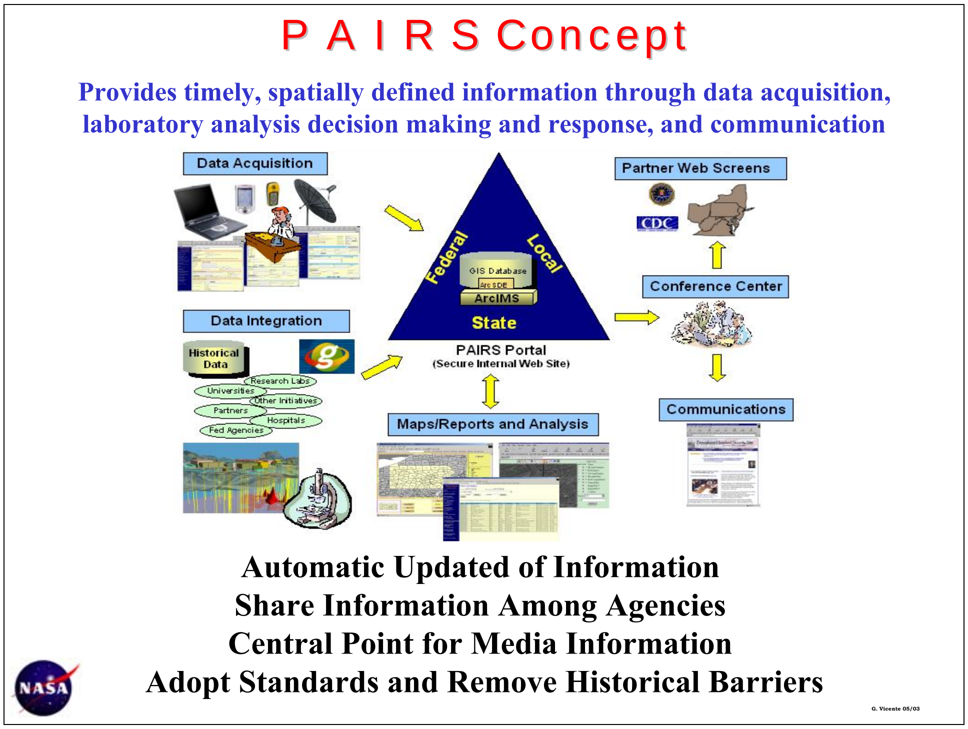


What is the Multi-State Incident Response System (MSIRS)?

- An interactive system that will provide high resolution, geo-located, real-time dynamic update on the environmental conditions that favor the WNV mosquito breeding
- Based on the PA Incident Response System (PAIRS) concept
- Now being developed by NASA GSFC Healthy Planet & State of PA DEP
- Results to be distributed through a user-friendly, interactive, dynamic, real-time WEB-GIS color map indicating the current areas with the most favorable conditions for mosquito breeding

Purpose: To optimize human and material resources management of mosquito control

G. Vicente 05/03

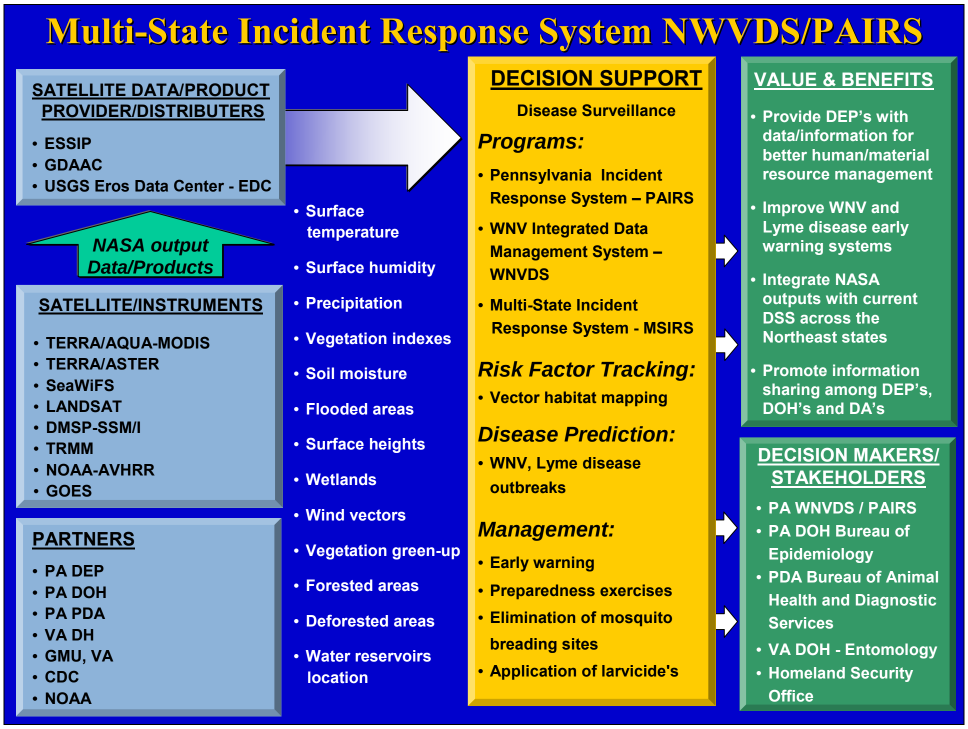


P A I R S Concept

Provides timely, spatially defined information through data acquisition, laboratory analysis decision making and response, and communication

Automatic Updated of Information
Share Information Among Agencies
Central Point for Media Information
Adopt Standards and Remove Historical Barriers

G. Vicente 05/03



Multi-State Incident Response System NWVDS/PAIRS

SATELLITE DATA/PRODUCT PROVIDER/DISTRIBUTERS

- ESSIP
- GDAAC
- USGS Eros Data Center - EDC

NASA output Data/Products

SATELLITE/INSTRUMENTS

- TERRA/AQUA-MODIS
- TERRA/ASTER
- SeaWiFS
- LANDSAT
- DMSP-SSM/I
- TRMM
- NOAA-AVHRR
- GOES

PARTNERS

- PA DEP
- PA DOH
- PA PDA
- VA DH
- GMU, VA
- CDC
- NOAA

- Surface temperature
- Surface humidity
- Precipitation
- Vegetation indexes
- Soil moisture
- Flooded areas
- Surface heights
- Wetlands
- Wind vectors
- Vegetation green-up
- Forested areas
- Deforested areas
- Water reservoirs location

DECISION SUPPORT

Disease Surveillance

Programs:

- Pennsylvania Incident Response System – PAIRS
- WNV Integrated Data Management System – WNVDS
- Multi-State Incident Response System - MSIRS

Risk Factor Tracking:

- Vector habitat mapping

Disease Prediction:

- WNV, Lyme disease outbreaks

Management:

- Early warning
- Preparedness exercises
- Elimination of mosquito breading sites
- Application of larvicide's

VALUE & BENEFITS

- Provide DEP's with data/information for better human/material resource management
- Improve WNV and Lyme disease early warning systems
- Integrate NASA outputs with current DSS across the Northeast states
- Promote information sharing among DEP's, DOH's and DA's

DECISION MAKERS/ STAKEHOLDERS

- PA WNVDS / PAIRS
- PA DOH Bureau of Epidemiology
- PDA Bureau of Animal Health and Diagnostic Services
- VA DOH - Entomology
- Homeland Security Office

MSIRS: NASA’s Role

To help health officials predict disease outbreaks by showing when and where habitats are suitable for mosquitoes to thrive by:

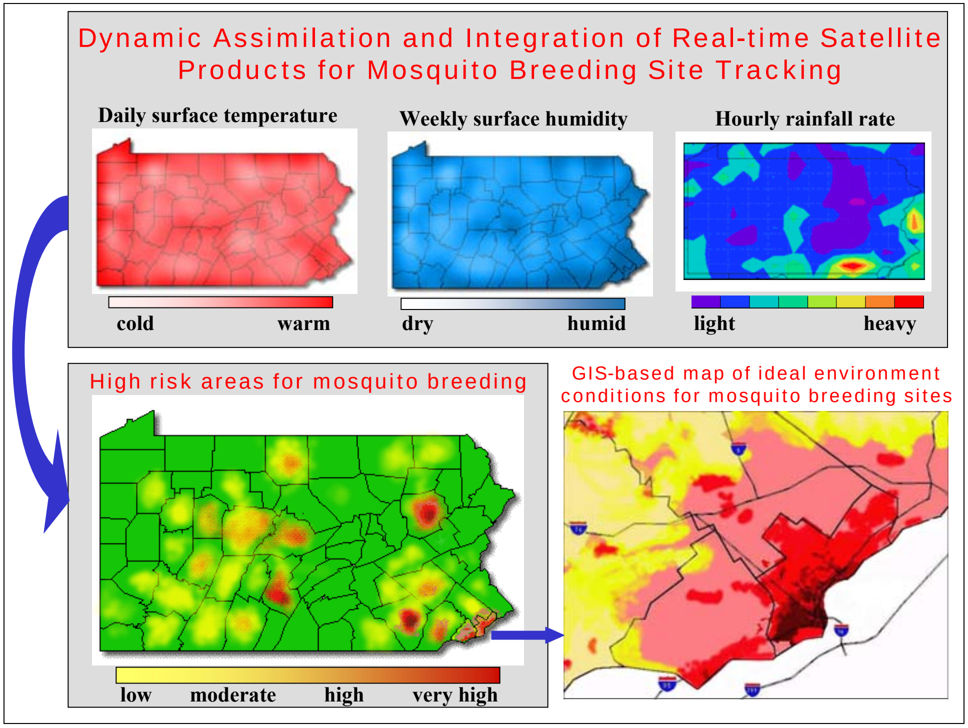
- ❖ **Provide high resolution, geo-located, real-time dynamic update on the environmental conditions that favor the WNV mosquito breeding**

- – **Providing real-time or historical date, observations, models – e.g.:**

  Surface temperature – Rainfall – Humidity

- – **Translating satellite data into state GIS system so can be merged with other local data**
  - **(e.g., bird migration routes, reported cases of WNV, human population centers)**

G. Vicente 05/03



Dynamic Assimilation and Integration of Real-time Satellite Products for Mosquito Breeding Site Tracking

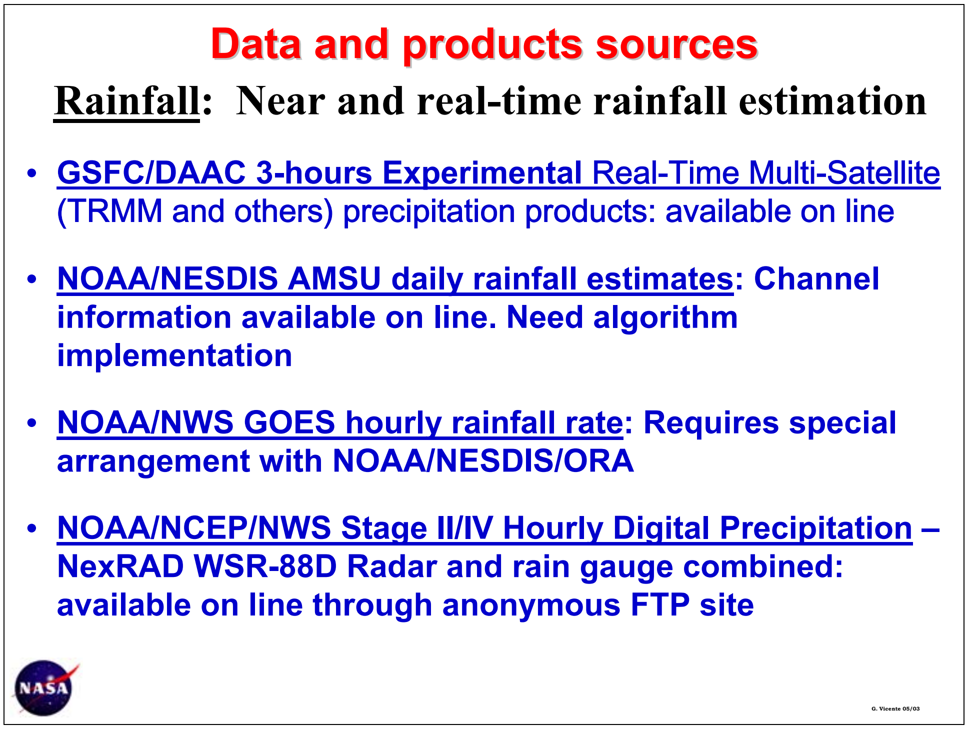
Daily surface temperature

Weekly surface humidity

Hourly rainfall rate

High risk areas for mosquito breeding

GIS-based map of ideal environment conditions for mosquito breeding sites

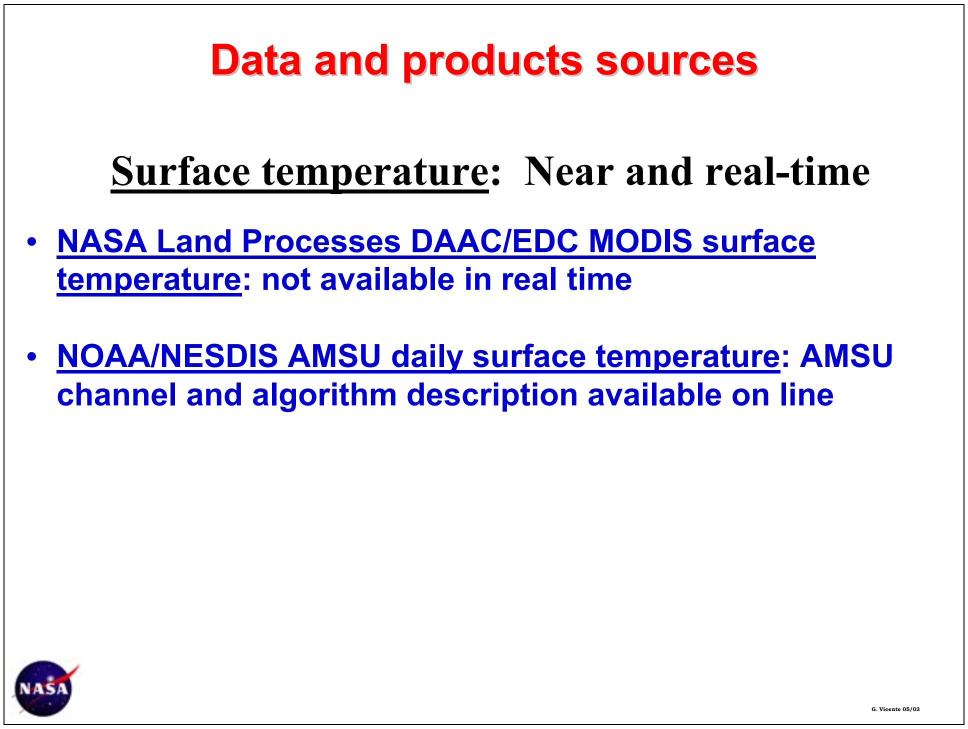


Data and products sources

<u>Rainfall</u>: Near and real-time rainfall estimation

- **GSFC/DAAC 3-hours Experimental** Real-Time Multi-Satellite (TRMM and others) precipitation products: available on line
- **NOAA/NESDIS AMSU daily rainfall estimates: Channel information available on line. Need algorithm implementation**
- **NOAA/NWS GOES hourly rainfall rate: Requires special arrangement with NOAA/NESDIS/ORA**
- **NOAA/NCEP/NWS Stage II/IV Hourly Digital Precipitation – NexRAD WSR-88D Radar and rain gauge combined: available on line through anonymous FTP site**

G. Vicente 05/03



Data and products sources

<u>Surface temperature</u>: Near and real-time

- **NASA Land Processes DAAC/EDC MODIS surface temperature: not available in real time**
- **NOAA/NESDIS AMSU daily surface temperature: AMSU channel and algorithm description available on line**

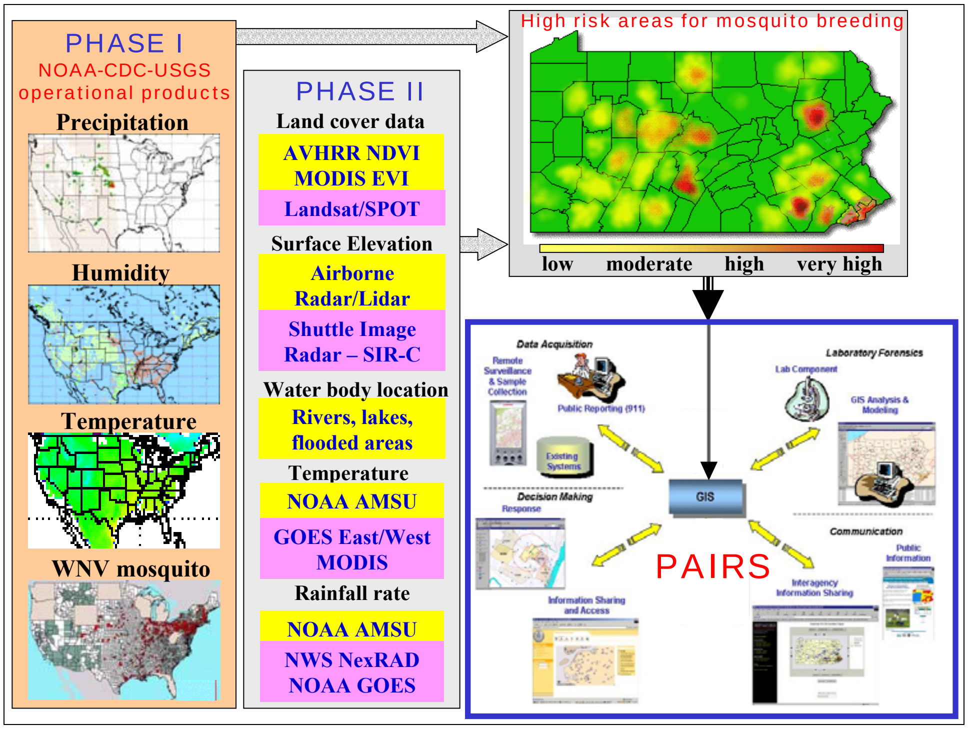
G. Vicente 05/03

Data and products sources

<u>Surface humidity:</u> Near and real-time

- NOAA/NESDIS AMSU daily surface humidity: AMSU channel and algorithm description available on line

G. Vicente 05/03



PHASE I
NOAA-CDC-USGS operational products

Precipitation

Humidity

Temperature

WNV mosquito

PHASE II

Land cover data
- AVHRR NDVI
- MODIS EVI
- Landsat/SPOT

Surface Elevation
- Airborne Radar/Lidar
- Shuttle Image Radar – SIR-C

Water body location
- Rivers, lakes, flooded areas

Temperature
- NOAA AMSU
- GOES East/West MODIS

Rainfall rate
- NOAA AMSU
- NWS NexRAD NOAA GOES

SUMMARY

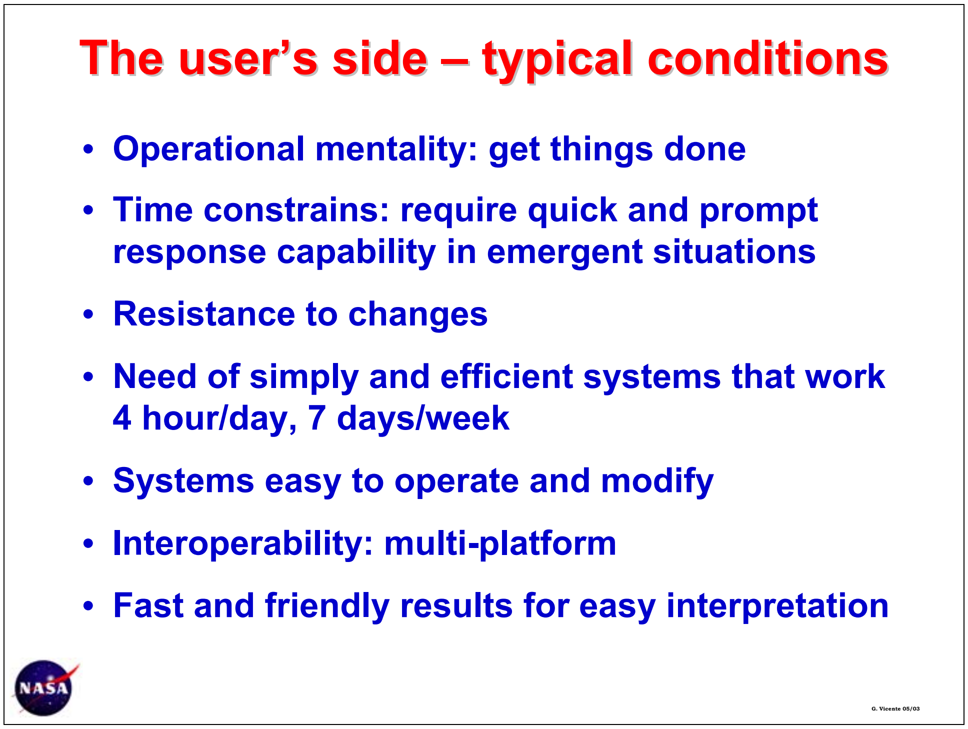
MSIRS A System for Locating Potential WNV Mosquito Breeding Sites

The NASA GSFC-PA/DEP MSIRS
(Multi-State Incident Response System)

Designed to help public health officials predict disease outbreaks by showing when and where habitats are suitable for mosquitoes to thrive by:

- **Dynamically combine real-time remote sensing derived environmental variables such as surface temperature, rainfall, humidity into single color scale identification maps**
- **Translating satellite data/products, model output into state GIS system so can be merged with other local data such as bird migration routes, reported cases of WNV, human population centers**

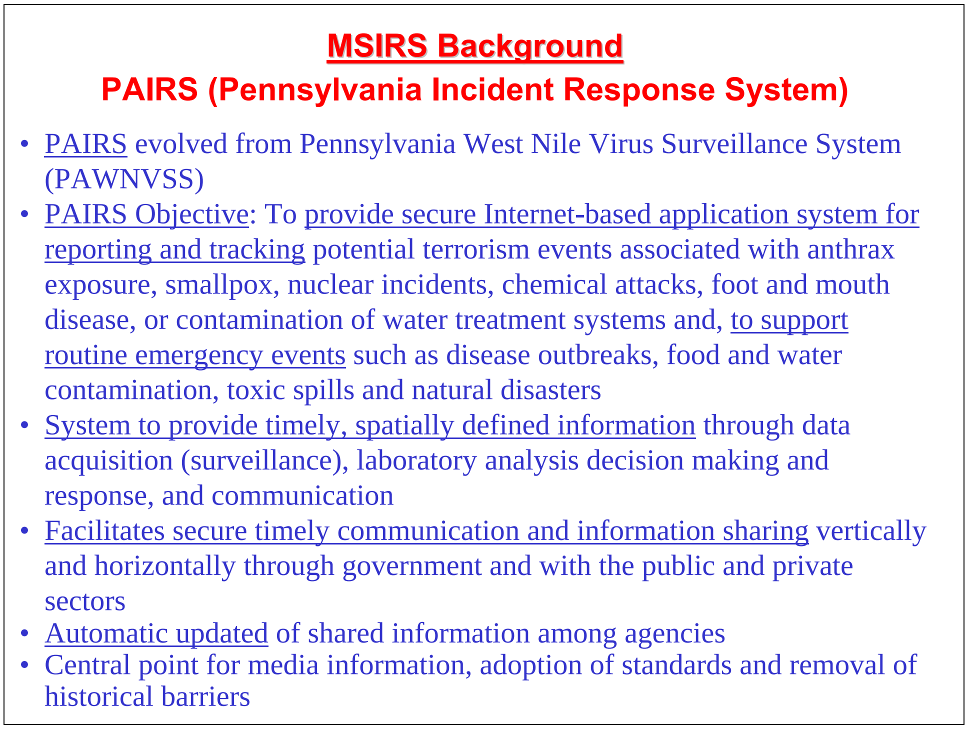
BACKUP SLIDES



The user's side – typical conditions

- Operational mentality: get things done
- Time constrains: require quick and prompt response capability in emergent situations
- Resistance to changes
- Need of simply and efficient systems that work 4 hour/day, 7 days/week
- Systems easy to operate and modify
- Interoperability: multi-platform
- Fast and friendly results for easy interpretation

G. Vicente 05/03



MSIRS Background

PAIRS (Pennsylvania Incident Response System)

- PAIRS evolved from Pennsylvania West Nile Virus Surveillance System (PAWNVSS)
- PAIRS Objective: To provide secure Internet-based application system for reporting and tracking potential terrorism events associated with anthrax exposure, smallpox, nuclear incidents, chemical attacks, foot and mouth disease, or contamination of water treatment systems and, to support routine emergency events such as disease outbreaks, food and water contamination, toxic spills and natural disasters
- System to provide timely, spatially defined information through data acquisition (surveillance), laboratory analysis decision making and response, and communication
- Facilitates secure timely communication and information sharing vertically and horizontally through government and with the public and private sectors
- Automatic updated of shared information among agencies
- Central point for media information, adoption of standards and removal of historical barriers

Communication and Interaction

PAIRS links Homeland Security, PEMA, Agriculture, Health and Environmental Protection. Agencies can:

- **Enter incident information from remote sites**
- **Send statewide notifications to other agencies**
- **View real time reports and maps of the incidents**
- **Add additional information/query incidents**
- **See patterns between incidents/cross political boundaries**

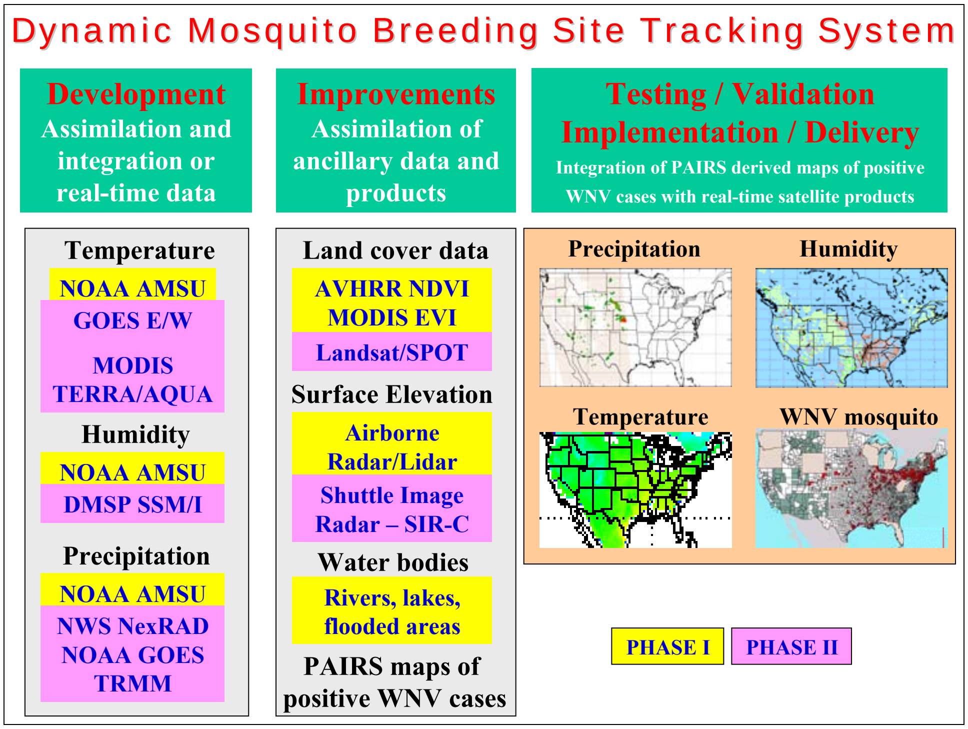
Conditions now and in the near future

Short-term evaluation of past 1 – 5 days atmospheric and surface environmental conditions

- **Take action in the spot using current information**
- **Require near real-time and real-time update of information**
- **Coordinated and integrated efforts among all members, from the data producers to end users**
- **Provide quick and accessible information about the location of potential mosquito breeding site locations**

Short-term forecast: 1 – 3 days in the future

- **Require numerical weather prediction model inputs**

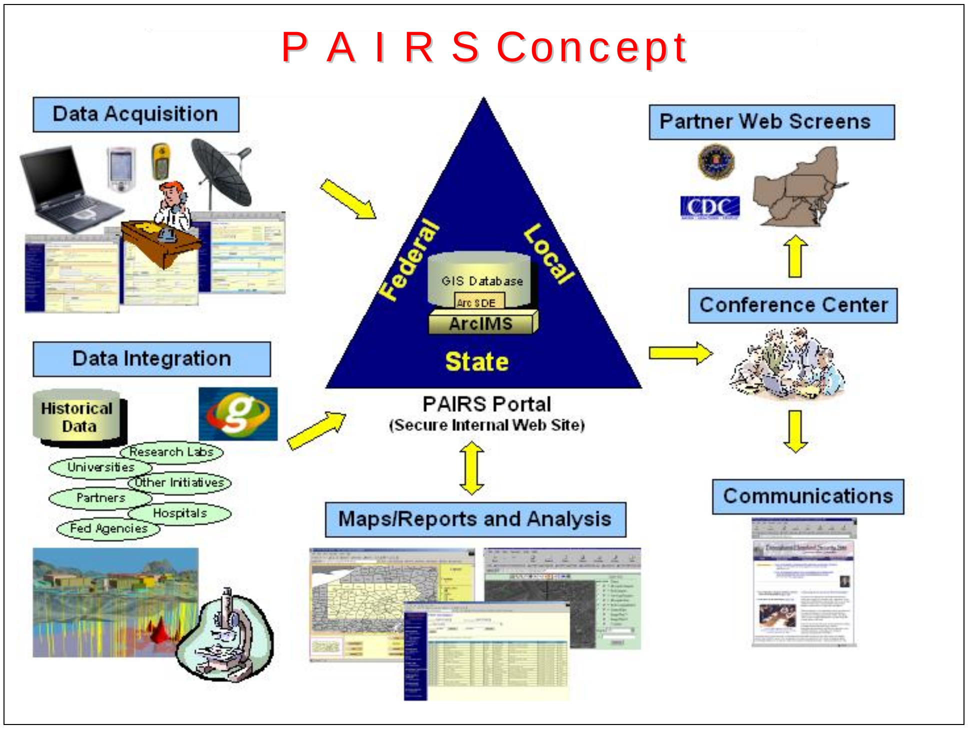


Dynamic Mosquito Breeding Site Tracking System

Development Assimilation and integration or real-time data	**Improvements** Assimilation of ancillary data and products	**Testing / Validation Implementation / Delivery** Integration of PAIRS derived maps of positive WNV cases with real-time satellite products
Temperature NOAA AMSU GOES E/W MODIS TERRA/AQUA Humidity NOAA AMSU DMSP SSM/I Precipitation NOAA AMSU NWS NexRAD NOAA GOES TRMM	Land cover data AVHRR NDVI MODIS EVI Landsat/SPOT Surface Elevation Airborne Radar/Lidar Shuttle Image Radar – SIR-C Water bodies Rivers, lakes, flooded areas PAIRS maps of positive WNV cases	Precipitation Humidity Temperature WNV mosquito

PHASE I PHASE II

Pennsylvania Incident Response System Architecture



P A I R S Concept

Data Acquisition

Data Integration

Historical Data

Research Labs

Universities

Other Initiatives

Partners

Hospitals

Fed Agencies

Federal

Local

State

GIS Database

Arc SDE

ArcIMS

PAIRS Portal
(Secure Internal Web Site)

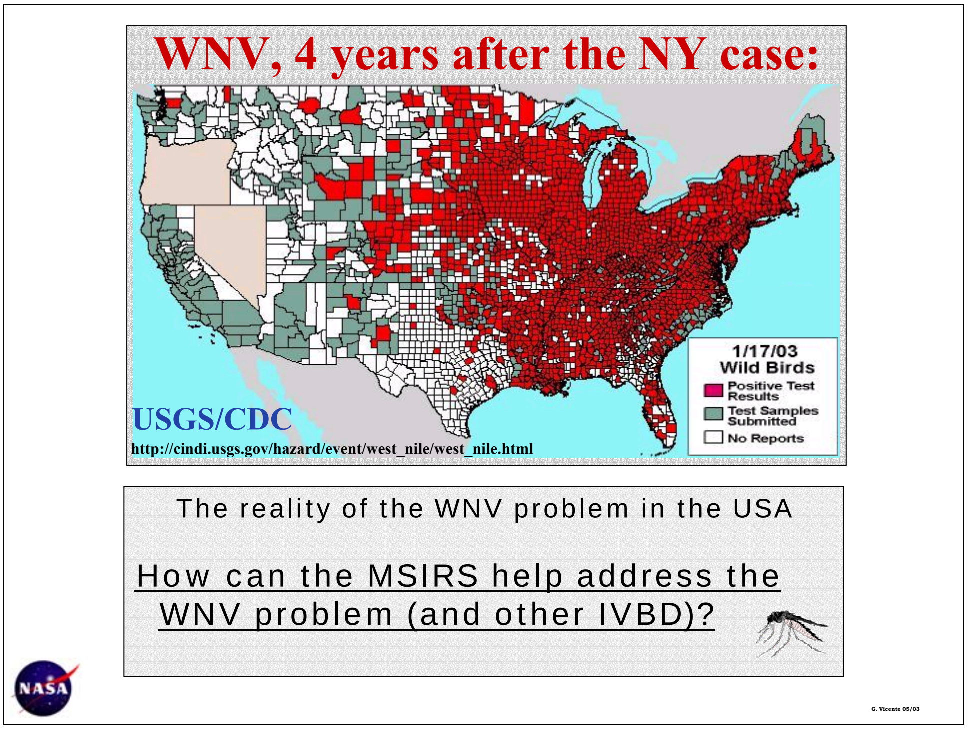
Maps/Reports and Analysis

Partner Web Screens

CDC

Conference Center

Communications



WNV, 4 years after the NY case:

1/17/03
Wild Birds
🟥 Positive Test Results
🟩 Test Samples Submitted
☐ No Reports

USGS/CDC

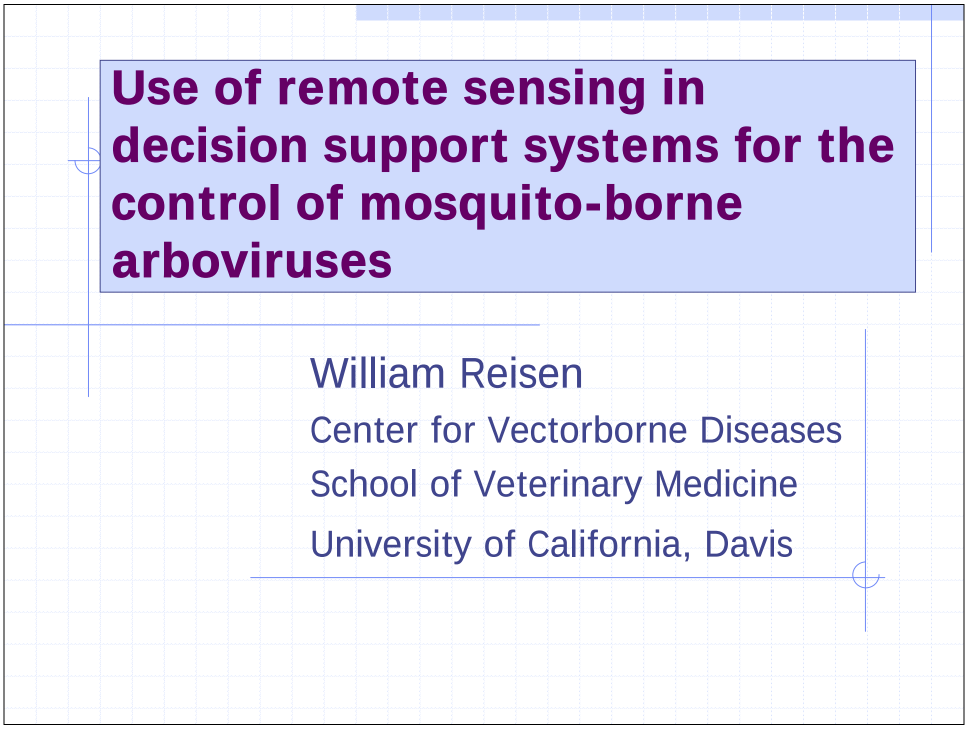
http://cindi.usgs.gov/hazard/event/west_nile/west_nile.html

The reality of the WNV problem in the USA

How can the MSIRS help address the WNV problem (and other IVBD)?

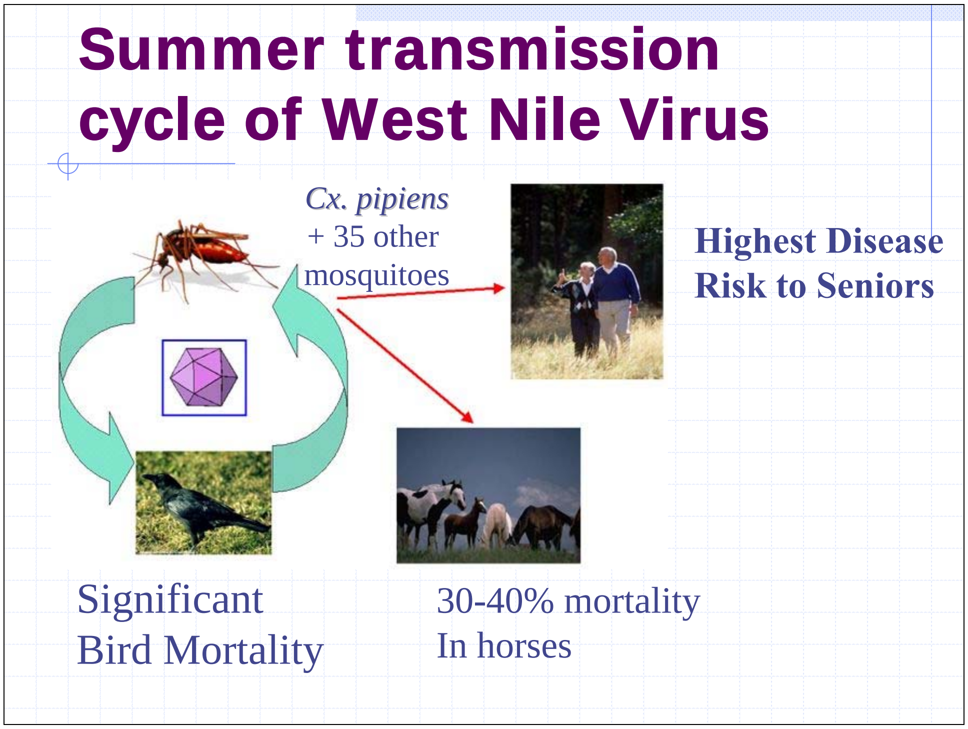
G. Vicente 05/03

William K. Reisen, PhD
"Use of Remote Sensing in Decision Support Systems for the Control of Mosquito-Borne Arboviruses"



Use of remote sensing in decision support systems for the control of mosquito-borne arboviruses

William Reisen
Center for Vectorborne Diseases
School of Veterinary Medicine
University of California, Davis



Summer transmission cycle of West Nile Virus

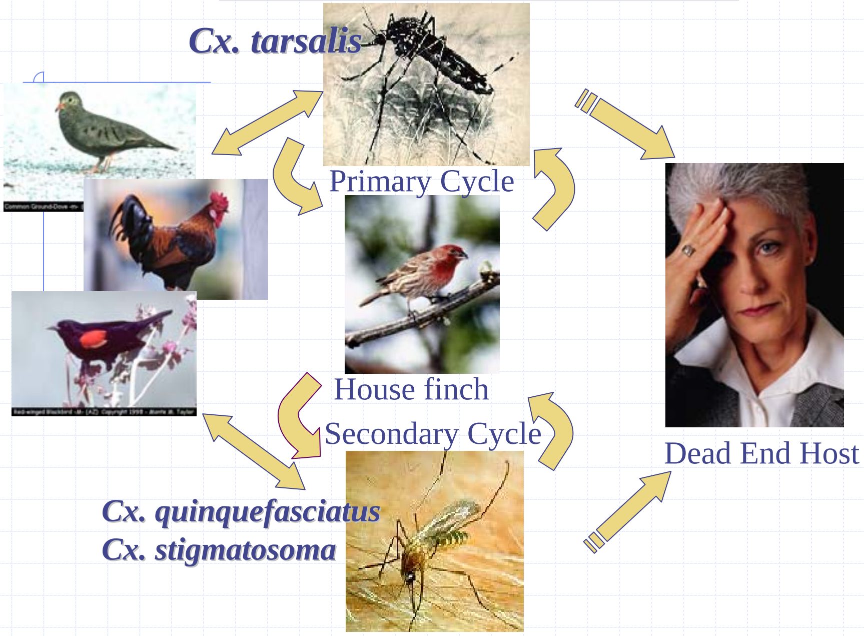
Cx. pipiens
+ 35 other mosquitoes

Highest Disease Risk to Seniors

Significant Bird Mortality

30-40% mortality In horses

SLE Transmission Cycles



Cx. tarsalis

Primary Cycle

House finch

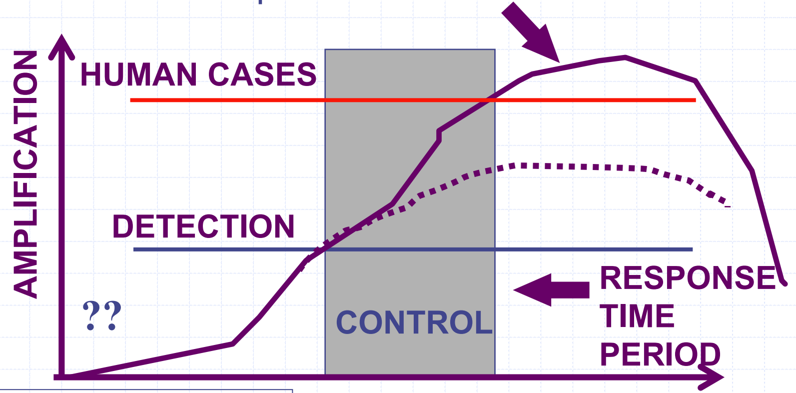
Secondary Cycle

Dead End Host

Cx. quinquefasciatus
Cx. stigmatosoma

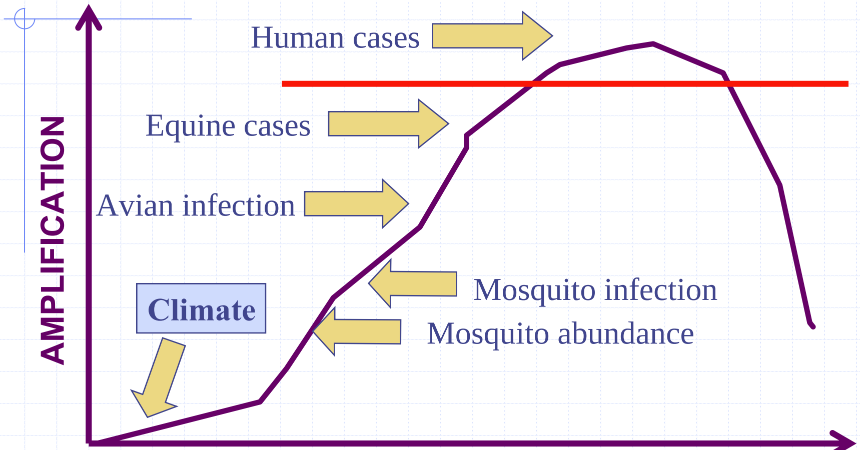
MOSQUITOBORNE VIRUS SURVEILLANCE AND CONTROL PARADIGM

Epidemic Curve



Virus overwintering unknown

Surveillance indicators



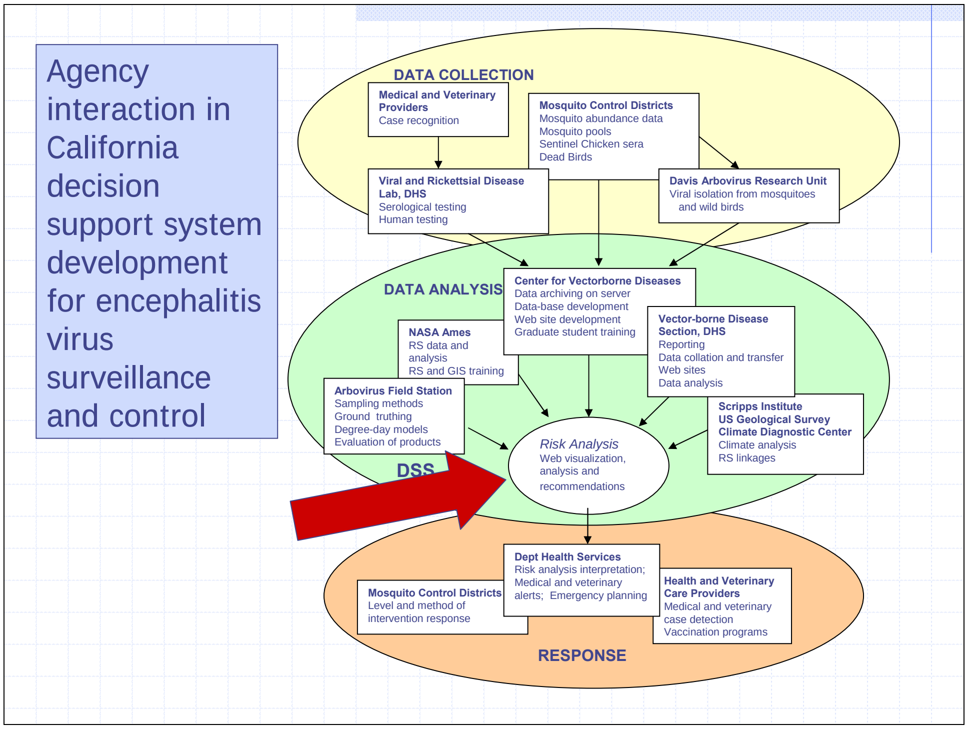
Earliest links between mosquito abundance and climate

EFFECTS OF CLIMATE FACTORS ON MOSQUITO-BORNE VIRUSES

- ↑**Temperature** ↑ **Rates**
  - ↓Mosquito generation times [↑ Pop. growth rate]
  - ↓Mosquito survivorship [↓ Life expectancy]
  - ↓Extrinsic incubation period of virus [↑ Trans. rate]
- ↑ **Water** ↑ **Abundance**
  - ↑Mosquito oviposition and larval habitats
  - ↑Mosquito population size [immediate]
  - ↑Vertebrate host population size [time delay]

Forecasting risk

Do we know enough?



Agency interaction in California decision support system development for encephalitis virus surveillance and control

DATA COLLECTION

Medical and Veterinary Providers
Case recognition

Mosquito Control Districts
Mosquito abundance data
Mosquito pools
Sentinel Chicken sera
Dead Birds

Viral and Rickettsial Disease Lab, DHS
Serological testing
Human testing

Davis Arbovirus Research Unit
Viral isolation from mosquitoes and wild birds

DATA ANALYSIS

Center for Vectorborne Diseases
Data archiving on server
Data-base development
Web site development
Graduate student training

NASA Ames
RS data and analysis
RS and GIS training

Vector-borne Disease Section, DHS
Reporting
Data collation and transfer
Web sites
Data analysis

Arbovirus Field Station
Sampling methods
Ground truthing
Degree-day models
Evaluation of products

Scripps Institute
US Geological Survey
Climate Diagnostic Center
Climate analysis
RS linkages

Risk Analysis
Web visualization, analysis and recommendations

DSS

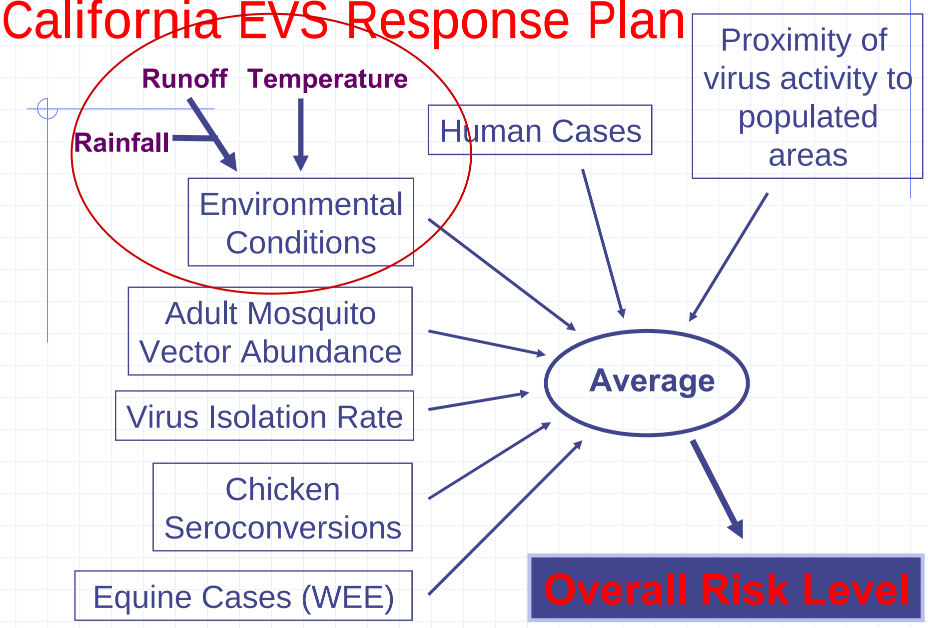
RESPONSE

Dept Health Services
Risk analysis interpretation;
Medical and veterinary alerts; Emergency planning

Mosquito Control Districts
Level and method of intervention response

Health and Veterinary Care Providers
Medical and veterinary case detection
Vaccination programs

California EVS Response Plan



Thresholds for risk assessment as defined in the encephalitis virus surveillance and response plan.

Risk Level	Environmental Conditions Rain	 Runoff	 Temperature	Adult Mosquito Abundance	Mosquito MIR/1,000	Chicken Seroconversions	Equine Cases	Human Cases	Proximity of Virus to Populated Areas
1	**Well Below Average**			**< 50% 10-yr. Avg.**	**0**	**0 conversions**	**0 Statewide**	**0 Statewide**	**Remote Area**
2	**Below Average**			**50-90% 10-yr. Avg.**	**0.1-1.0**	**1 conversion**	■	■	**Rural Area**
3	**Average**			**91-150% 10-yr. Avg.**	**1.1-2.0**	**$PF^a > 1$ $C/PF^b \leq 1$**	**≥ 1 Statewide 0 Local**	**≥ 1 Statewide 0 Local**	**Small Town**
4	**Above Average**			**151-300% 10-yr. Avg.**	**2.1-5.0**	**PF > 1 $1 < C/PF \leq 3$**	**1-2 Local**	■	**Suburban Area**
5	**Well Above Average**			**> 300% 10-yr. Avg.**	**> 5.0**	**PF > 1 C/PF > 3**	**> 2 Local**	**≥ 1 Local**	**Urban Area**
Overall Response Level	Normal Season **(1.0 to 2.5)** Emergency Planning **(2.6 to 4.0)** Epidemic **(4.1 to 5.0)**								

[a] PF = Number of positive flocks.

[b] C/PF = Number of conversions per positive flock.

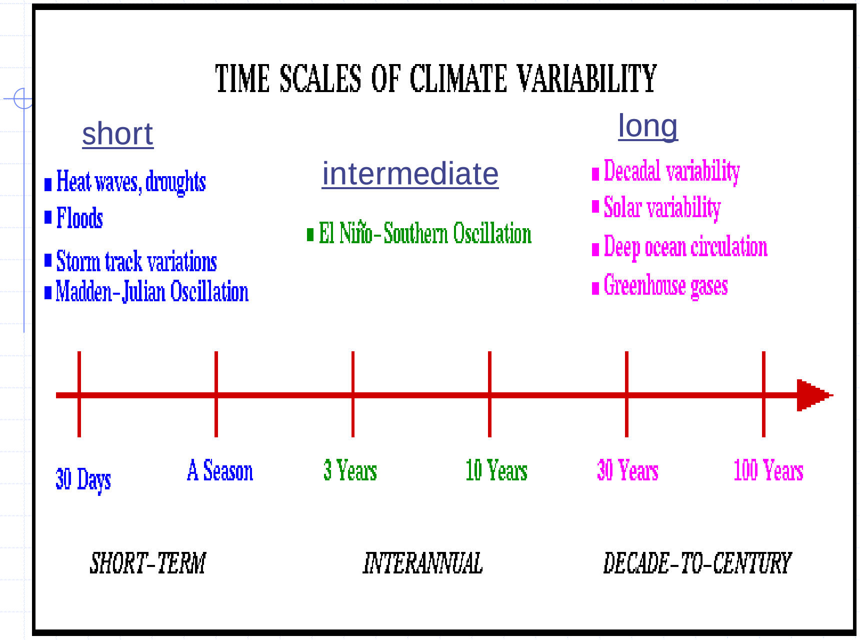
Average of individual factor levels

Remote sensing be used to enhance climate measures

- Mapping - land cover analysis: crops, standing water, vegetation classification
- Remote measures of temperature and water – compare to ground measures
- Remote measures of ecosystem response to temperature and water - vegetation indices [NDVI]
- Forecast [ENSO] vs. real-time measurement

SCALE MATTERS

THE LONG AND SHORT OF IT…



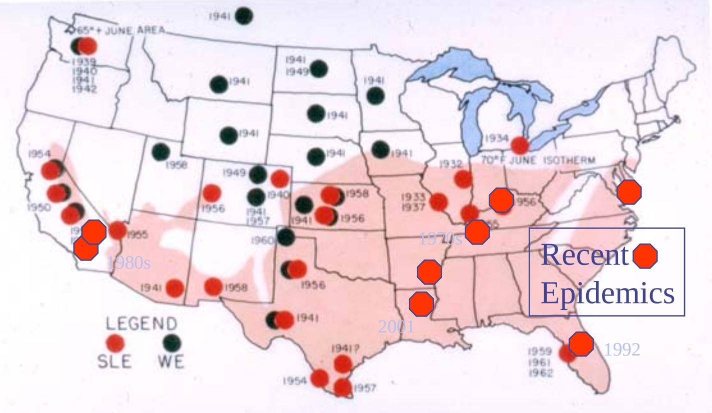
TIME SCALES OF CLIMATE VARIABILITY

short
- Heat waves, droughts
- Floods
- Storm track variations
- Madden-Julian Oscillation

intermediate
- El Niño-Southern Oscillation

long
- Decadal variability
- Solar variability
- Deep ocean circulation
- Greenhouse gases

Distribution of WEE and SLE epidemics in relation to the 70F isotherm

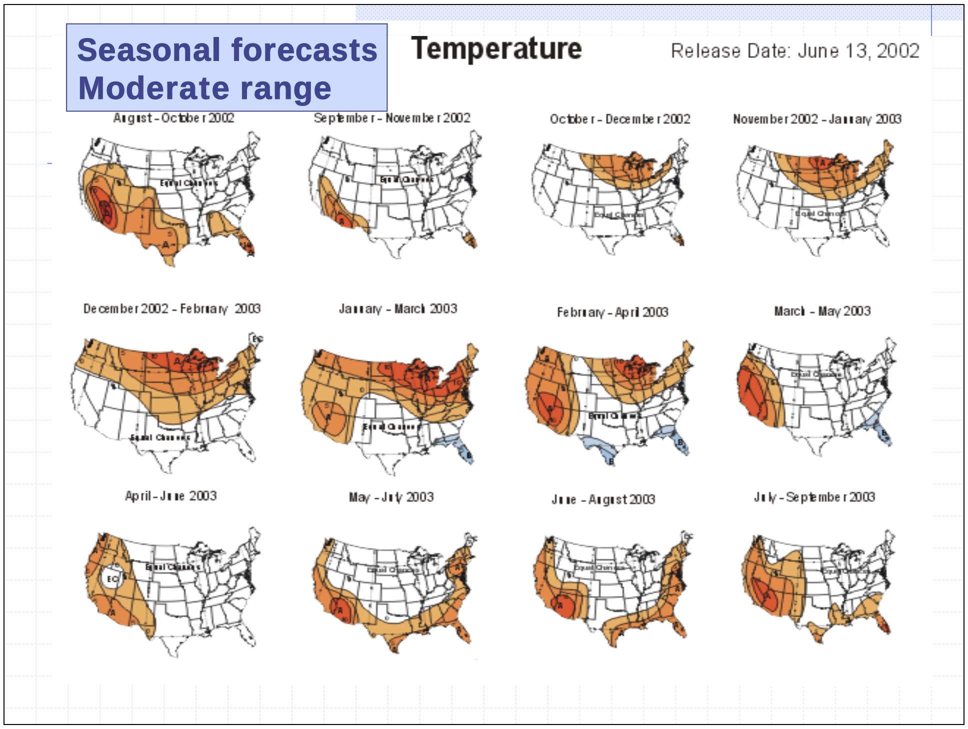


Distribution of recorded human outbreaks of St. Louis and western encephalitis in the United States in relation to the 70° F June isotherm. (A.D. Hess, et al., 1963)

Long range: Global warming trends may alter distribution

ENSO

- **Links present among climate variability, mosquito abundance and virus activity**
- **Viruses respond differently**
  - **WEE associated with El Nino**
  - **SLE associated with La Nina**
  - **WN unknown**
- **Research needed to improve skill of long term prediction of mosquito and virus activity based on global circulation models**



Seasonal forecasts Moderate range

Temperature

Release Date: June 13, 2002

August - October 2002

September - November 2002

October - December 2002

November 2002 - January 2003

December 2002 - February 2003

January - March 2003

February - April 2003

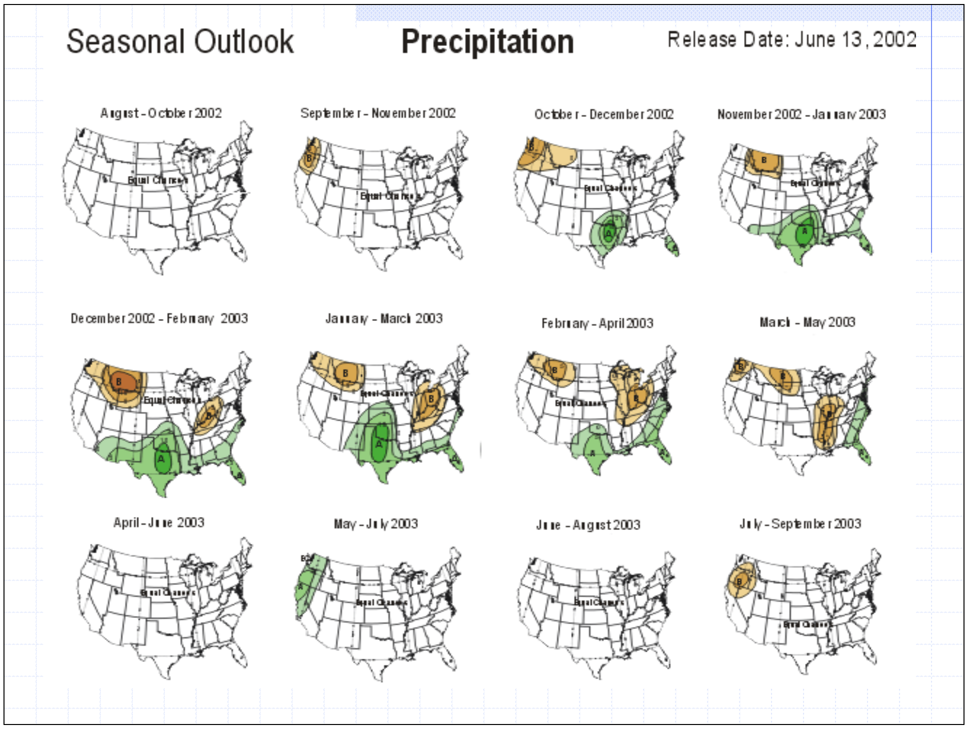
March - May 2003

April - June 2003

May - July 2003

June - August 2003

July - September 2003



Seasonal Outlook

Precipitation

Release Date: June 13, 2002

August - October 2002

September - November 2002

October - December 2002

November 2002 - January 2003

December 2002 - February 2003

January - March 2003

February - April 2003

March - May 2003

April - June 2003

May - July 2003

June - August 2003

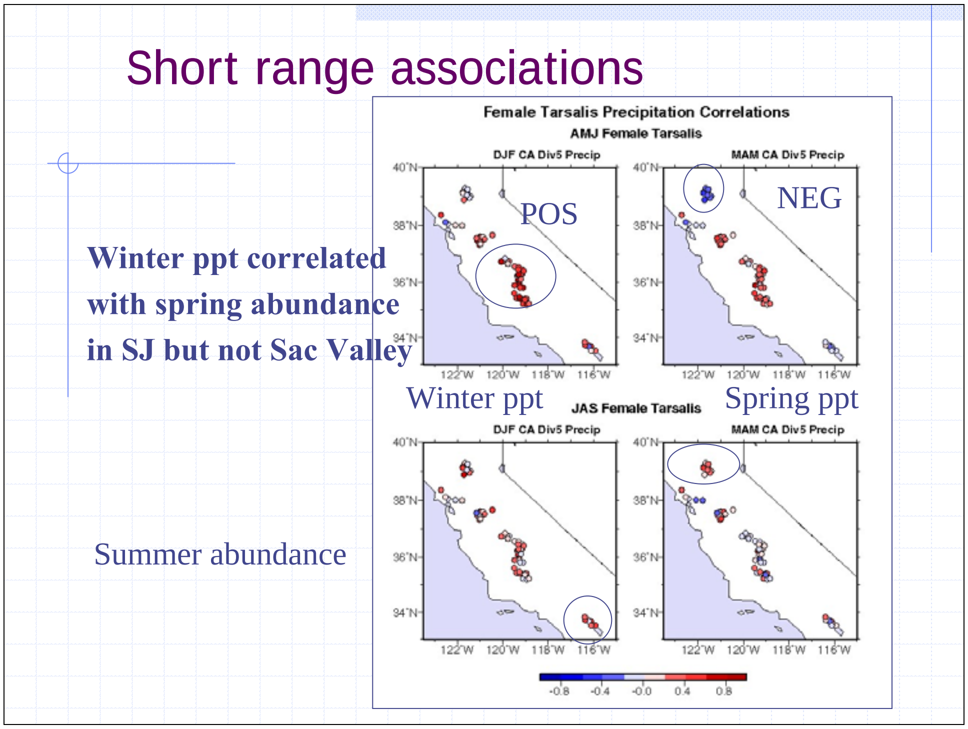
July - September 2003

- **Short range changes**

“Climate is what you expect,
weather is what you get…”
Anon.

Weather

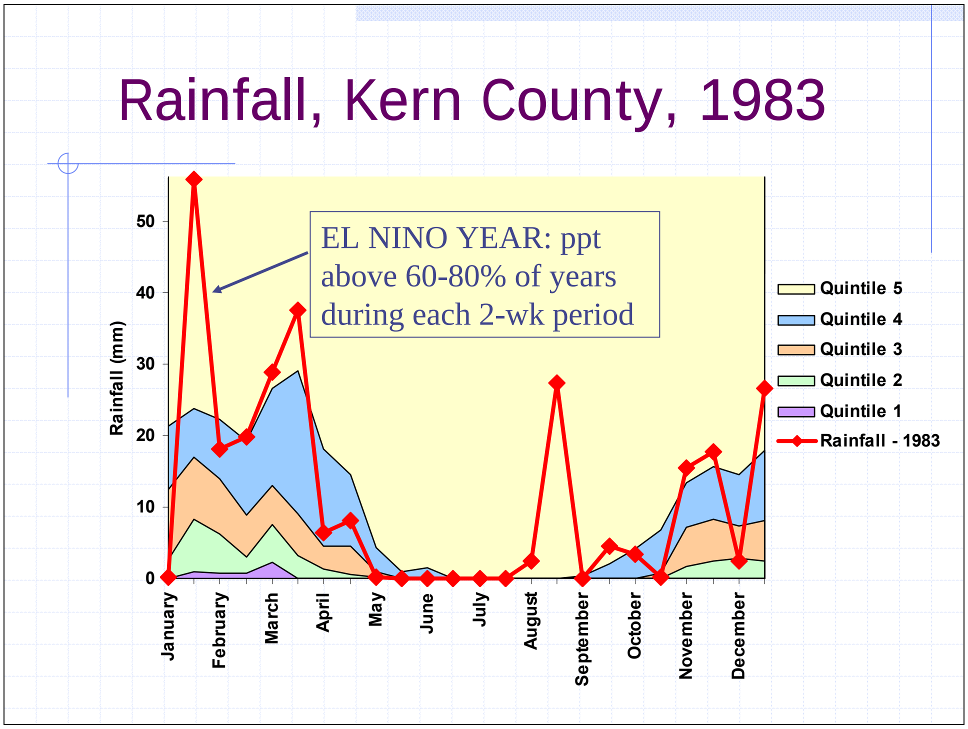
- Necessary to monitor weather to “truth/correct” long range predictions
- Short term predictions have greater accuracy for immediate health and mosquito control planning
- Short term variations can alter long term climate trends and impact vector-borne disease epidemiology



Short range associations

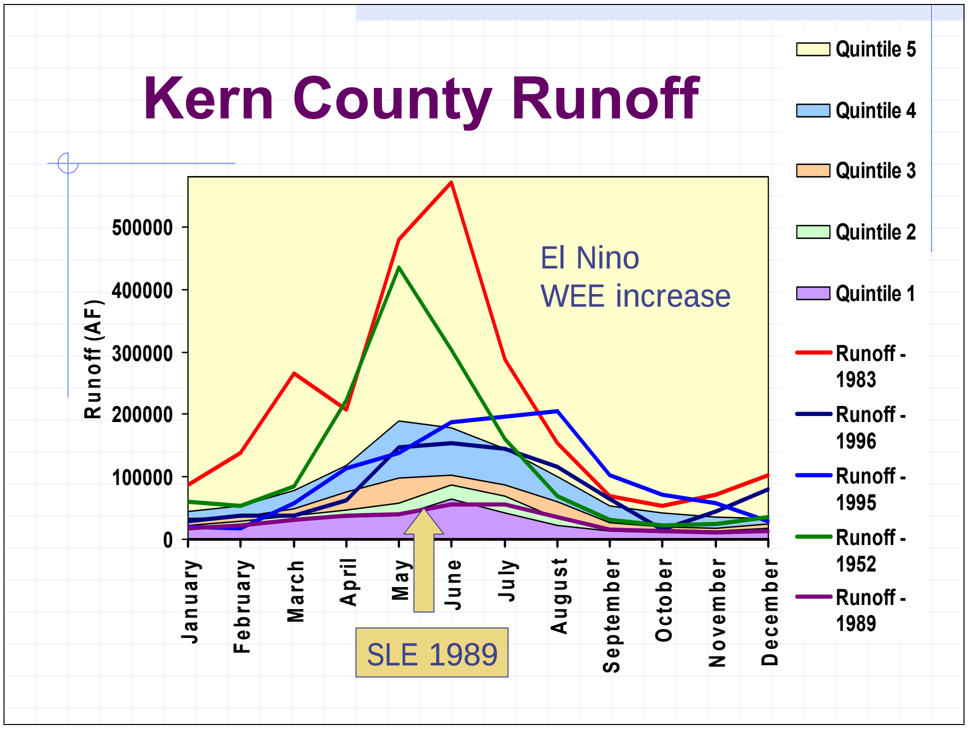
Winter ppt correlated with spring abundance in SJ but not Sac Valley

Summer abundance



Rainfall, Kern County, 1983

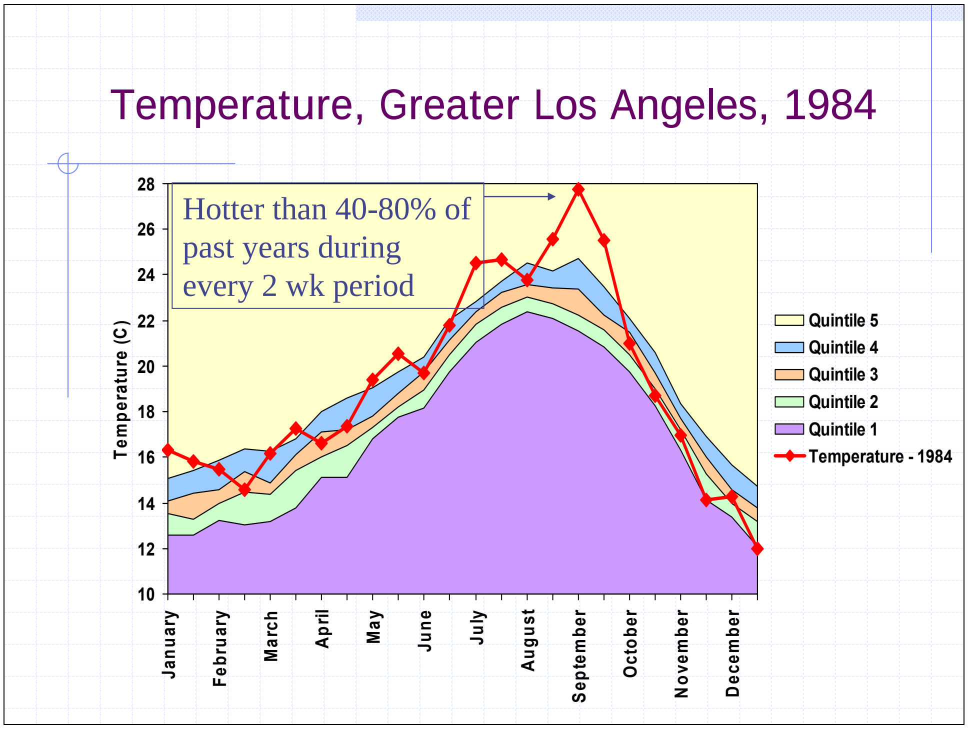
EL NINO YEAR: ppt above 60-80% of years during each 2-wk period



Kern County Runoff

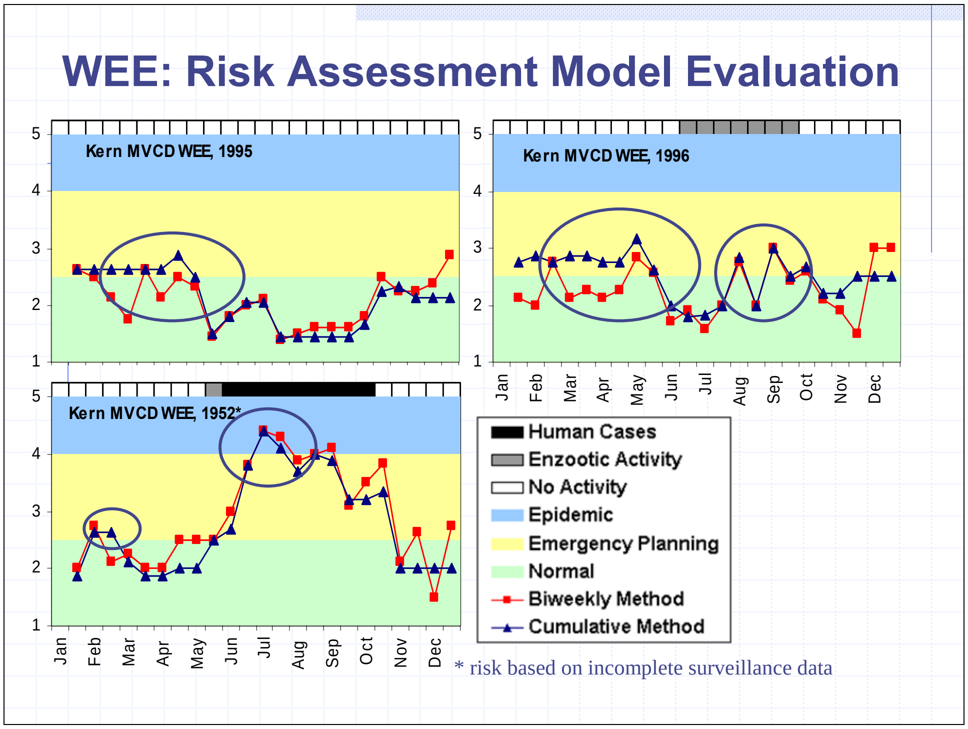
El Nino
WEE increase

SLE 1989



Temperature, Greater Los Angeles, 1984

Hotter than 40-80% of
past years during
every 2 wk period



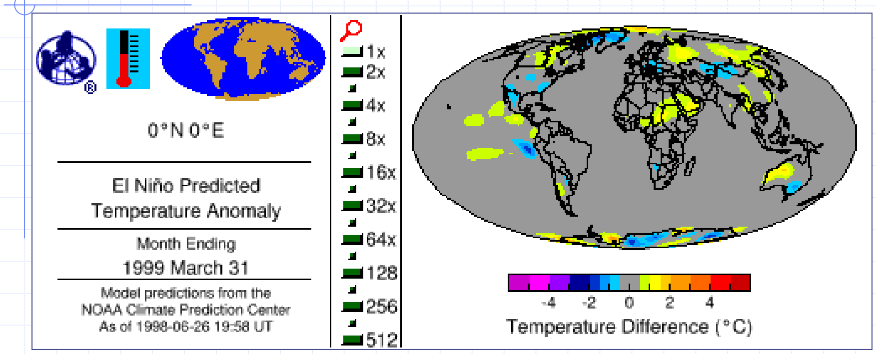
WEE: Risk Assessment Model Evaluation

* risk based on incomplete surveillance data

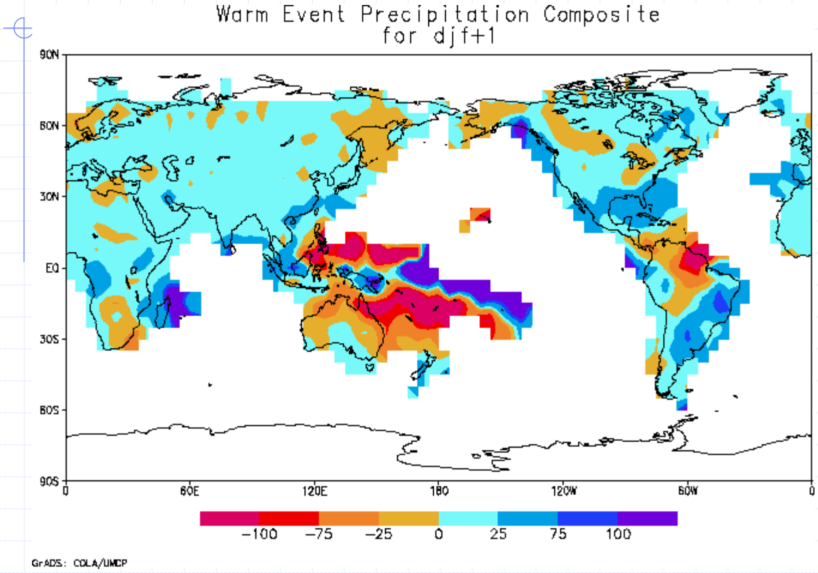
Spatial scales

- CONUS views: frequent real-time views of large areas
- STATE views: risks of focal outbreaks
- LOCAL views: better for intervention

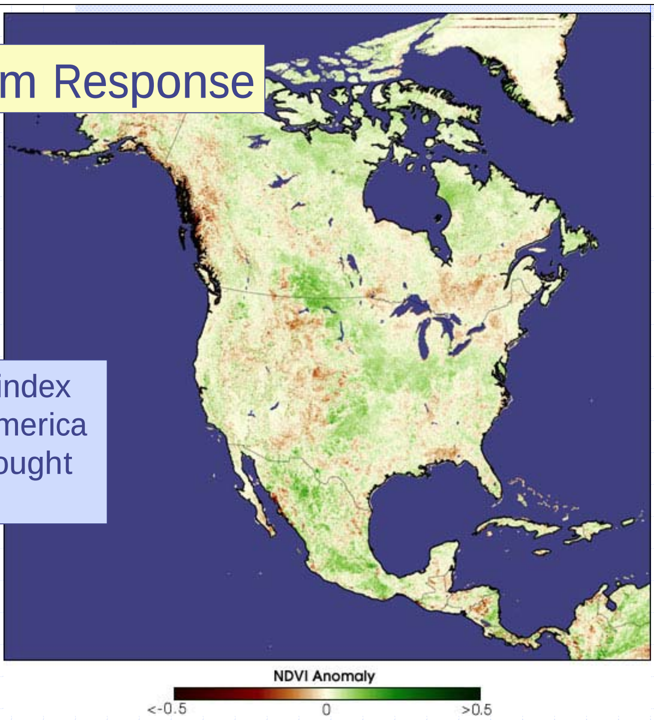
Remotely sensed Sea Surface Temperature to measure ENSO strength



Summer precipitation due to ENSO changes



Ecosystem Response



Vegetative index for North America showing drought in the west

SRTM Perspective View with Landsat Overlay:
San Joaquin Valley, California

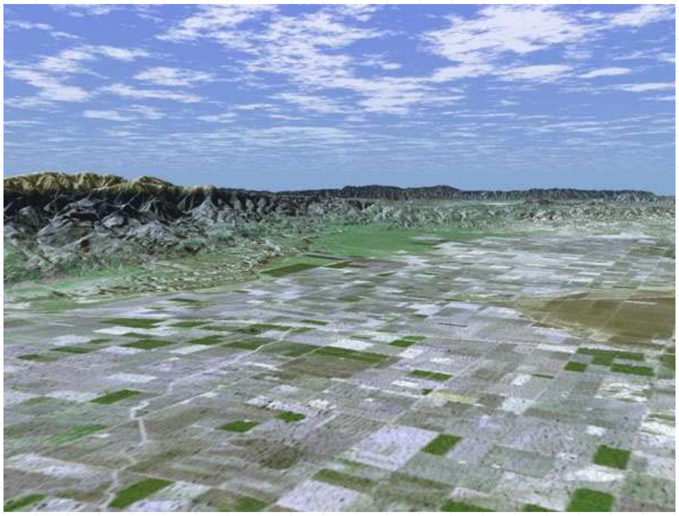
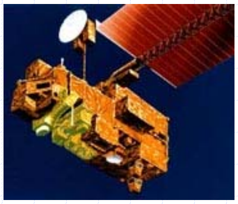
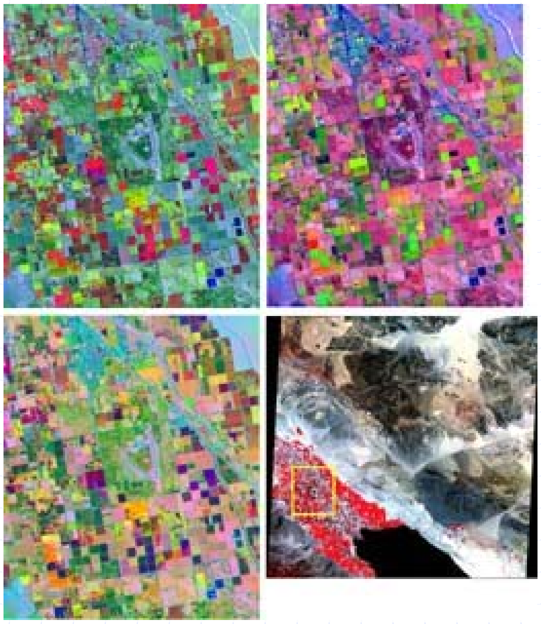
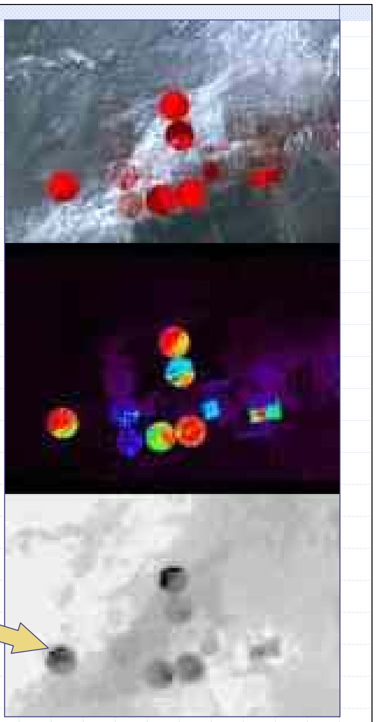


Image of Salton Sea from Asterweb showing different imaging bands useful in ground cover identification





Center pivot irrigated fields, Railroad Valley, Nevada

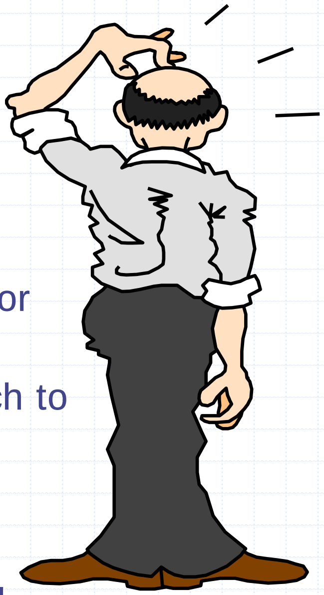


NDVI images with healthy crops shown in red.

Darker fields are colder and most likely are wetter

Images from Asterweb

How will we use Remote Sensing?



- Surveillance and interpretation tool when combined with GIS
- Need top down direction for local utilization
- Need considerable research to develop predictive skill
- Skill level dependent upon intensity of model training
- Intensity of model training dependent upon available data

Uses of climate variability

Long term Forecast - seasons	Disaster planning Vaccination programs Early season vector control
Short term forecasts - weeks	Truth long term forecasts Anticipate changes in risk
Real time Measures – current	Measure changes in climate, surveillance indicators and magnitude of anomaly Initiate appropriate response