Integrating Monitoring and Decision Tools for Sustainability

GEOSS
The Global Earth Observation System of Systems

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WHAT IS GEOSS?

- A comprehensive, coordinated and sustained observations of the Earth system
- To improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system.
- To provide timely, quality long-term global information as a basis for sound decision making, and the enhanced delivery of benefits to society

WHY GEOSS?

- GEOSS is a step toward addressing the challenges articulated by United Nations Millennium Declaration and the 2002 World Summit on Sustainable Development, including the achievement of the Millennium Development Goals.

GEOSS? HOW?

- EOS-III, Brussels, February 16, 2005, 60 countries and 33 organizations approved
  - **GEOSS's 10-year implementation plan, containing 2-yr, 6-yr & 10-yr outcomes, and**
  - **a permanent secretariat hosted by the U.N.'s World Meteorological Organization in Geneva**

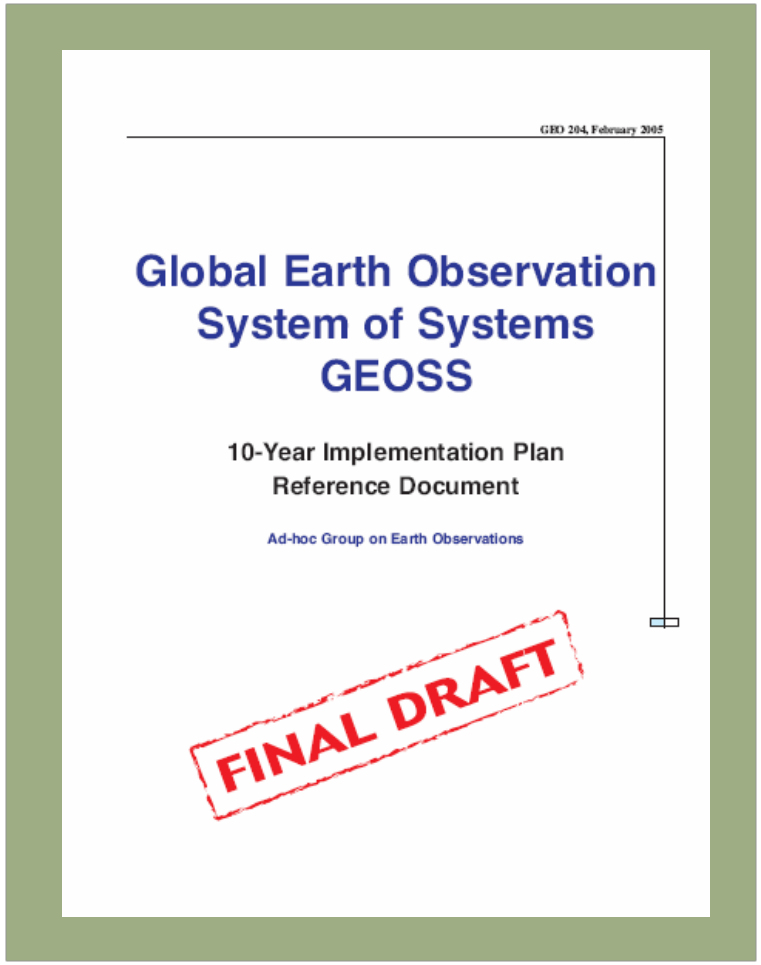
The Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan

http://earthobservations.org/

Understanding the Earth system is crucial to

- enhancing human health, safety and welfare,
- alleviating human suffering including poverty,
- protecting the global environment
- reducing disaster losses, and
- achieving sustainable development.

GEOSS 10-Year Implementation Plan Reference Document


GEO 204, February 2005

Global Earth Observation System of Systems GEOSS

10-Year Implementation Plan Reference Document

Ad-hoc Group on Earth Observations

FINAL DRAFT

Purpose is:

- **to provide detail to complement the 10 Year Implementation Plan**
- **form the basis for actions in the GEOSS being prepared in year 2005 and subsequent work plans**
- **but the document remains a "reference" not a "negotiated" text**

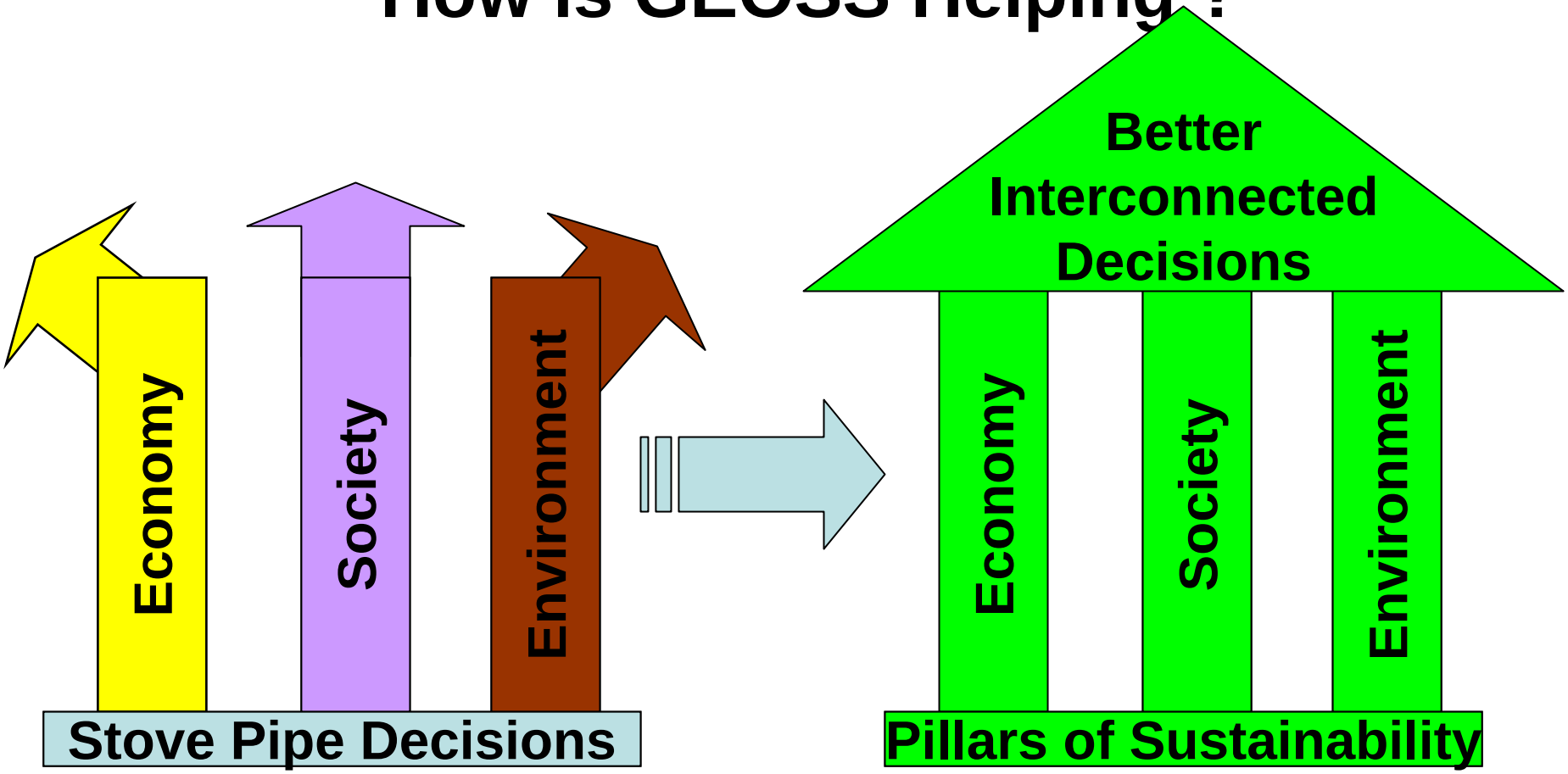
http://iwgeo.ssc.nasa.gov/

A global system of Earth observations would provide us with tools & capacity

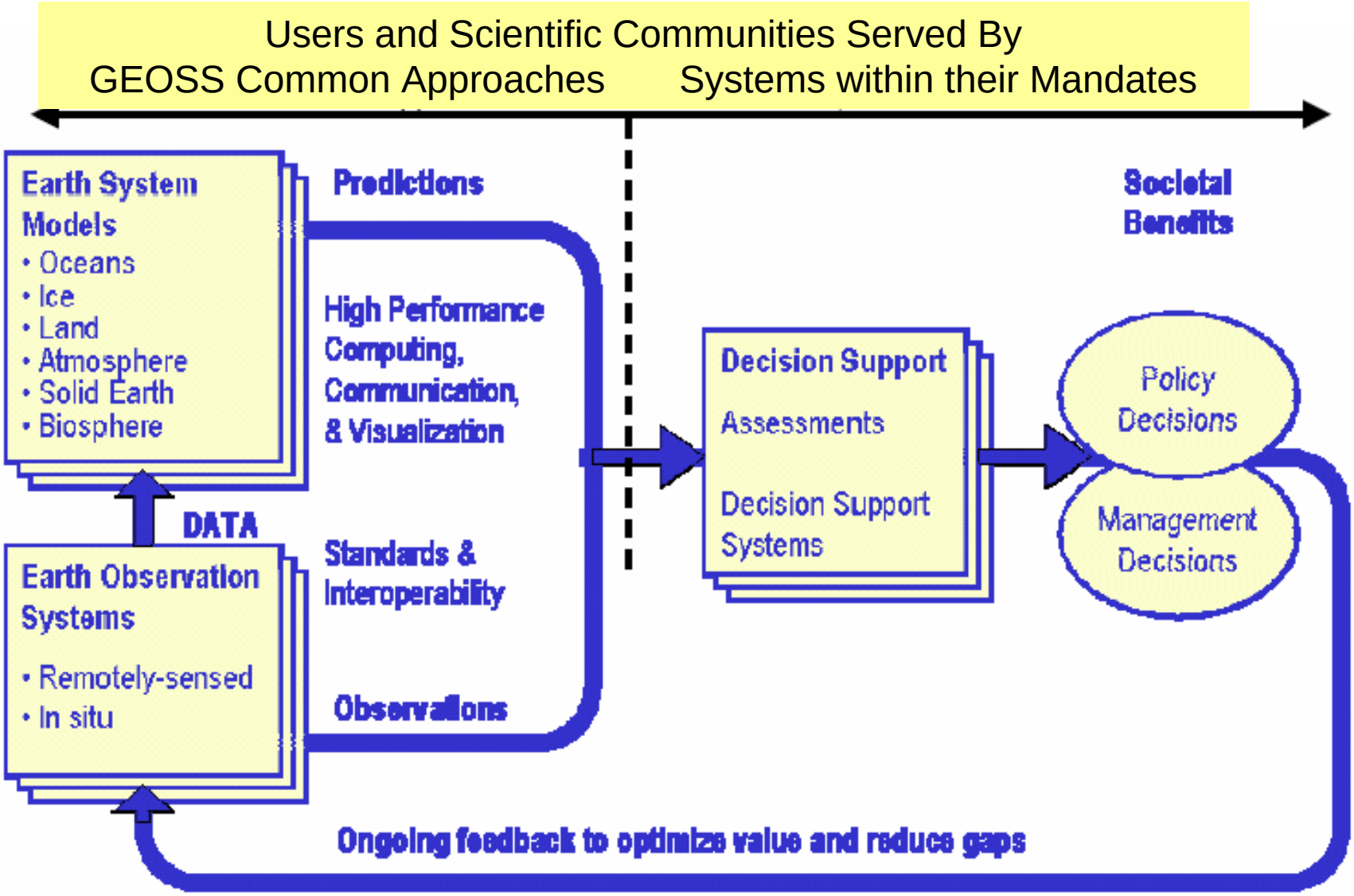
- ***to make national and global air quality forecasts,***
- ***to know in advance when droughts would occur and how long they would last, and***
- ***to predict the outbreak of deadly diseases by tracking the environmental factors that contribute to their spread.***

The availability of these types of observational data would transform the way we relate and react to our environment, providing significant societal benefits through improved human health and well-being, environmental management, and economic growth.

Sustainability
Making the Interconnections
How is GEOSS Helping ?



The GEOSS Architecture



Nine GEOSS Societal Benefits

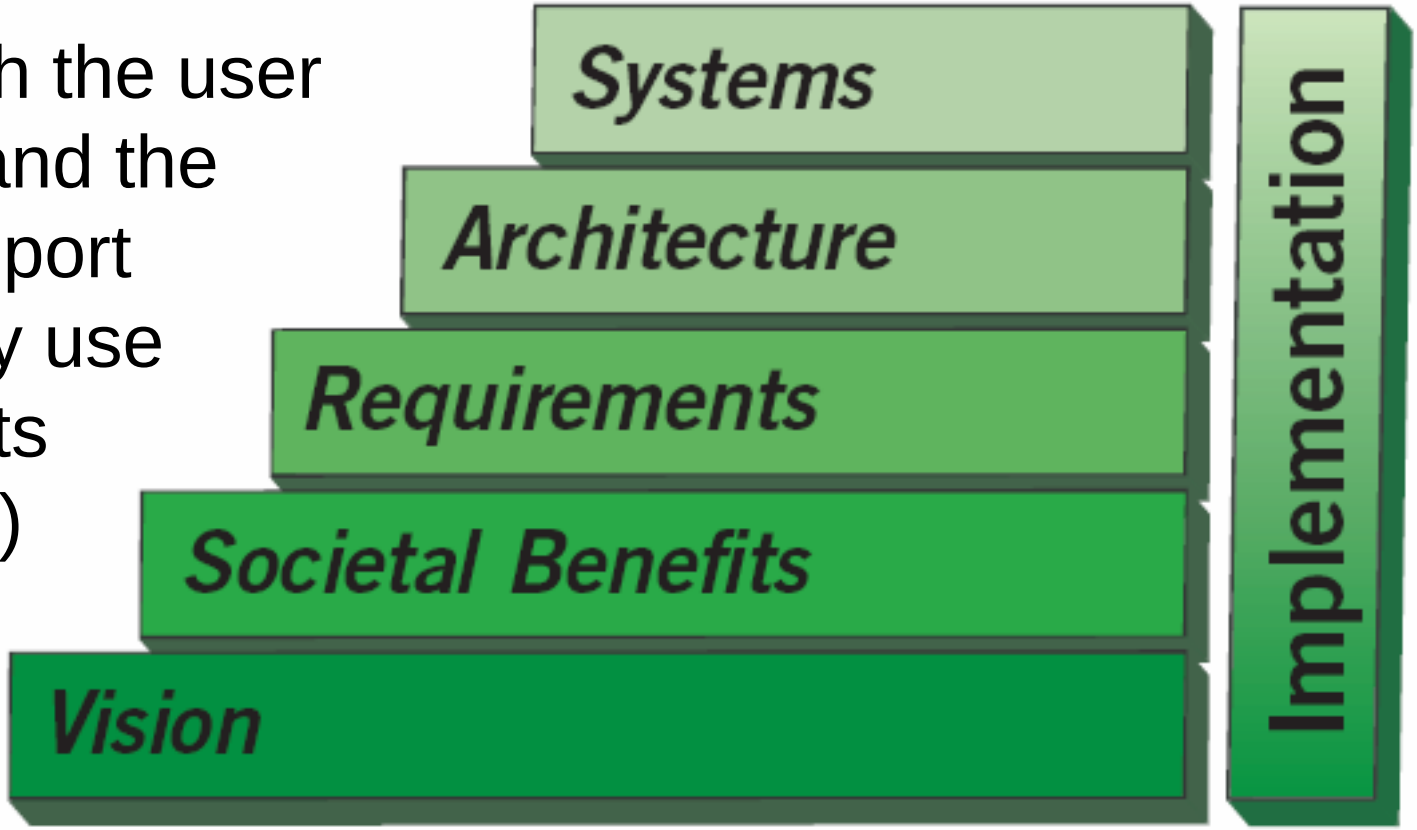
1. Improve Weather Forecasting
2. Reduce Loss of Life and Property from Disasters
3. Protect and Monitor Our Ocean Resource
4. Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change
5. Support Sustainable Agriculture and Forestry, and Combat Land Degradation
6. Understand the Effect of Environmental Factors on Human Health and Well-Being
7. Develop the Capacity to Make Ecological Forecasts
8. Protect and Monitor Water Resources
9. Monitor and Manage Energy Resources

Vision Statement

- Enable a healthy public, economy, and planet through an integrated,
- comprehensive, and sustained Earth observation system.

Approach to Implementing the U.S. Integrated Earth Observation System

Interface with the user community and the decision support systems they use (requirements specification)



THE SPECTRUM OF USERS

From observations

- Earth observations & earth system models
- Data-to-Information archiving & services
- Decision support tool development
- Decision making
- Assessment of benefits

- Earth system scientists and modelers
- Earth system service providers
- Environmental process modelers & researchers
- Enviromental managers
- Public officials, advocacy groups and the Public

To societal benefits

User Requirements for Earth Observations

Generally well documented

Earth observations & earth system models	Earth system scientists and modelers
Data-to-Information archiving & services	Earth system service providers
Decision support tool development	Environmental process modelers & researchers
Decision making	Policy Makers & Environmental managers
Assessment of benefits	Public officials, advocacy groups and the Public

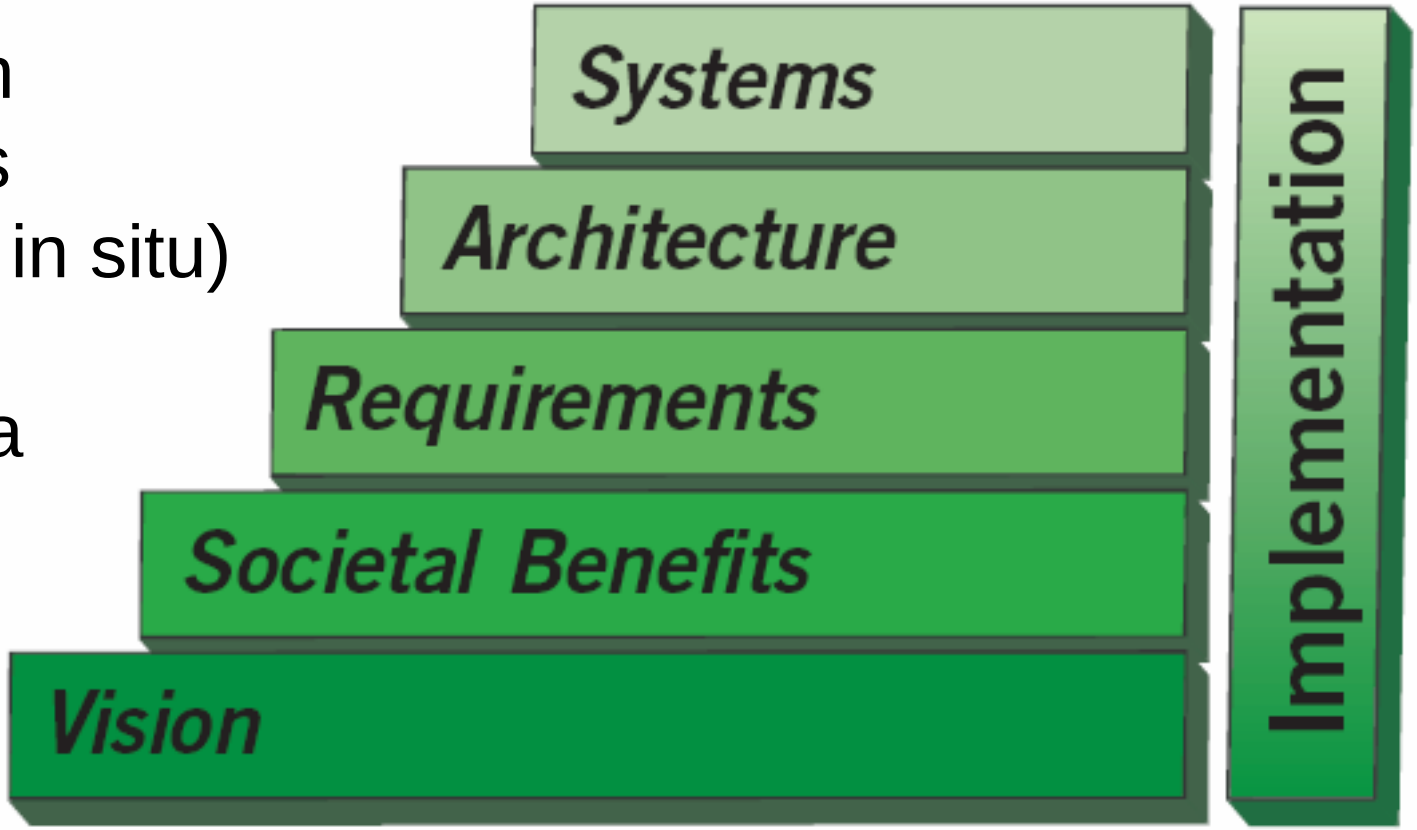
Less able to document needs

Approach to Implementing the U.S. Integrated Earth Observation System

Collect Earth observations (remote and in situ)

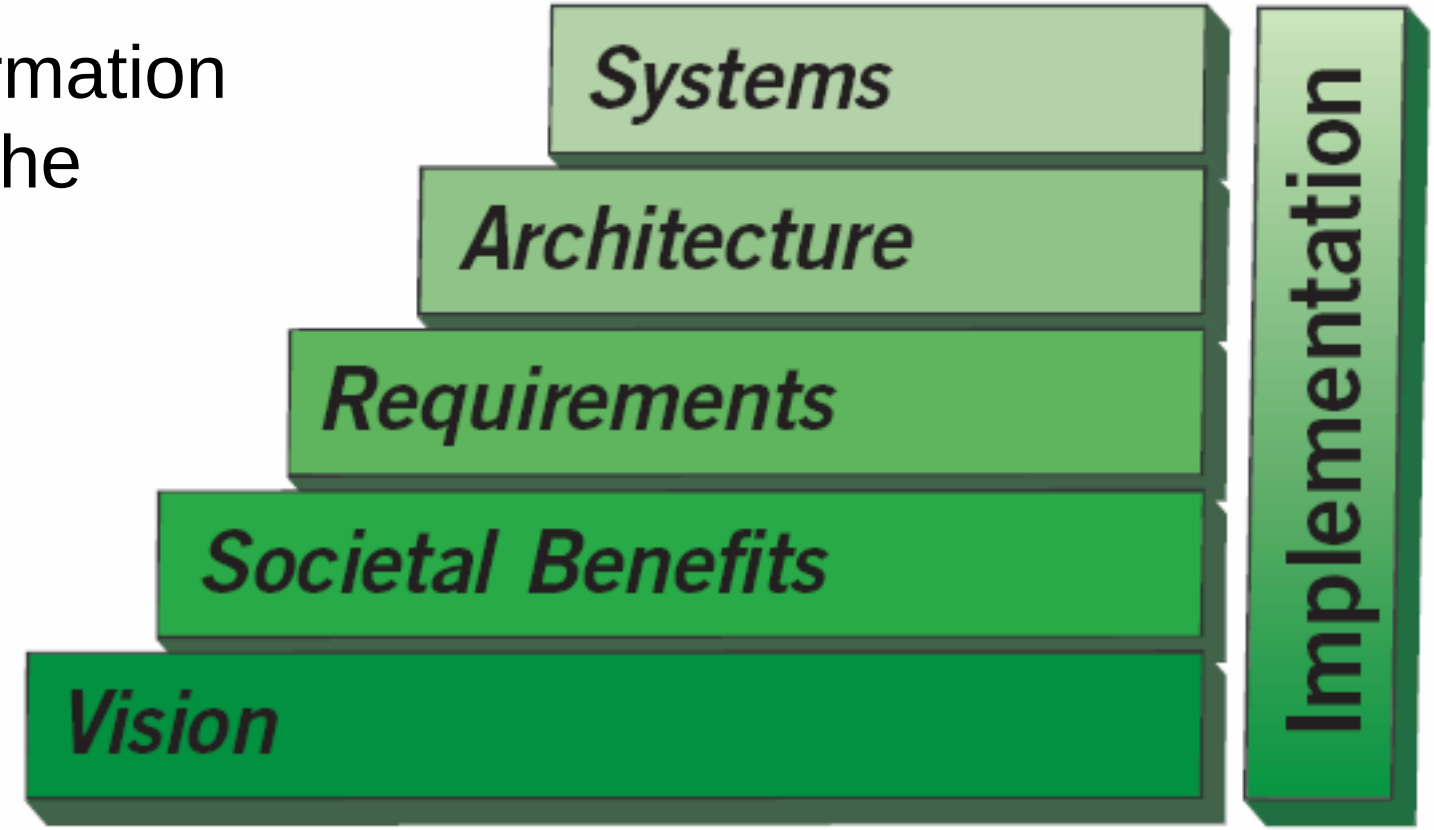
Manage data

Sustain capacity



Approach to Implementing the U.S. Integrated Earth Observation System

Deliver information (tailored to the needs of the user community)

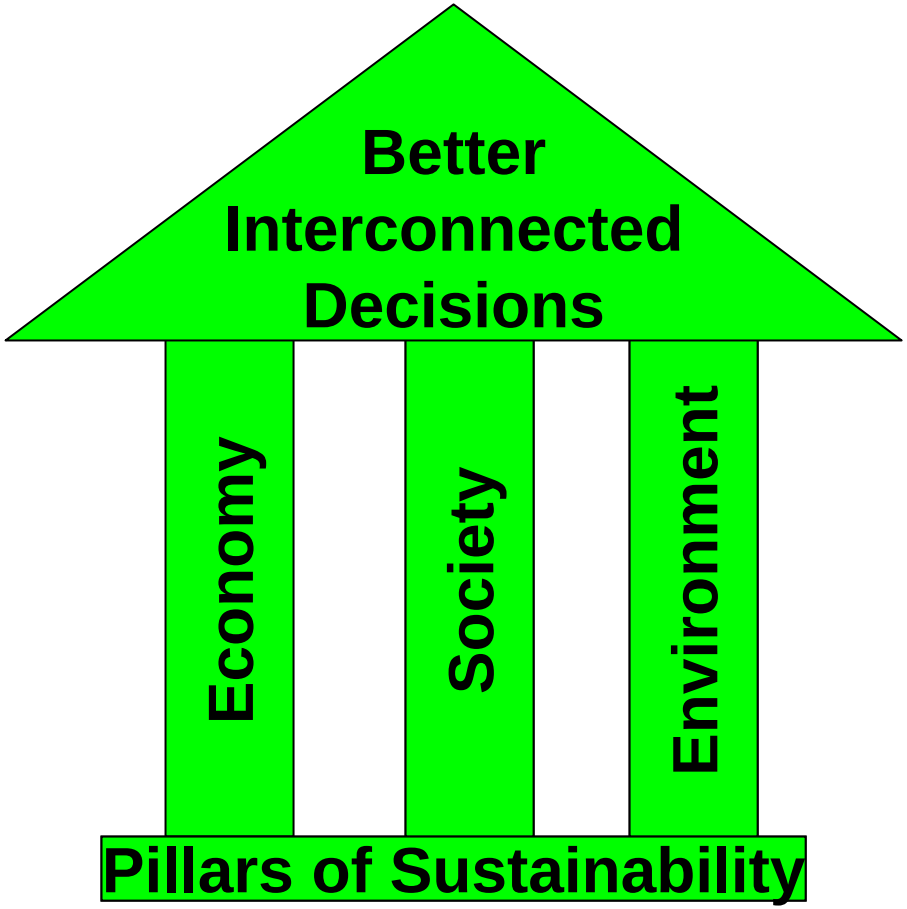


Focus on the Decision Support Tools In Each of the Pillars

Get the DST Developers And Users to Identify Unfilled Data and Information Needs

Convey User Require-ments to GEOSS

Partner with GEOSS To Build Decision Support Systems



GEOSS Air Quality-Public Health Example

Enhanced Earth observations that lead to better air quality data & the ability to predict air pollution episodes would contribute to improvements in human health via

- reduced incidence of acute attacks & deaths from chronic respiratory diseases, such as asthma
- fewer air pollution-related emergency room visits
- fewer days absent from school or work

Air pollution affects the environment in many ways that ultimately impact on our health and well-being by

- reducing visibility
- damaging crops, forests, and buildings; acidifying lakes and streams
- stimulating the growth of algae in estuaries

Rapid development and urbanization around the globe has created air pollution that threatens people everywhere, as air pollution can travel great distances across oceans and national boundaries.

Integrating Existing Systems

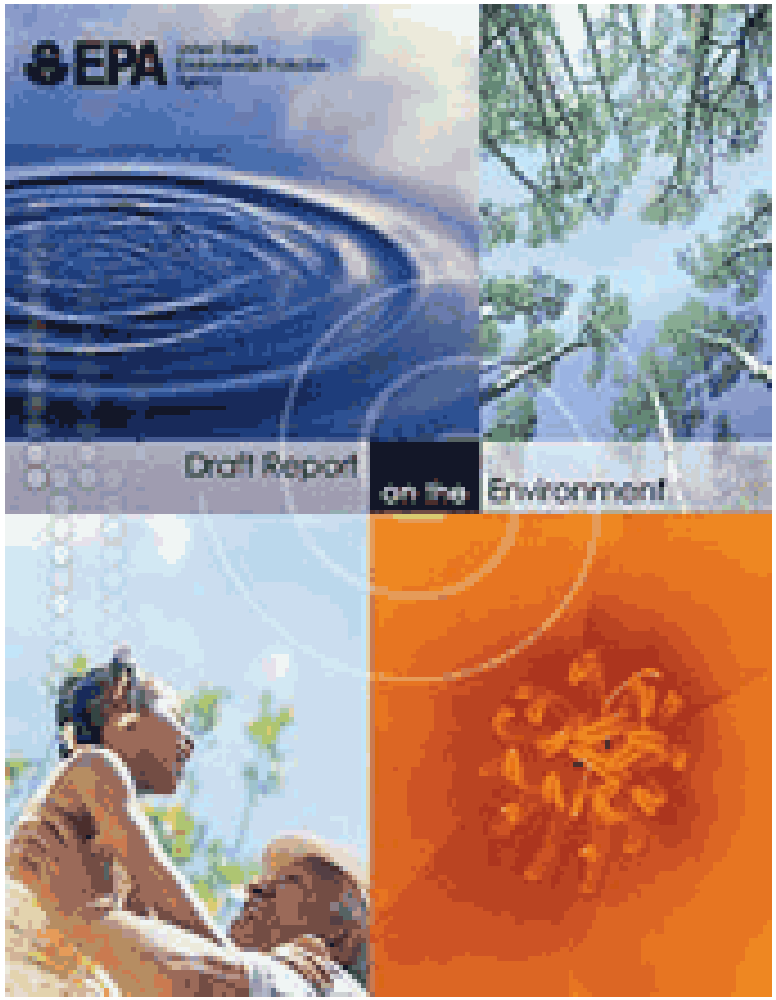
AIRNOW

NOAA EPA AQ Forecasting

Public Health Dose-Response

Warning Systems

Draft Report on the Environment



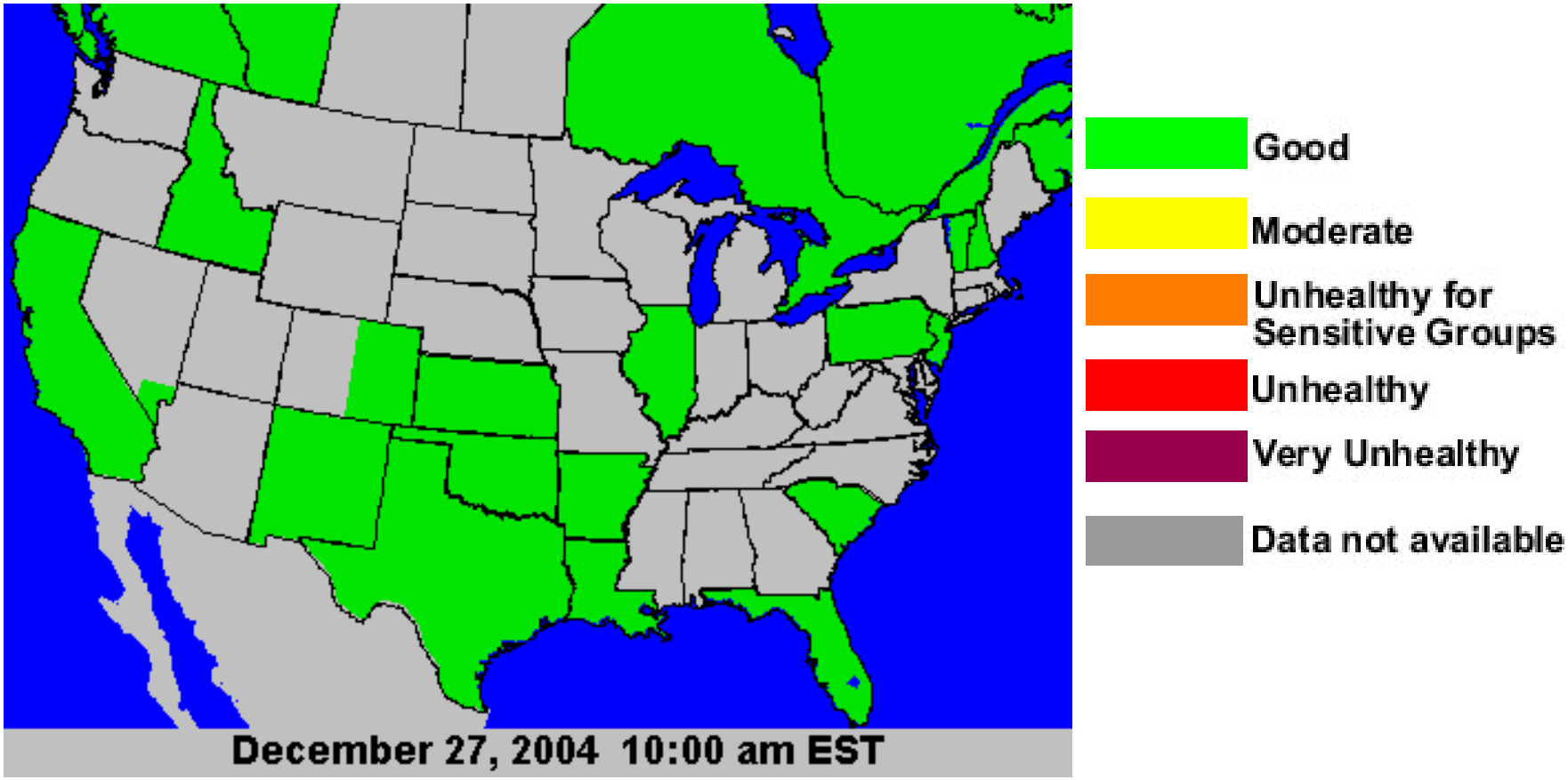
- Describes current national environmental conditions and trends using existing data and indicators
- Identifies data gaps and research needs
- Discusses the challenges government and our partners face in filling those gaps

What does the Report on the Environment say about Air?

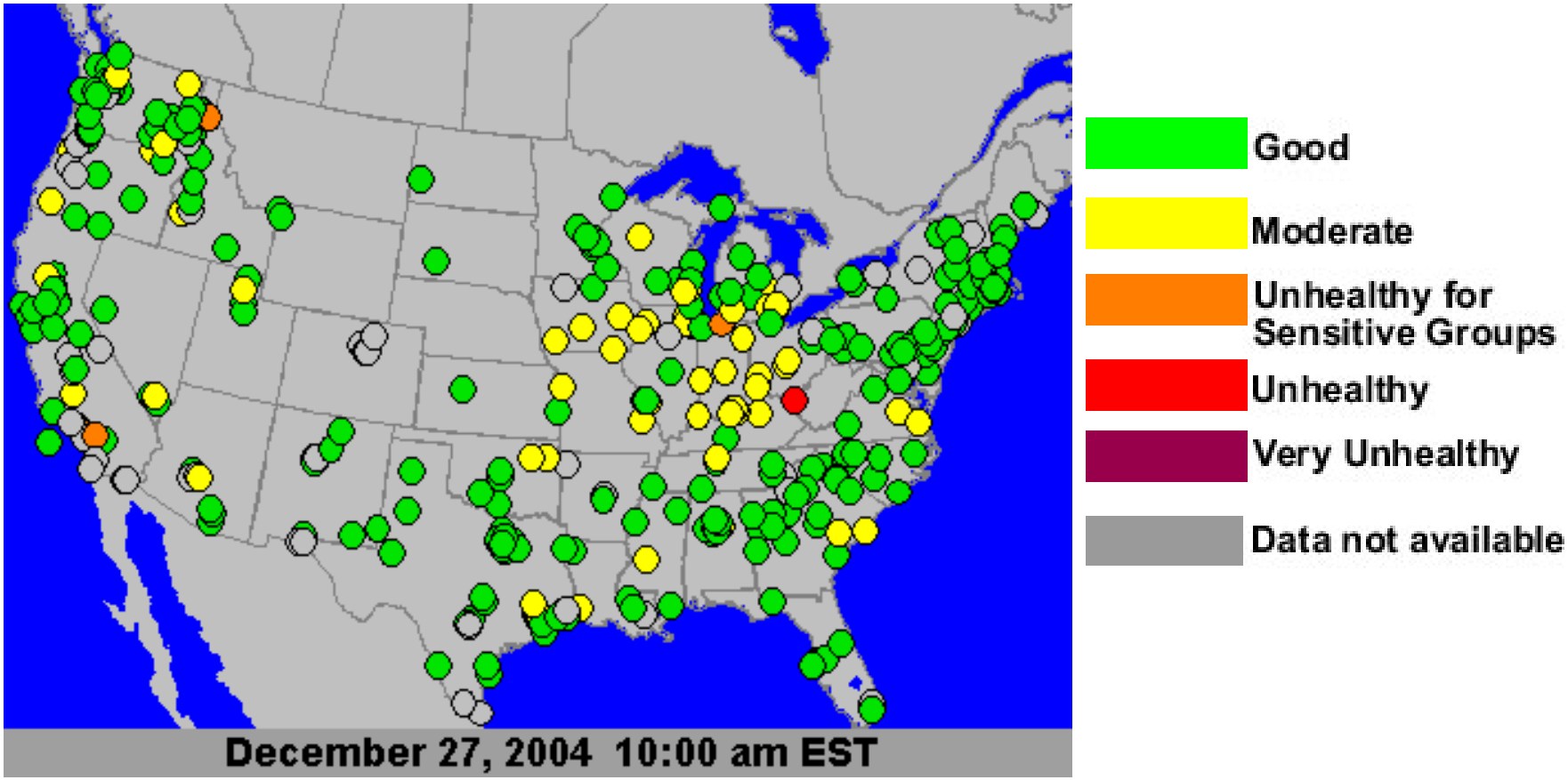
- “In general, there are some very good measures of outdoor air quality.”

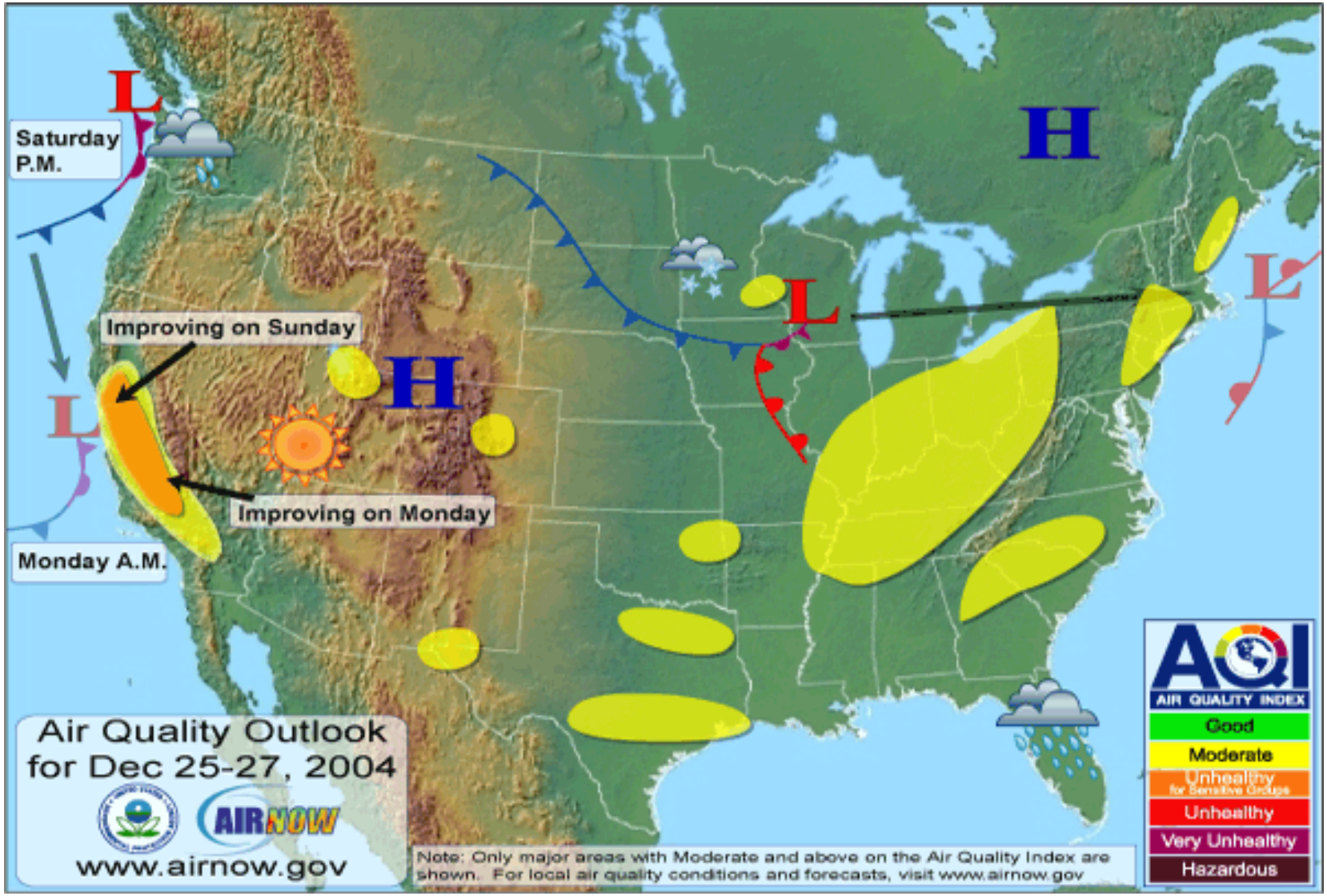
- However . . . “There is a need for measures to compare actual and predicted human health and ecological effects related to exposure to air pollutants.”

Current AQI - Ozone



Current AQI - Particle Pollution(PM2.5)




Saturday P.M.
L
H
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Improving on Sunday
Improving on Monday
Monday A.M.
Air Quality Outlook for Dec 25-27, 2004
AIRNOW
www.airnow.gov
Note: Only major areas with Moderate and above on the Air Quality Index are shown. For local air quality conditions and forecasts, visit www.airnow.gov
AQI
AIR QUALITY INDEX
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
Very Unhealthy
Hazardous

The Air Quality Characterization Challenge and Steps Being Taken in the U.S.

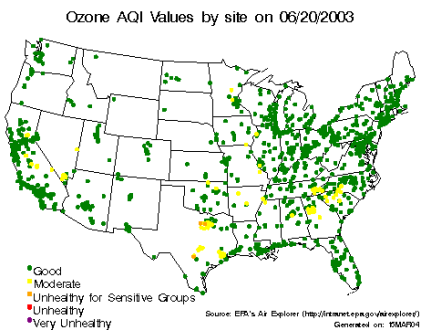
- Issue: Cannot monitor at all locations, but want to know air pollution characteristics and concentrations everywhere.
  - To better evaluate air quality attainment directly
  - To better relate to health and environmental improvements

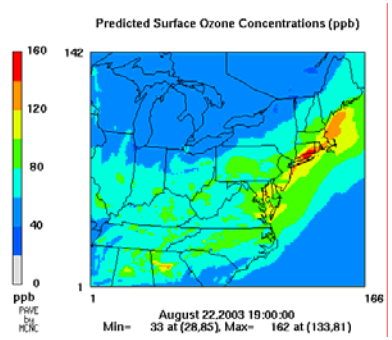
- Solution: Combined predictive approaches taking advantages of different data strengths

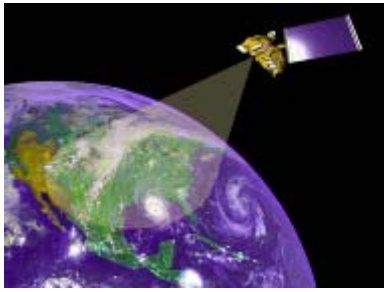
Sources of Air Quality Characterization / Concentration Information

- Ambient air monitoring data
- Air quality modeling output
  e.g. CMAQ)
- Satellite data
  (e.g. MODIS)

Partnerships in Characterizing Air Quality



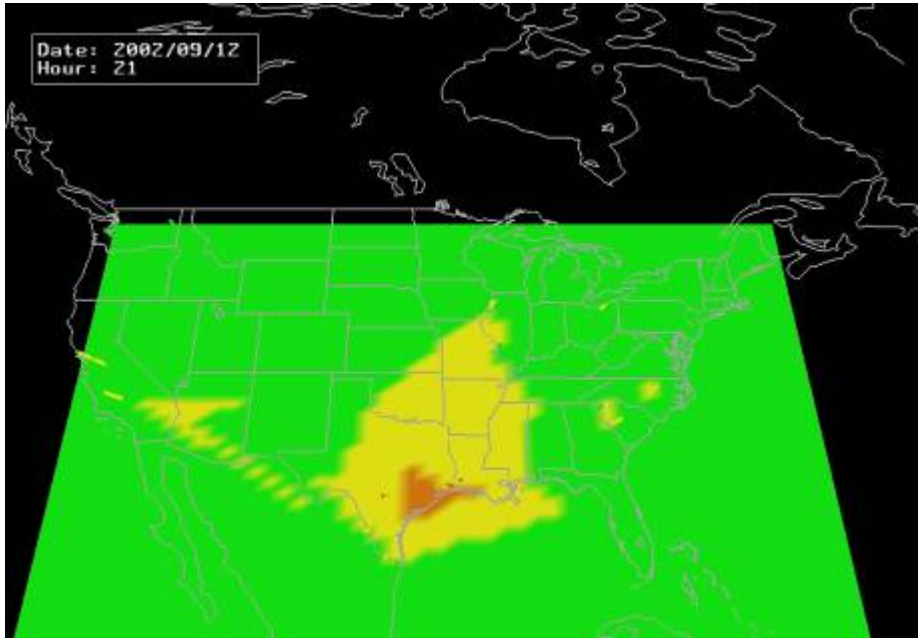




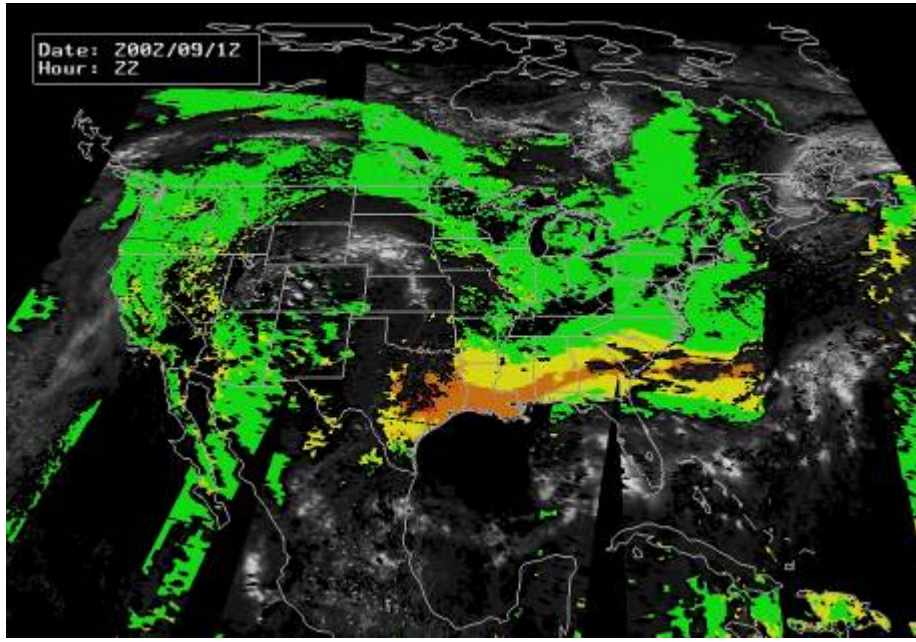
Monitoring ⟷ Modeling ⟷ Satellite

12 September 2002

Linear Interpolation
Surface $PM_{2.5}$ Monitors



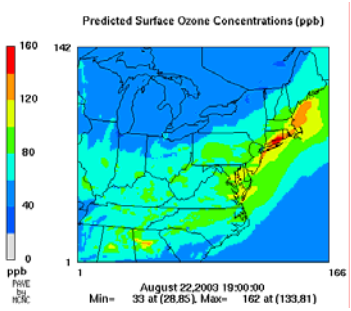
MODIS AOD



Satellite measurements capture important spatial gradients and meteorology influences, extremely important for public health side of air quality.

Linking Air Quality and Public Health?

- Do different air quality characterization methods improve capabilities for environmental public health tracking?



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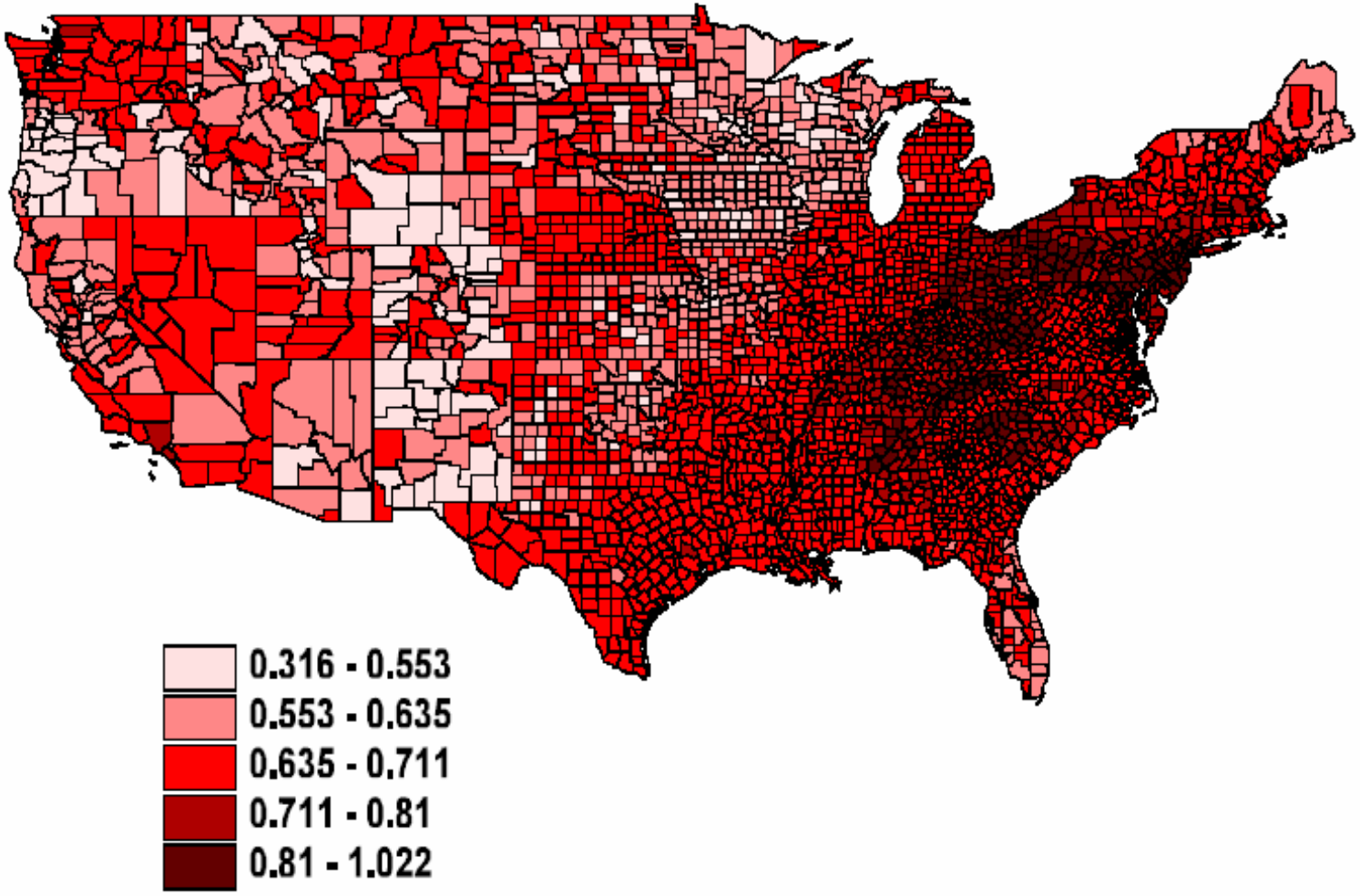
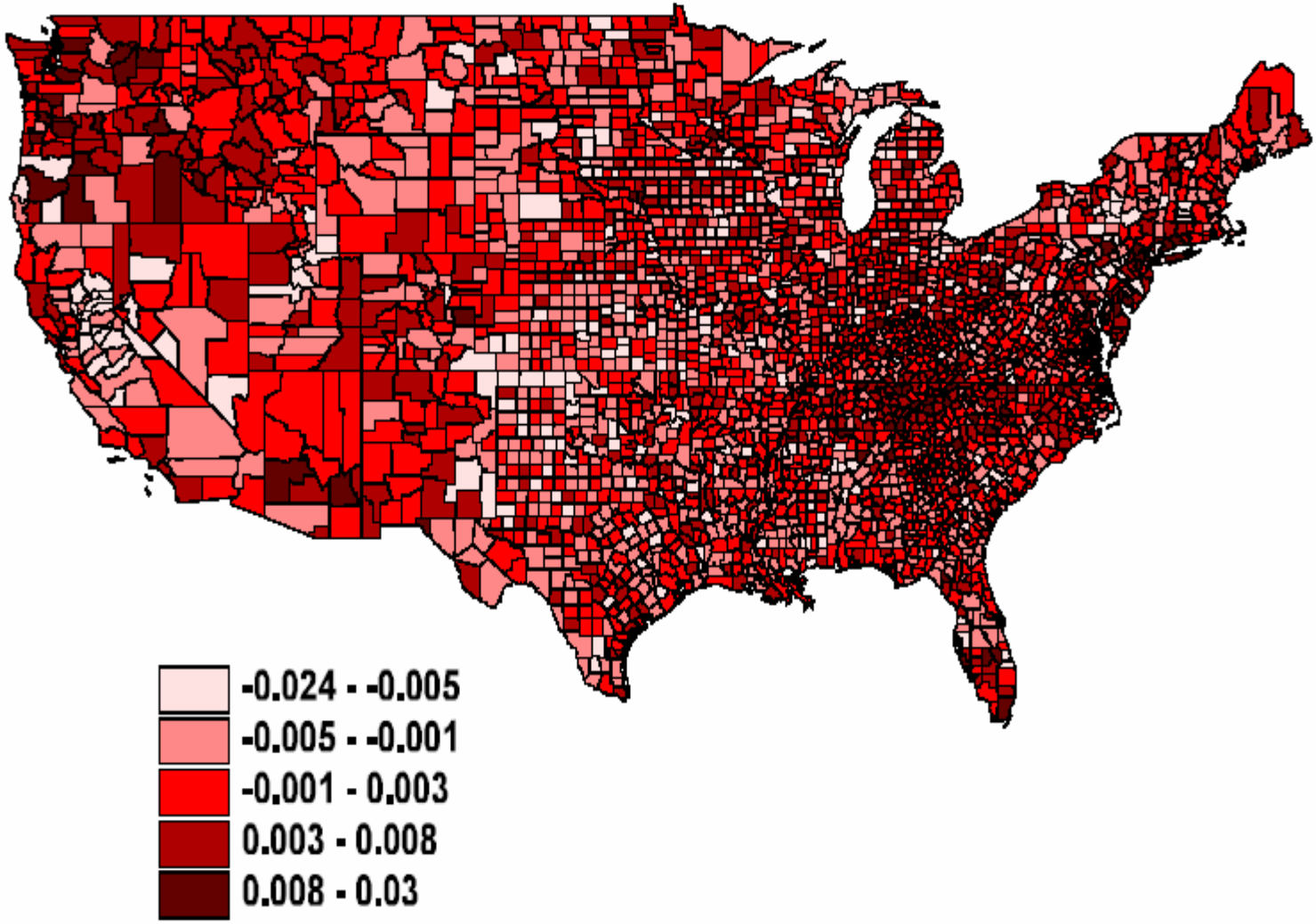
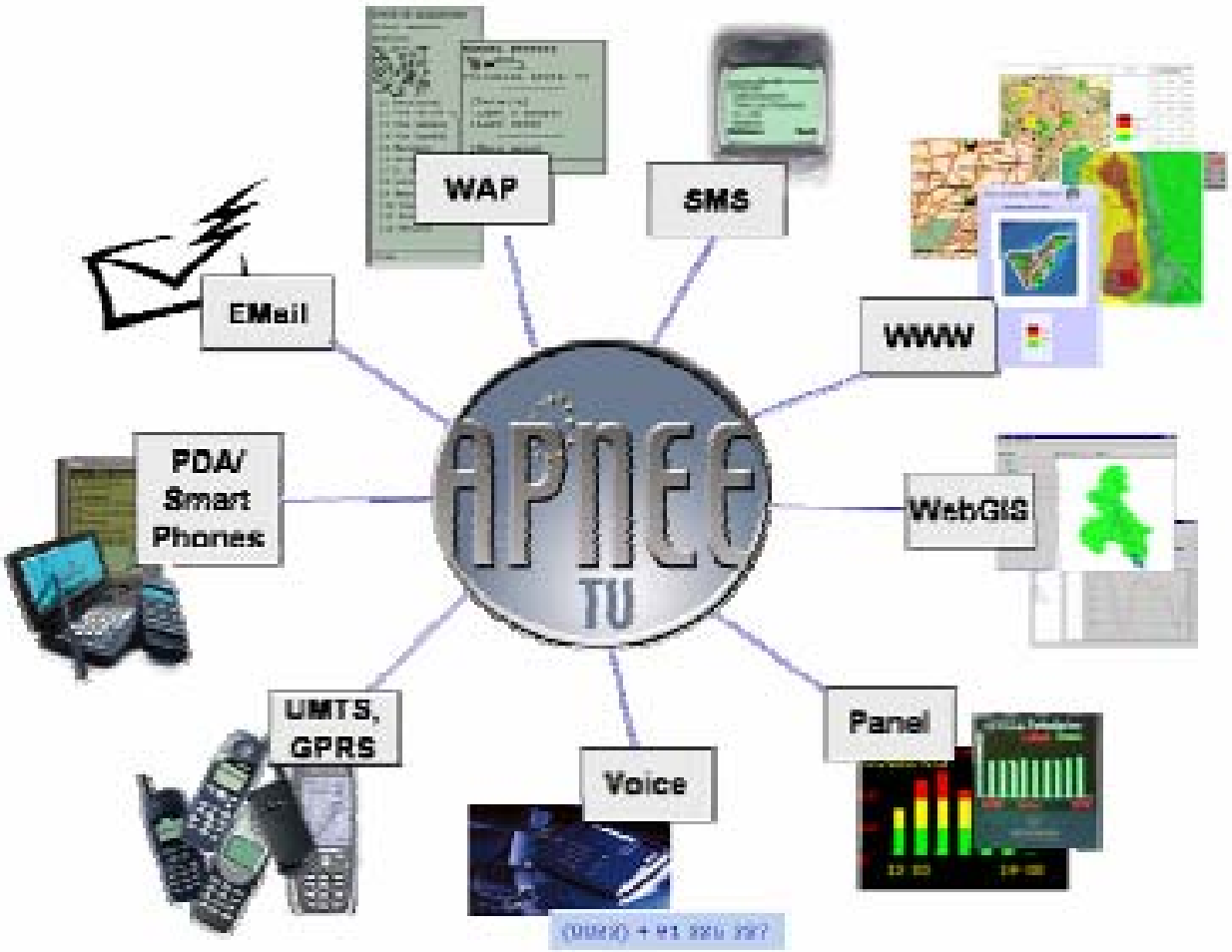


Percent increase in monthly mortality per increase in 1 $\mu g/m^3$ of $PM_{2.5}$ concentrations (June, 2000).



Change in monthly percent increase in mortality by adding ozone predictive surface

Warning Sensitive Sub-populations in Real-Time



User Requirements for Enhanced Integrated Systems

New Satellite Instruments

New Public Health Studies

Accountability – Measuring Societal Benefits

Identifying User Requirements for Atmospheric Observations

Atmospheric Composition

Continuous Emissions Data

Human Activity of the General Population

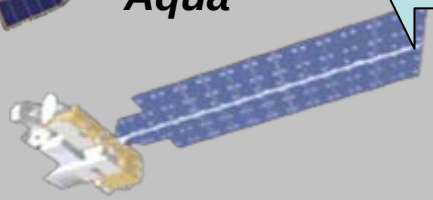
Intercontinental Transport Monitoring

Vertical Profiles of Atm Variables

Air Quality

TOMS-EP

Aqua



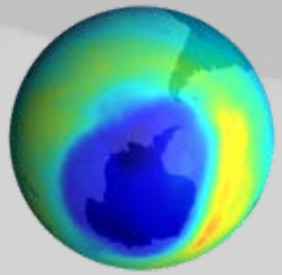
Tasking

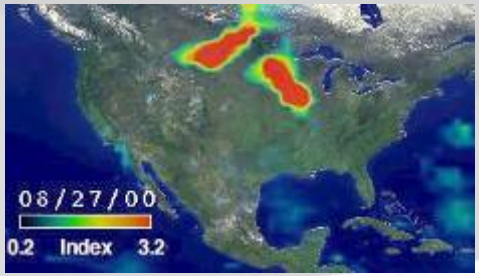
EDOS: Mission Control

Downlink

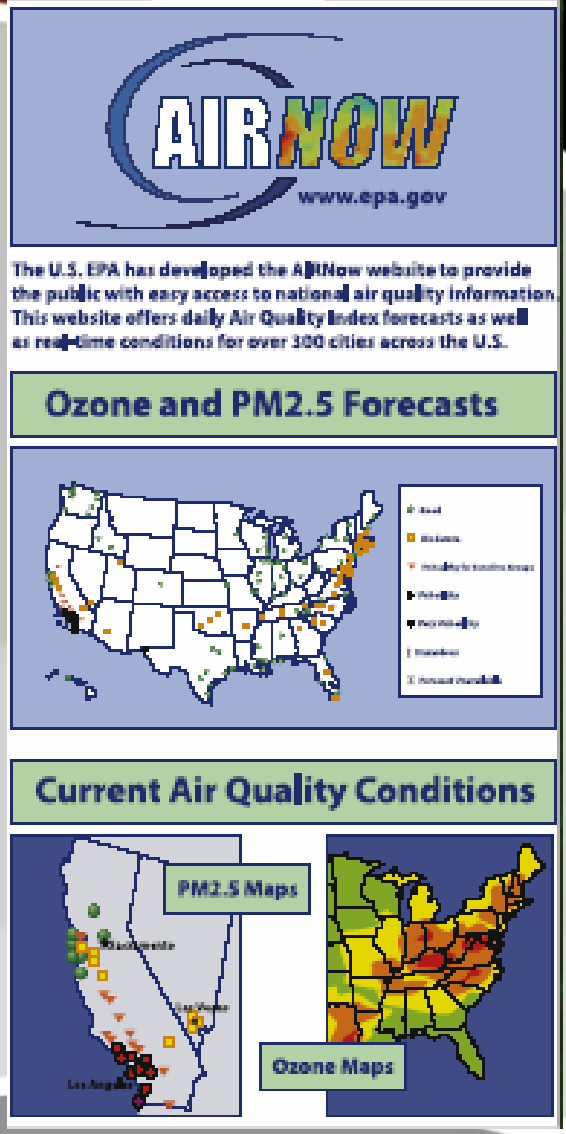
EOSDIS & DAACs

Exploitation



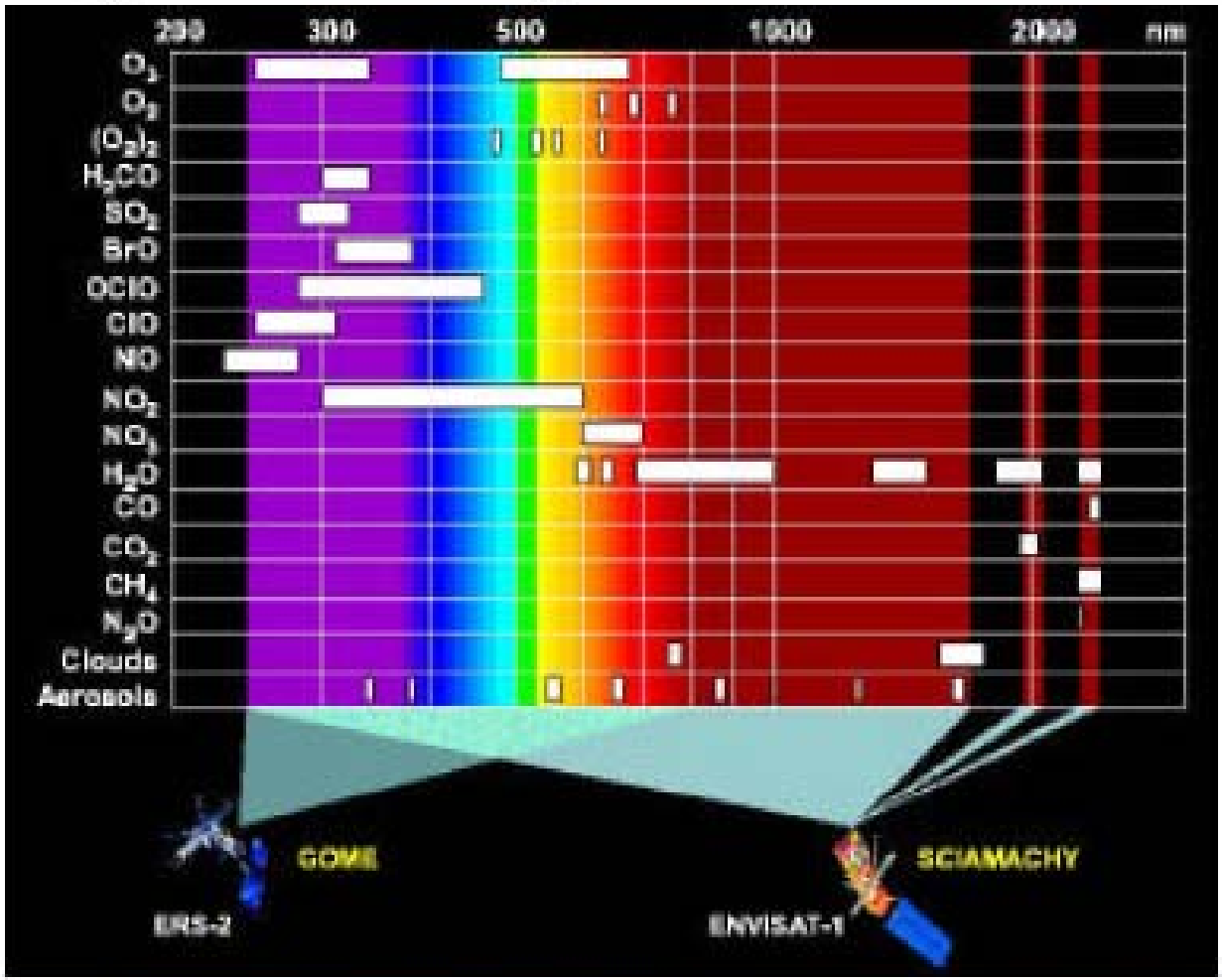


Societal Benefits



Current State of Science Observes O_3, NO_2, H_2CO, SO_2 in UV-VIS

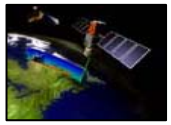
Trace Gases and Aerosols Important for Air Quality



CO & PM in IR

What is possible on GOES-R in 2012?

Research → Decision Tools → Operations

	2004- 2005	2006- 2008	2009-2012	2012 and beyond
SCIENCE	Pilot Studies: Initial research Shows satellite can provide Supra-regional Observations Initial research on use in Regional & Global Air Quality Models	Demonstrate use of LEO satellite data to fill data gaps in non-urban areas and for data assimilation	Air Quality data assimilation and prediction	Air Quality Forecast as Part of WRF Initiative within NASA/NOAA/EPA ESMF
Nationwide Data	MODIS AIRS OMI one, PM CO data		(potential) Geostationary Observatory for Tropospheric Air Chemistry 	

Applications Research → Validation & Verification → Applications Demonstration

APPLICATIONS	EPA, State, Local, and Tribal Air Quality Management Organizations			Air Quality Management Tools (mature products)
	Ozone, CO, Aerosol	Ozone, NO_2, CO, SO_2, HCHO, Aerosol	All NAAQS Criteria Pollutants (except Pb)	

Identifying User Requirements for Public Health

Relationships between Pediatric Asthma & Socio-economic/Urban Variables in Baltimore, MD

- Optical & thermal infrared satellite data for the following Urban Variables
  - Degree of urbanization (built area) & degree of vegetation
- Two variables explained 95% of the spatial variability of asthma hospital admissions: NDVI & PFH

Identifying Societal Benefits

From Increasing Data on Environmental Factors Affecting Health & Well-Being

- **Improved visibility and reduced haze for tourism**
- **Improved understanding of global transport of pollutants**
- **Early warnings for harmful exposures**
- **Improved, lower cost mitigation/ prevention programs**
- **Reduced releases of air and toxic pollutants**
- **Reduced lung-related diseases & premature death**
- **Reduced hospital admissions & use of medicines**
- **Reduced absences from work and school; lower sick pay costs**
- **Improved resiliency of crops; increased yields**

Impacts of Poor Air Quality on Society

- 60,000 deaths per annual (mean) [Science 289, 2000]
- $143 billion per annual (mean) [American Lung Association, 2001]