Nasa's Public Health Program: How We Can Use NASA Satellite Data To Study Global Public Health Issues

Jeffrey C. Luvall
NASA Marshall Space Flight Center
Huntsville, AL
jluvall@nasa.gov

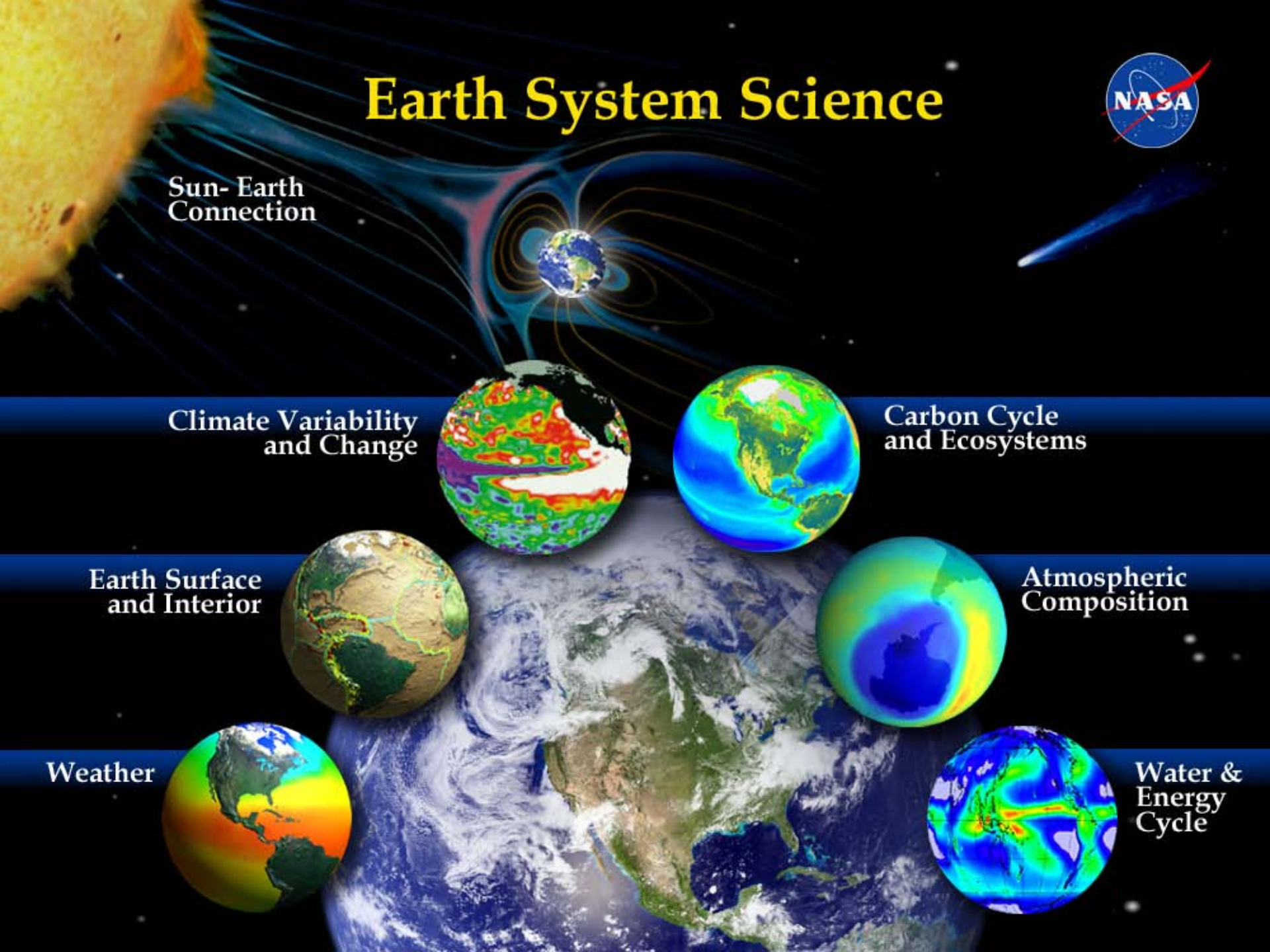
2010 NASA Science Plan

The 2010 Science Plan identifies the direction NASA has received from the Administration and Congress, advice received from the nation's science community, principles and strategies guiding the conduct of our activities, and challenges we face. The plan that results enables NASA, as Administrator Bolden says, to "do the best science, not just more science."

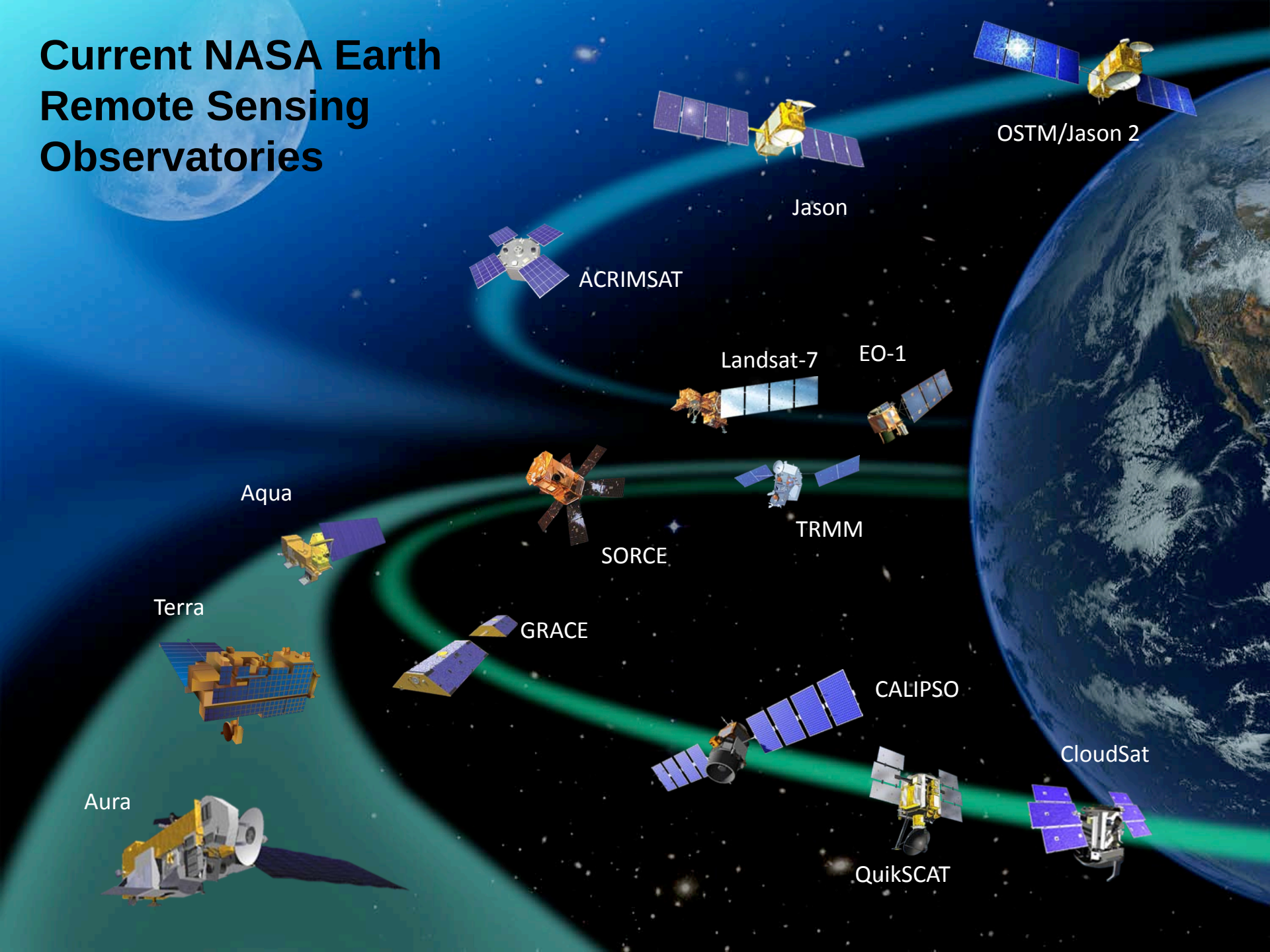
The NASA Earth Science strategic goal is stated as, ***"Advance Earth System Science to meet the challenges of climate and environmental change."***

http://science.nasa.gov/media/medialibrary/2010/08/30/2010SciencePlan_TAGGED.pdf

Earth System Science



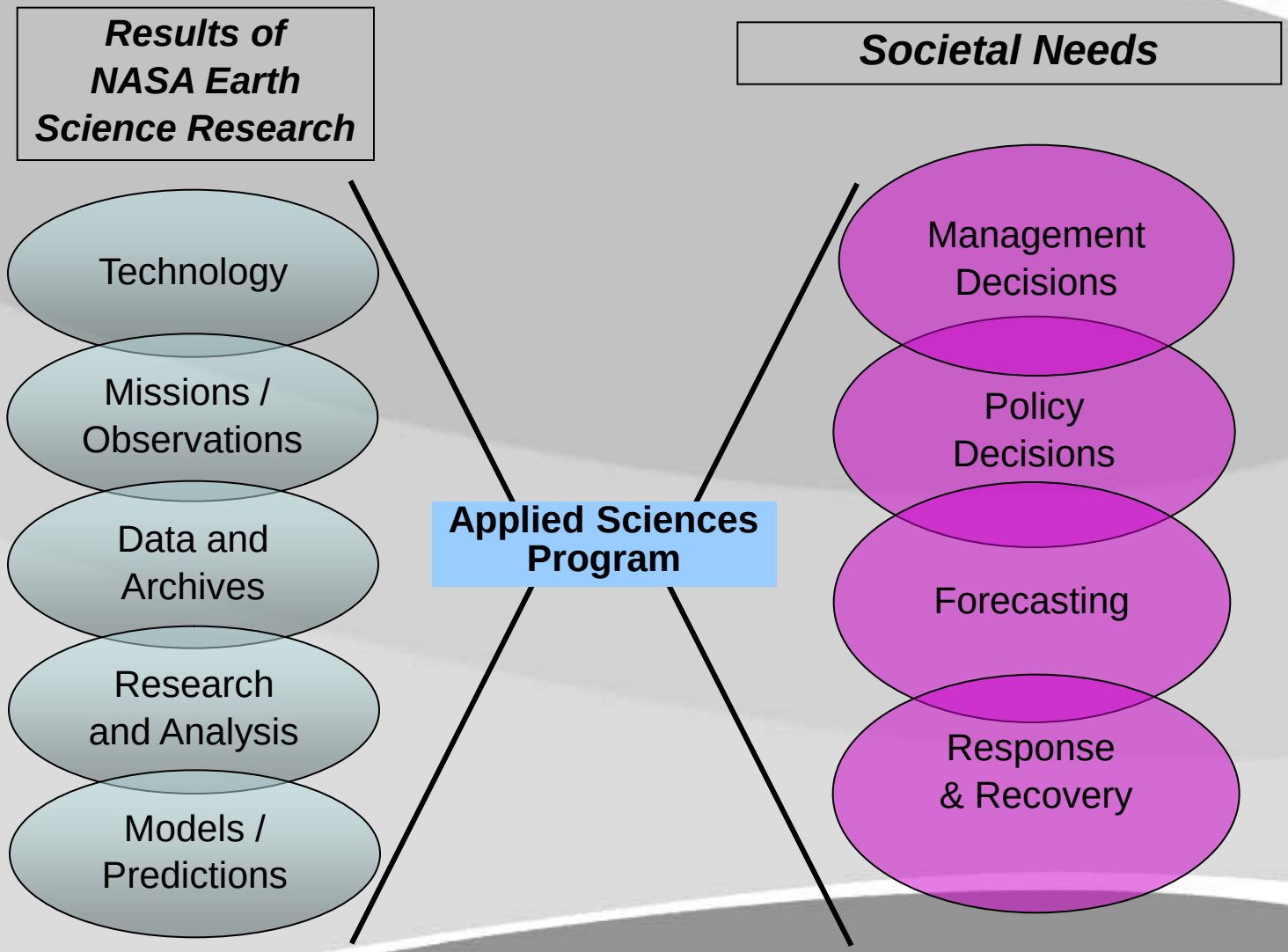
Current NASA Earth Remote Sensing Observatories



NASA Applied Sciences Program Mission Statement

Advance the realization of societal and economic benefits from NASA Earth science by identifying societal needs, conducting applied research and development, and collaborating with application developers and users.

NASA Applied Sciences Architecture



Applied Sciences Program

Eight Program Elements

Agricultural Efficiency

Air Quality

Climate

Disaster Management

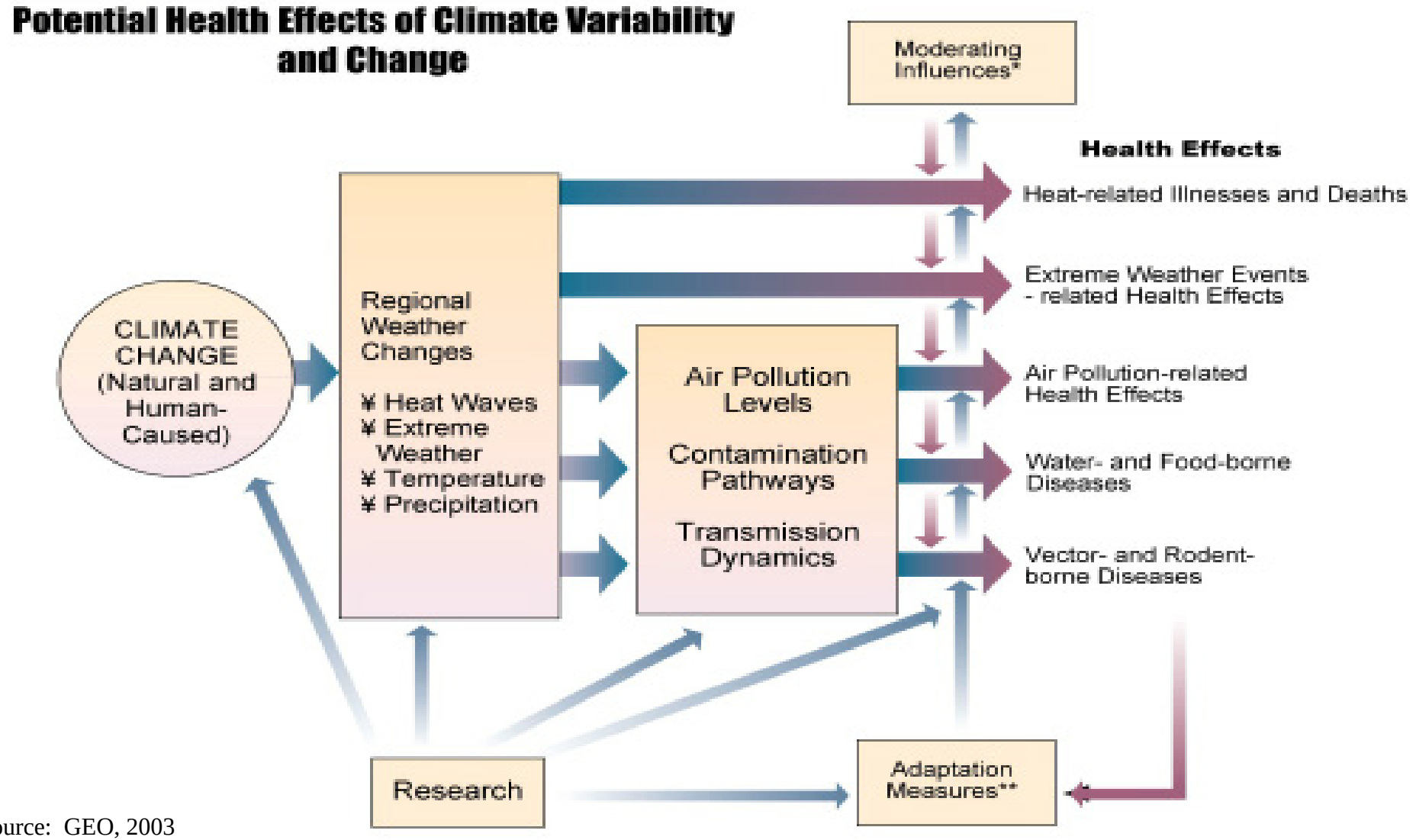
Ecological Forecasting

Public Health

Water Resources

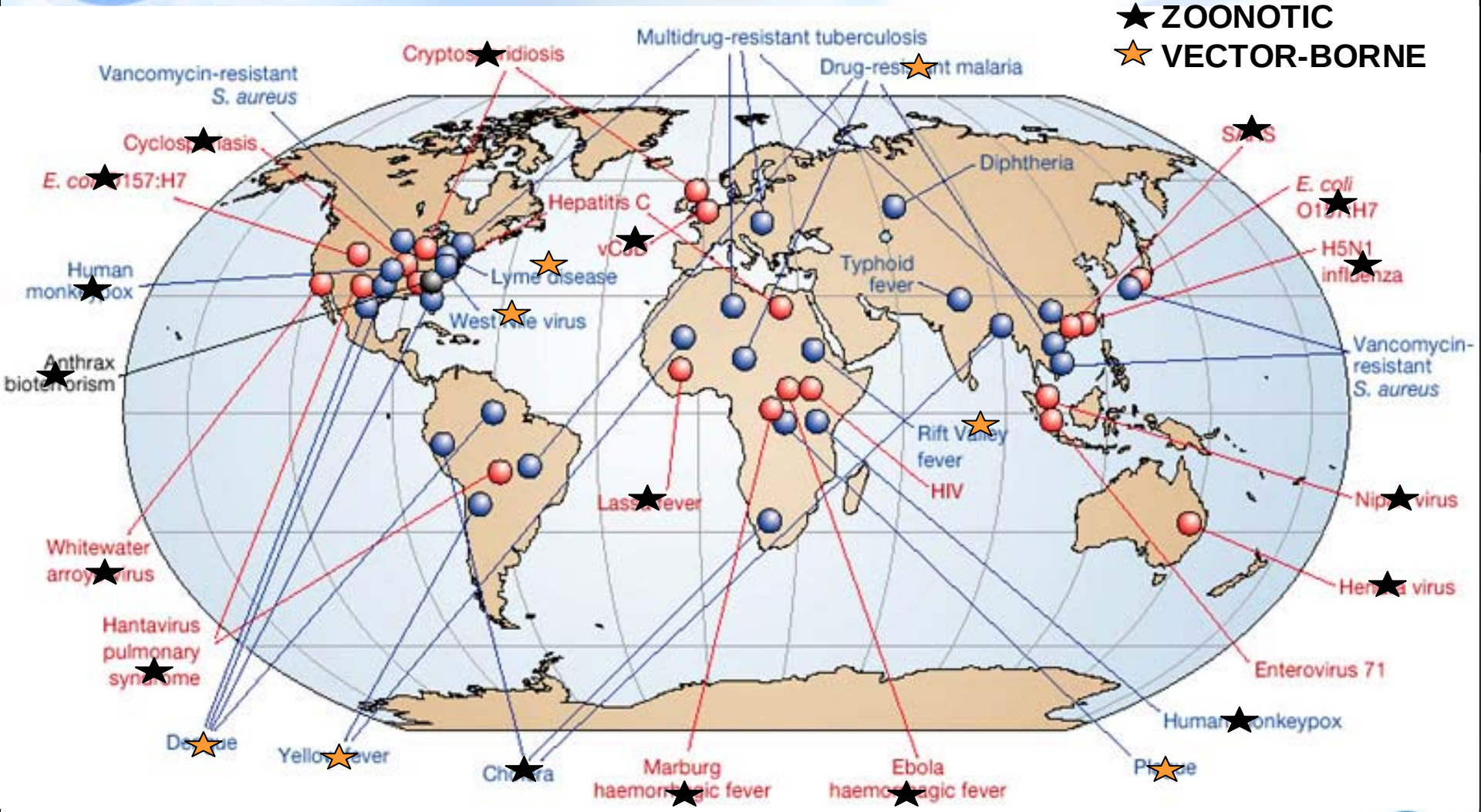
Weather

Why public health?



Source: GEO, 2003

Global Emerging Diseases*



* Modified from Morens et al. 2004 *Nature* 430:242

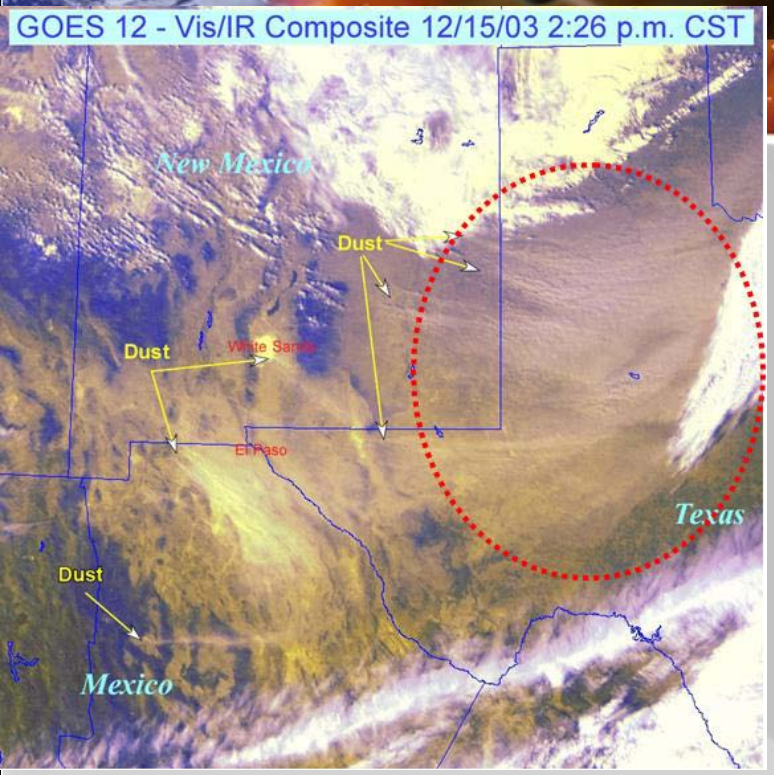
New Environmental Threats

This visible image of the Gulf oil slick was taken on May 9 at 19:05 UTC (3:05 p.m. EDT) from MODIS aboard NASA's Aqua satellite. Crude oil brings volatile organic compounds into the air which can react with nitrogen oxides to produce ozone.

Focus Areas of Public Health

The Public Health application area focuses on Earth science applications to public health and safety, particularly regarding ***infectious disease***, ***emergency preparedness and response***, and ***environmental health*** issues. The application explores issues of toxic and pathogenic exposure, as well as natural and man-made hazards and their effects, for risk characterization/mitigation and improvements to health and safety.

Dust Surveillance in the Southwest USA



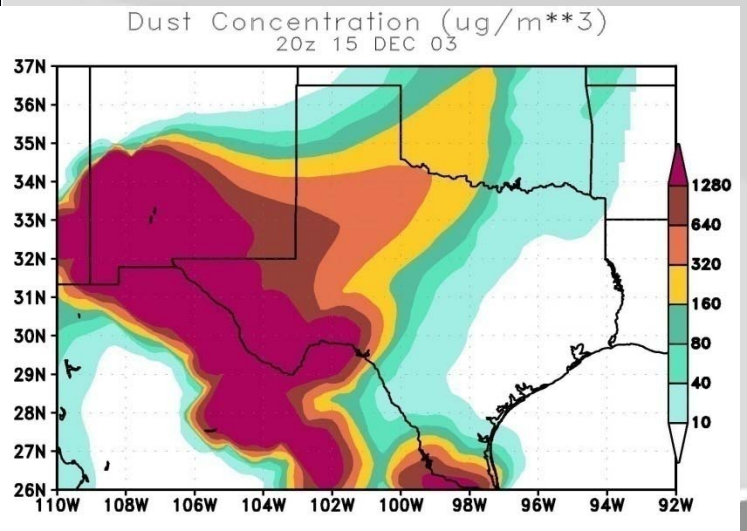
http://phairs.unm.edu

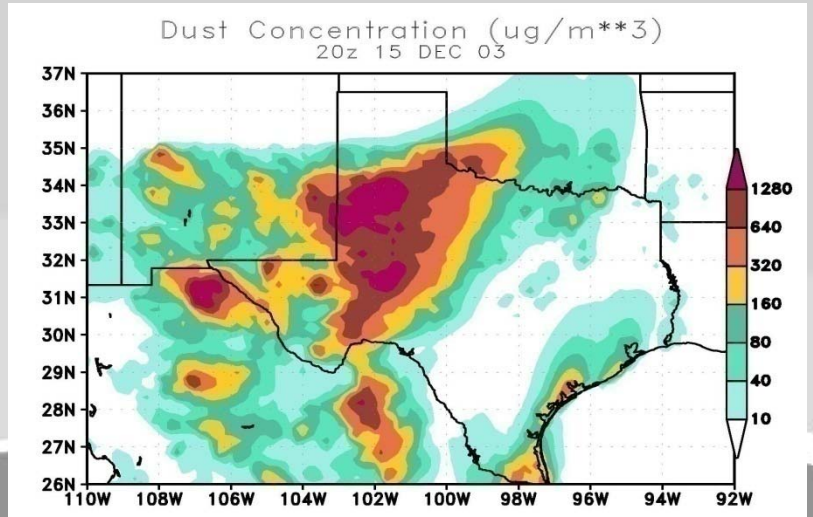
http://nmtracking.unm.edu

Upper Left: Dust observed from the NOAA GOES 12 satellite at 20:26 UTC on December 15, 2003. The red dashed line encircles a large dust storm occurring in west Texas.

Lower Left: DREAM modeled dust concentration distribution for 20:00 UTC on December 15, 2003, before ingesting NASA MODIS land cover observations.

Lower Right: DREAM modeled dust concentration distribution for 20:00 UTC on December 15, 2003, after ingesting NASA MODIS land cover observations. Note that the DREAM model much more accurately represents the NOAA GOES 12 observed dust storm after ingesting NASA Earth science satellite observations.





Dust Surveillance in the Southwest USA

Investigators: S. Morain, UNM; W. Sprigg, UA

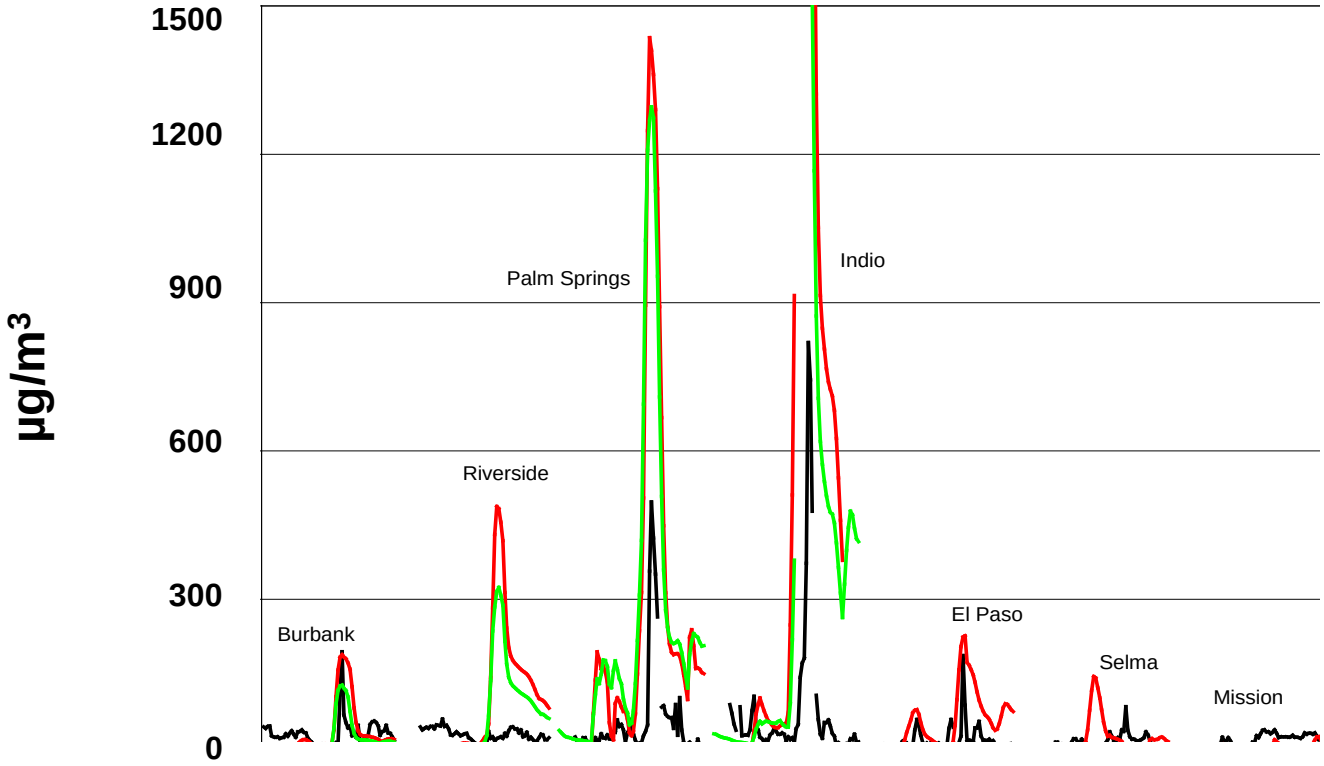
Applied Sciences Program

Discovering Innovative & Practical Applications of NASA Earth Science

The dust projects in the desert SW have three primary components: 1) improving forecasts of fine particulates by assimilating monthly masks of PM into the DREAM model (nested inside the WRF of NOAA); 2) incorporating MODIS AOD and modeled fine particulates from DREAM into CMAQ to estimate aerosol concentrations over the 4-corners region of Utah, Arizona, Colorado and New Mexico; and 3), integrating the products from these data and models into the New Mexico EPHTS for analysis and dissemination.

By using monthly data for barren land distribution, it is possible to identify PM sources through change detection methods. The PM sources are derived from a 16-day NDVI land cover product combined with an improved land cover classification algorithm to inventory land patterns that alternate between cropped and barren ground.

Results have shown that the timing of dust storms in the desert SW can be accurately forecast with 48 hours notice 67% of the time.



Dust Storm, January 4- 6, 2007

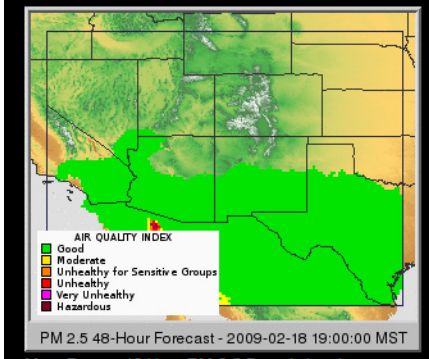
Black = PM_{10} observed (AIRNow data); Red=PM_{10} (ED/eta Run 15a); Green=PM_{10} (ED/eta Run 20a)

Dust Surveillance in the Southwest USA

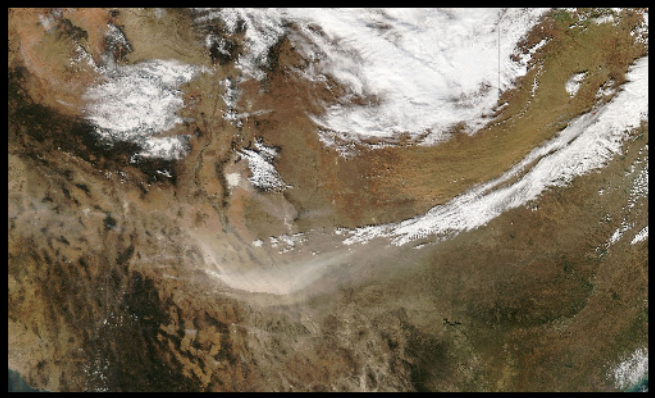
Applied Sciences Program
Discovering Innovative & Practical Applications of NASA Earth Science

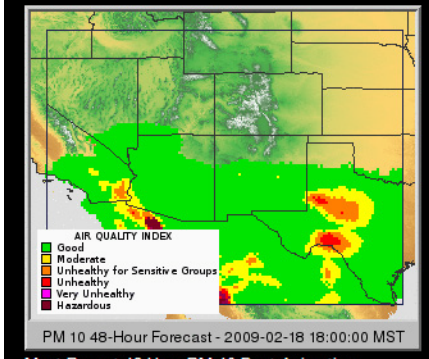
PHAiRS Home Page

Converging NASA Mission Measurements and Products with Decision Support Systems to Validate and Benchmark Public Health Medical Alerts and Early Warning Systems



Most Recent 48-Hour PM 2.5 Dust Animation

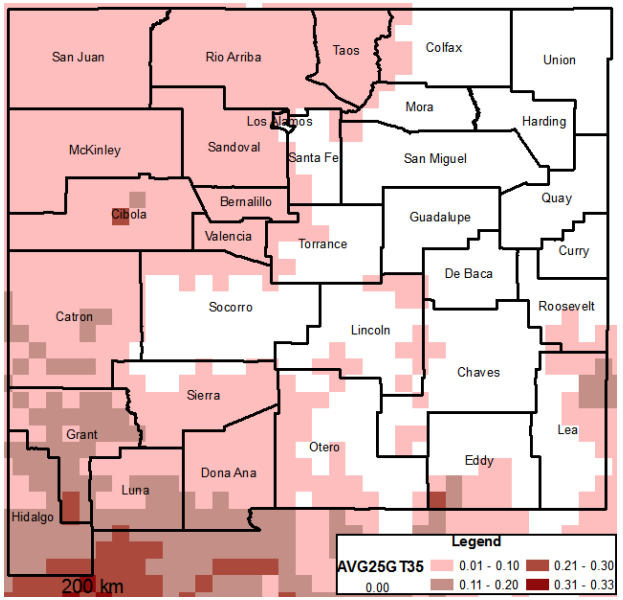




Most Recent 48-Hour PM 10 Dust Animation

Dust Storm in Texas: The same weather system that brought snow and ice to the American Midwest just after Thanksgiving 2005 also kicked up significant dust in western Texas and eastern Mexico. The winds associated with this cold front also fanned the flames of grass fires in the region, adding smoke to the mixture of aerosols. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Aqua satellite captured this image on November 27, 2005. In this image, the most obvious dust cloud is a pale beige dust plume swirling through Texas and Mexico. However, a second, more orange-colored cloud of dust blows across northern Texas. And in New Mexico, a bright white patch of ground—White Sands, New Mexico—is giving off a streamer of dust that blows southeast. According to TimesRecordNews.com, the temperature change from this cold front was extreme, and such big temperature changes often mean severe winds. Parts of northern Texas saw wind speeds around 100 kilometers per hour (60 miles per hour). Resulting dust storms reduced visibility to just 4 kilometers (2.5 miles) in some areas, and swamped local fire departments with calls regarding both fires and downed power lines. NASA image courtesy the MODIS Rapid Response Team at NASA GSFC. The MODIS Rapid Response Team provides daily images of this region.

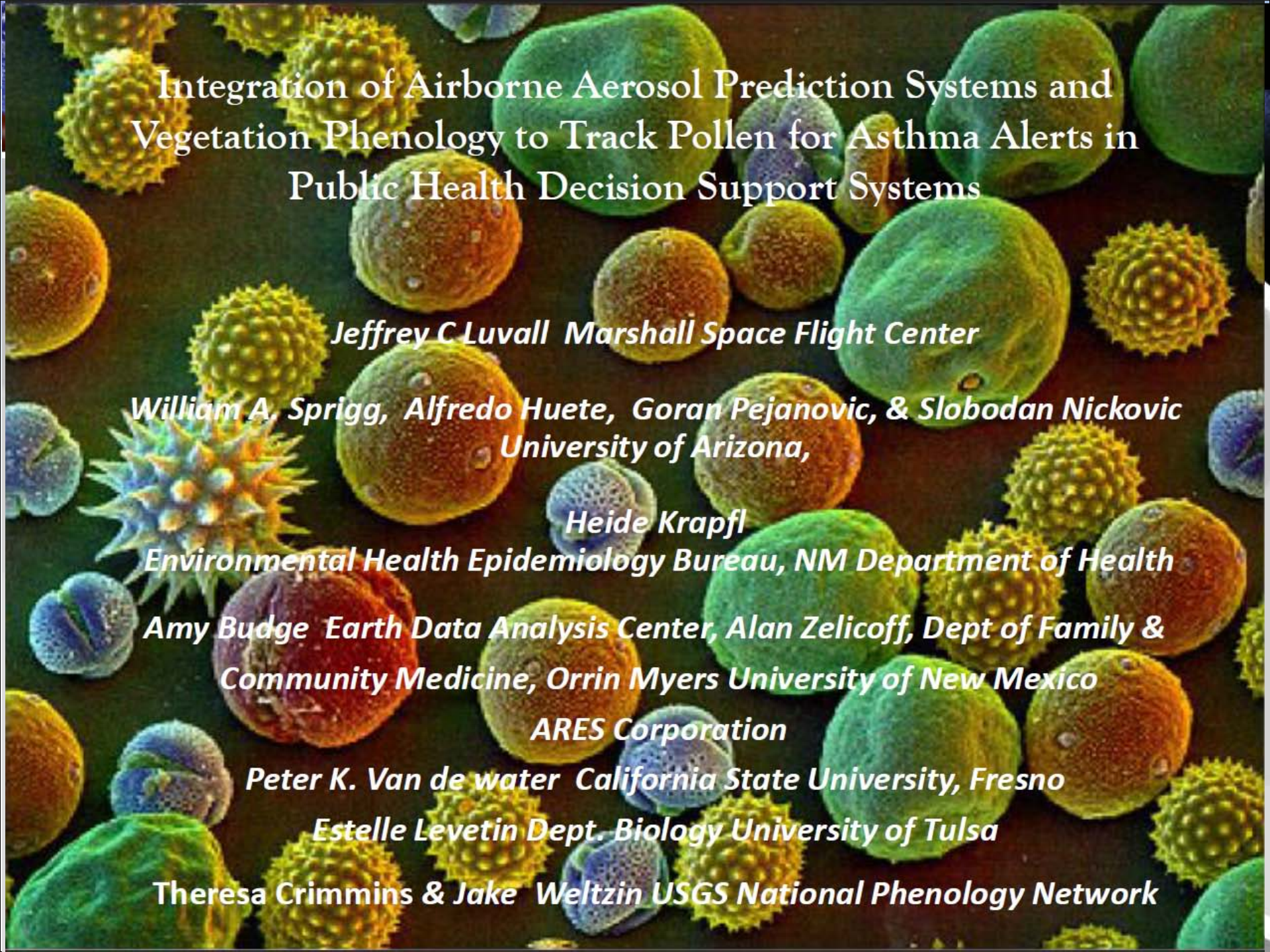
ENPHASYS Daily Average Dust Forecast >35µg/m³, April 2009



Sample Advisories

Southwest NM: For April 6-8, expect moderate windblown dust late in the evening on the 6th, dissipating gradually through the night but increasing and peaking in concentration between 12N and 3PM on the 7th. There is a chance for moderate dust between 6 AM and 8 AM on the 8th

Daily 48-hour dust forecasts now available on a website (http://nmtracking.unm.edu) linked with the NM DoH EPHT web portal. Data are then available to the national EPHTN. Experimental dust advisories are now being issued at the request of the Albuquerque Public Schools and the NM DoH.



Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

Jeffrey C Luvall Marshall Space Flight Center

William A. Sprigg, Alfredo Huete, Goran Pejanovic, & Slobodan Nickovic University of Arizona,

Heide Krapfl
Environmental Health Epidemiology Bureau, NM Department of Health

Amy Budge Earth Data Analysis Center, Alan Zelicoff, Dept of Family & Community Medicine, Orrin Myers University of New Mexico

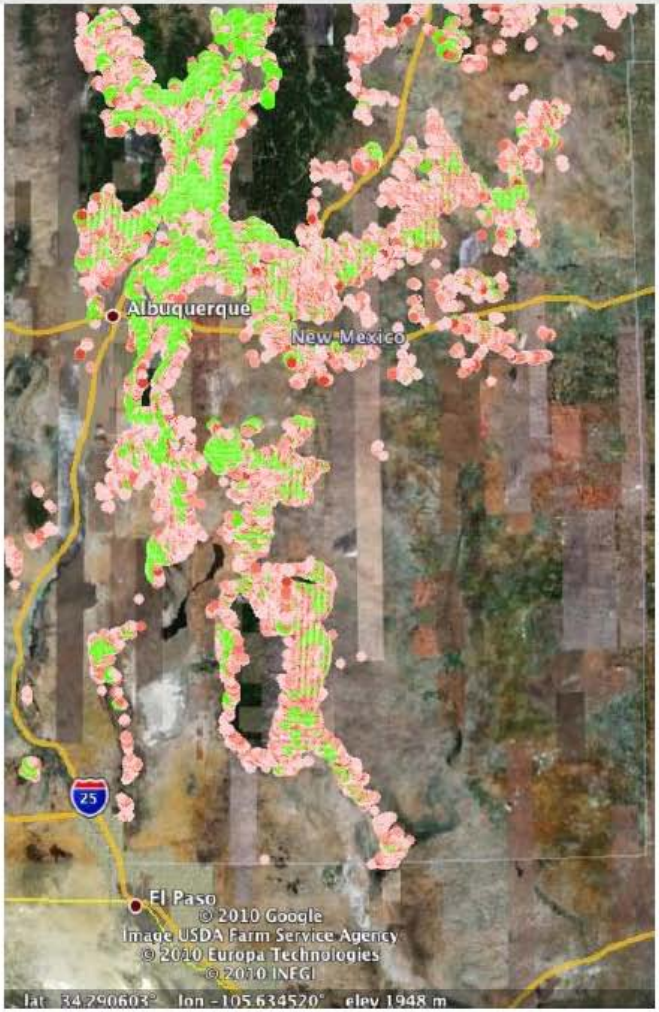
ARES Corporation

Peter K. Van de water California State University, Fresno

Estelle Levetin Dept. Biology University of Tulsa

Theresa Crimmins & Jake Weltzin USGS National Phenology Network

Goal: Quantify Juniper Pollen Emission "**Sources**" for input to PREAM model.



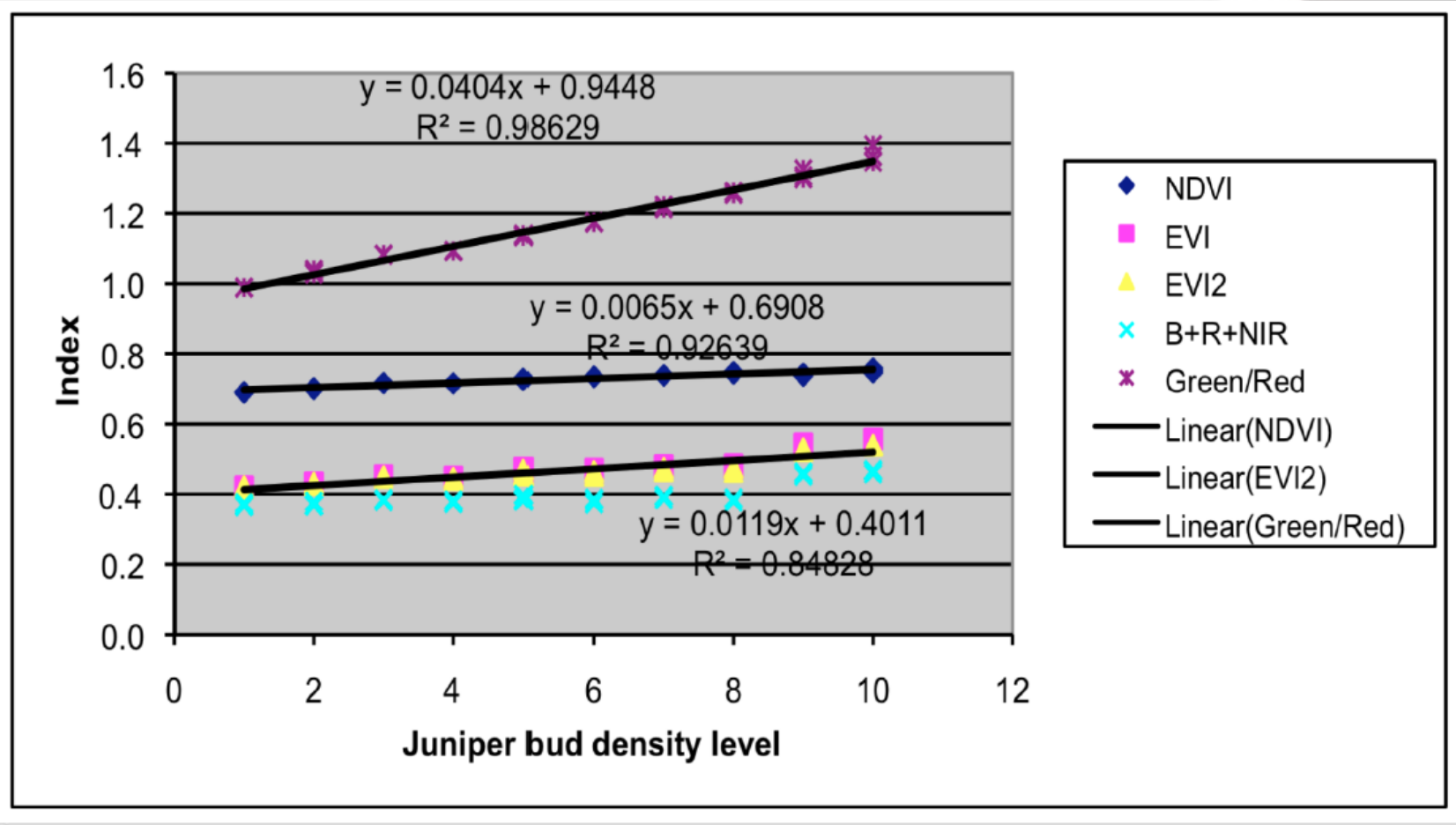
Juniper density (relative)*

- 50%
- 60%
- 70%
- 80%
- 90%

*Juniper from Land Cover classes S038, S074, and S112 are mapped.

Challenge: *Juniper is commonly mapped as "Land Cover Classes" and actual Juniper tree cover is not known.*

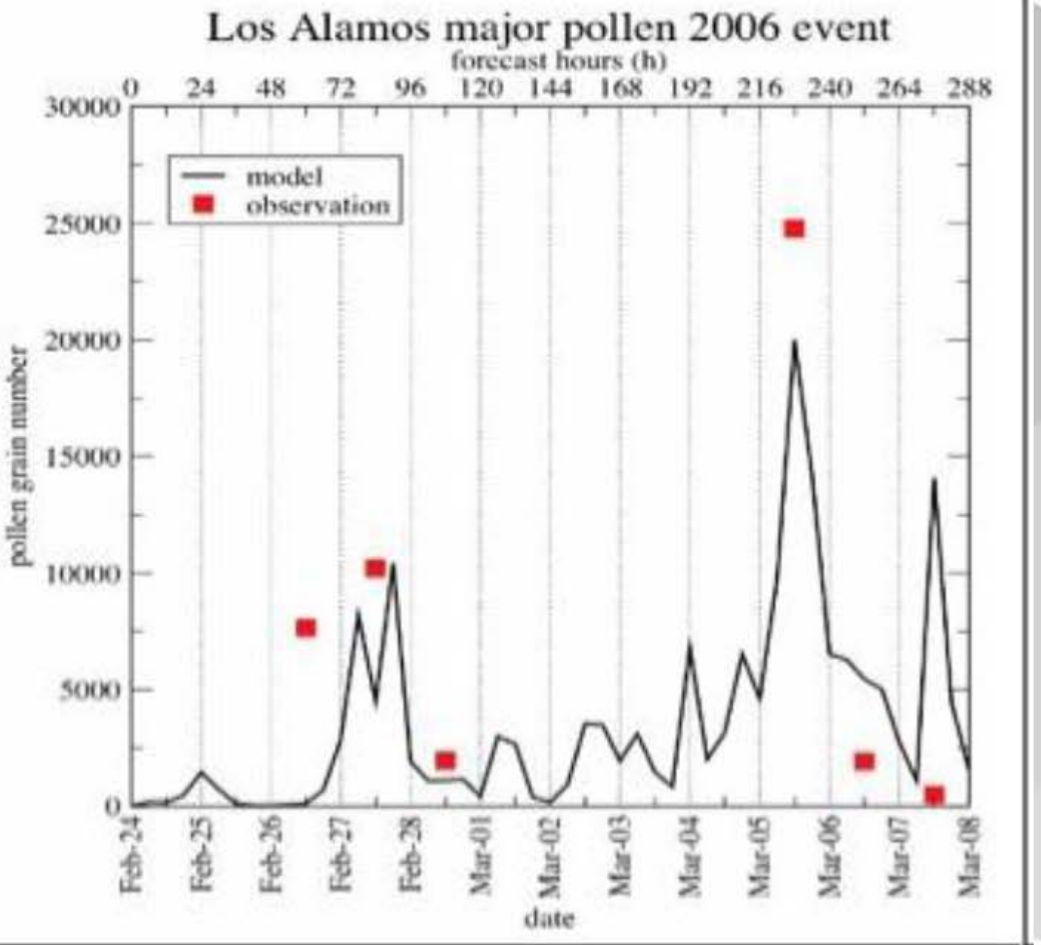
Relationships between spectral indices and juniper bud density levels



DREAM (Dust REgional Atmospheric Model)

– as --

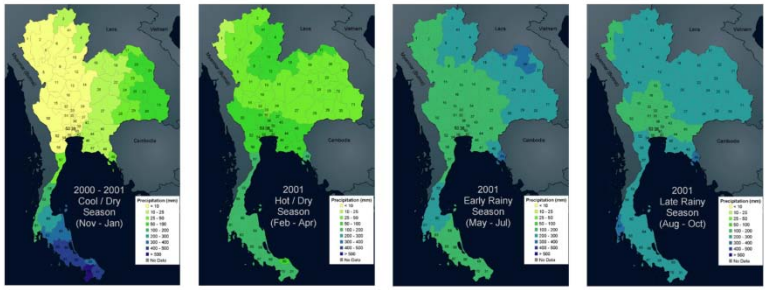
PREAM (Phenology REgional Atmospheric Model)



Man ploughs the sea like a leviathan, he soars through the air like an eagle; his voice circles the world in a moment, his eyes pierce the heavens; he moves mountains, he makes the desert to bloom; he has planted his flag at the north pole and the south; yet millions of men each year are destroyed because they fail to outwit a mosquito.

-- Paul F. Russell, 1931

Collaboration with DOD, USGS, USAID, and Columbia U. on Malaria



Precipitation is one of the main environmental determinants that promotes malaria transmission. The precipitation distribution in provincial resolution, based on NASA TRMM observations, is shown for the four Thailand season from 2000 to 2001.

This image shows vegetation density (NDVI) over Africa in May 2008. By closely monitoring vegetation in regions affected by increased rainfall, scientists can identify areas at increased risk for outbreaks of malaria.

Problem: Malaria kills up to 3 million people yearly worldwide, many of whom are children. In addition, malaria costs African nations approximately $12 billion in economic productivity. The health and economic consequences of malaria make it a destabilizing phenomenon. Accurate characterization of malaria risk is important because of its impact on US military and humanitarian personnel and operations. Global climate change may expand malaria risk areas to new locales, particularly higher altitudes.

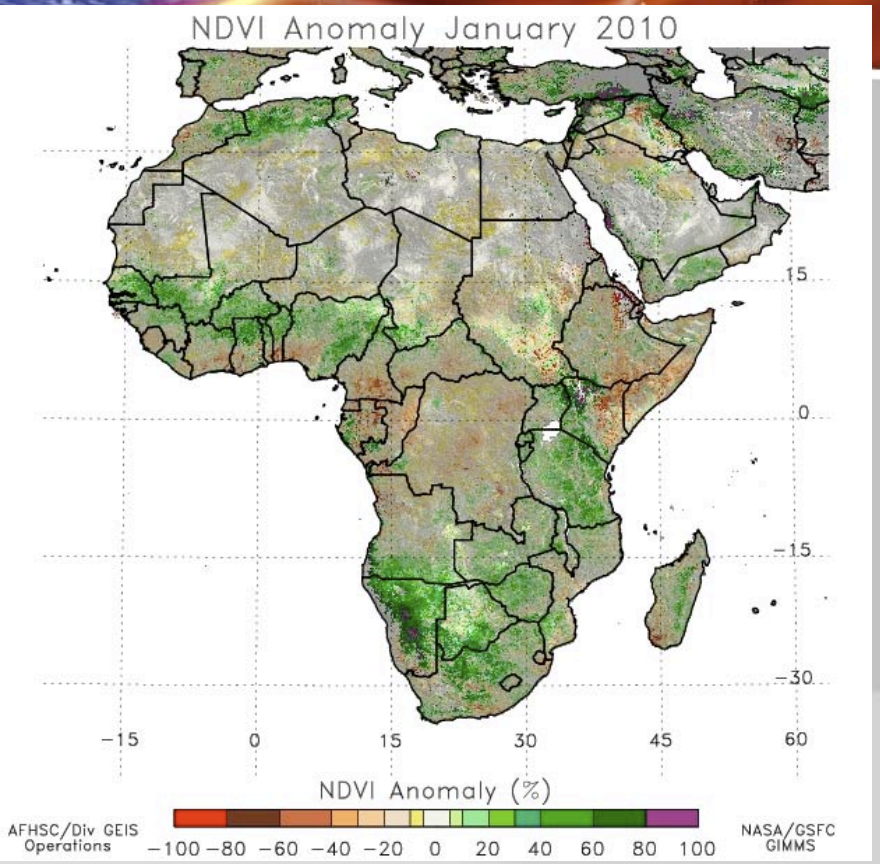
Solution: NASA and DOD (through GSAT) and USGS, USAID, and Columbia U. (through MEWS) are partners in utilizing environmental parameters such as precipitation, temperature, and vegetative cover to better characterize malaria transmission risks.

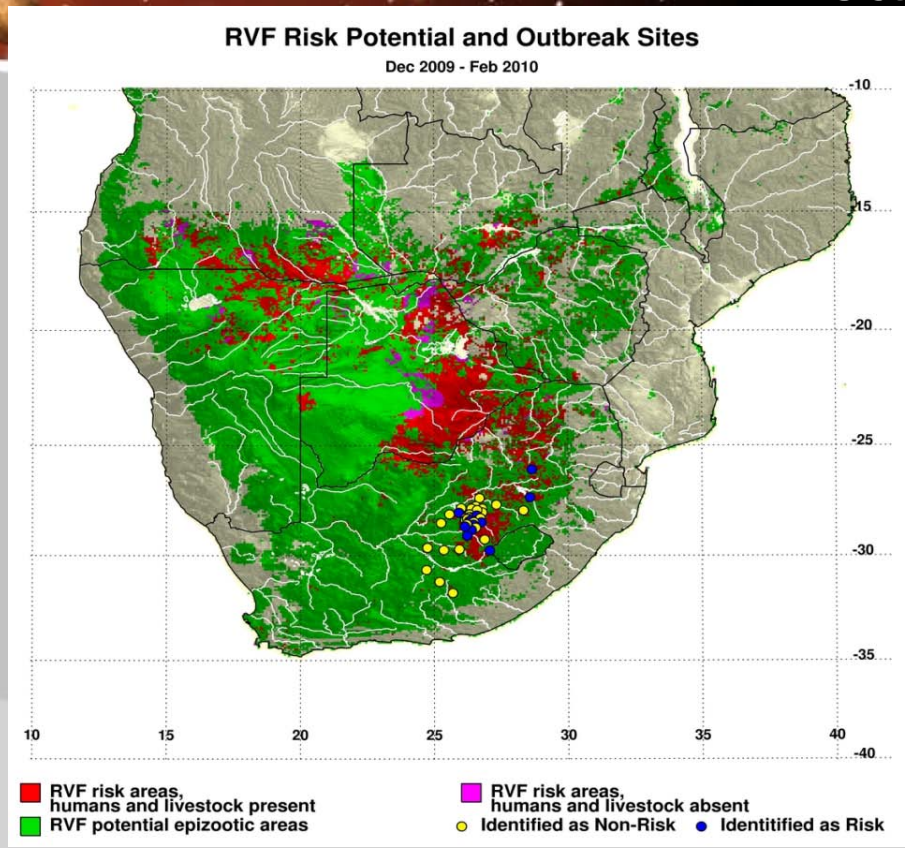
NASA Research Results: Model predictive capabilities and observations from NASA Earth-observing satellites such as Terra, Aqua, and TRMM.

Status: Current and future malaria risks have been forecast in a quantitative, dynamic, and accurate manner in Thailand, Afghanistan, and Indonesia. Rolling 10-day rainfall anomaly products and 8-day Vectorial Capacity products are produced for Africa and these data are disseminated on the web as both graphic and GIS products (available at the ADDS website: http://earlywarning.usgs.gov/fews/africa/index.php).

Investigators: R. Kiang, M. Brown, NASA Goddard

Collaboration with DOD on Rift Valley Fever in Africa





Left: NDVI anomalies for January 2010 are above normal in southern Africa. During December-February rainfall and NDVI were above normal indicating elevated risk of RVF activity for January and February.

Right: Enhanced RVF risk map incorporating livestock, human population data, SRTM digital data, and NDVI resulting in a two-level risk category at regional scale. Confirmed February 2010 RVF outbreaks in South Africa are identified by circles. The advanced awareness on the developing RVF threat gave partners such as WHO and FAO the opportunity to plan and execute disease outbreak prevention, preparedness, and “control-and-response” actions, including advising farmers to vaccinate livestock. Monthly risk maps available at: http://www.geis.fhp.osd.mil

Investigator: J. Pinzon, SSAI

Collaboration with Columbia U. on Meningitis in the African Sahel

A large plume of African dust blows out over the Atlantic Ocean. This true color image of the dust event was acquired on February 11, 2002, by MODIS. Particles contained in dust clouds are suspected to be responsible for nasal irritations facilitating meningitis transmission in Africa.

The project is exploring environmental and demographic risk factors as predictors for meningitis outbreaks in the African Sahel, particularly in Niger.

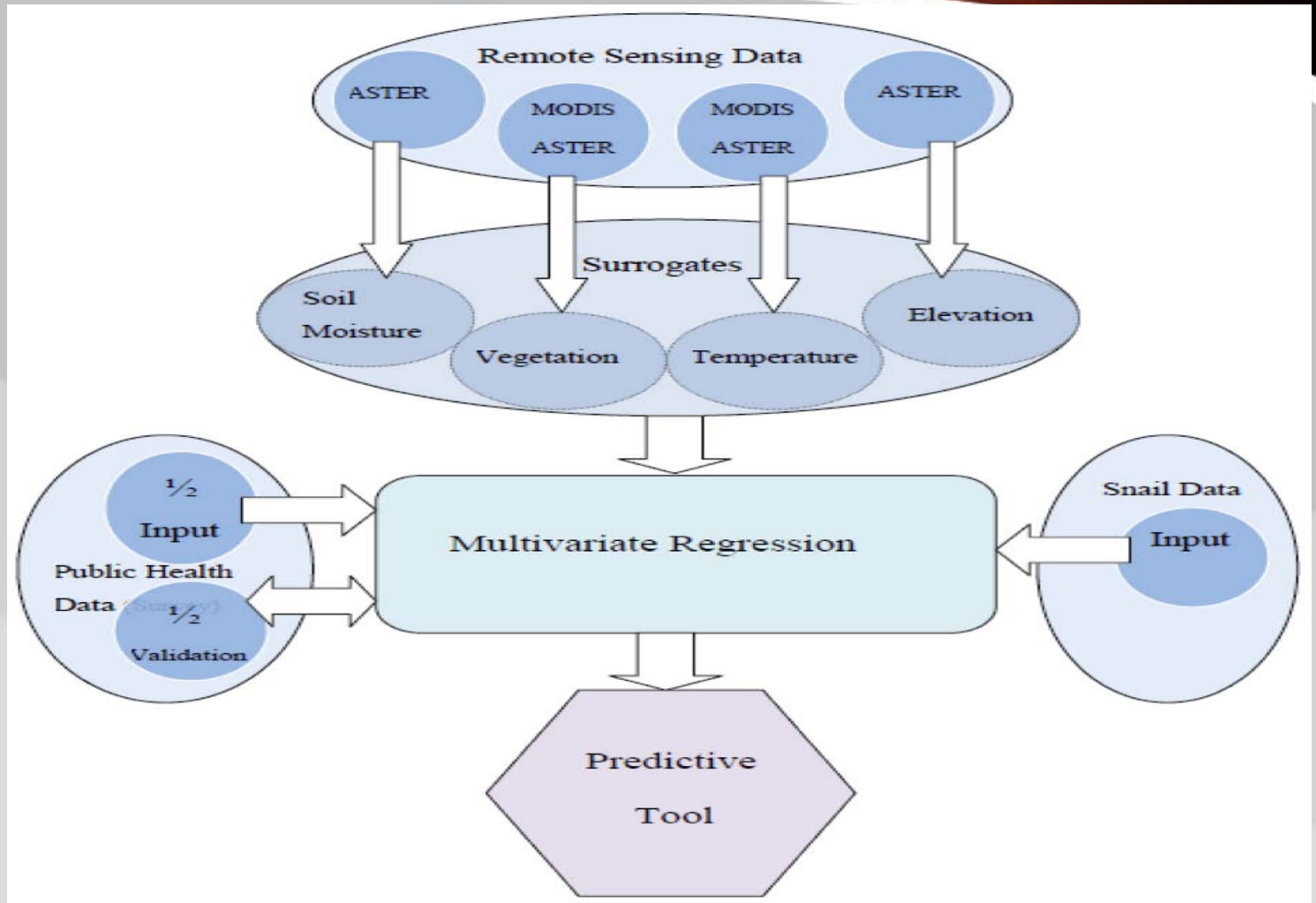
The approach will take advantage of different sources of environmental information: in-situ data, model outputs and satellite observations (including those from the Multi-angle Imaging Spectroradiometer and TRMM). The latter are an important contribution in areas of sparse data coverage, poor real-time reporting, and limited access to reliable environmental information – such as the Sahel.

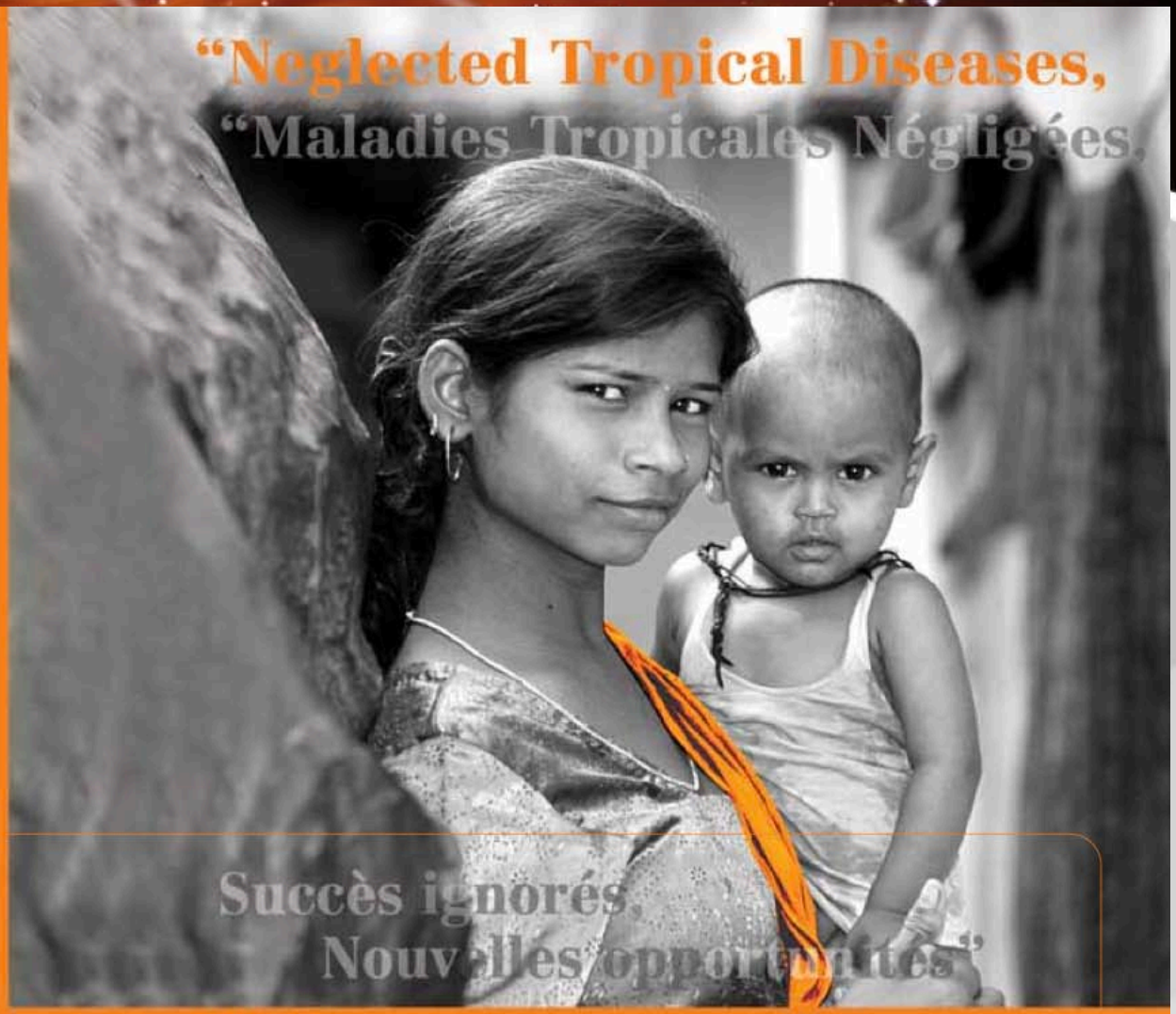
Investigator: S. Trzaska, IRI/Columbia U.

Neglected dieseases in Latin America & Caribbean

- Denge
- Schistosomiasis
- Dust induced Asmtha
- soil-transmitted helminths
- Chagas
- TB

Filariasis
Fascioliasis
Triatomines (Reduviidae: Triatominae) - spatial distribution
Leishmaniasis
Leprosy
Hookworm


Remote Sensing Data
ASTER
MODIS
ASTER
MODIS
ASTER
ASTER
Surrogates
Soil
Moisture
Vegetation
Temperature
Elevation
½
Input
Public Health
Data
½
Validation
Multivariate Regression
Snail Data
Input
Predictive
Tool



World Health Organization

Hidden successes,
Emerging opportunities"

NASA

WHO is currently focusing on 14 neglected tropical diseases:

- Buruli ulcer
- Chagas disease
- Cholera/Epidemic diarrhoeal diseases
- Dengue/dengue haemorrhagic fever
- Dracunculiasis (guinea-worm disease)
- Endemic Treponematoses (yaws, pinta, endemic syphilis…)
- Human African trypanosomiasis
- Leishmaniasis
- Leprosy
- Lymphatic filariasis
- Onchocerciasis
- Schistosomiasis
- Soil-transmitted helminthiasis
- Trachoma

World Health Organization 2006

Ranking of NTDs in LAC by Prevalence and Distribution

Disease	Population Currently Infected in LAC	Population At Risk in LAC	Major Vulnerable Populations or Geographic Areas	Number LAC Countries Infected	Percentage of LAC Population Infected (% Poor People Infected)
Trichuriasis	100 million	523 million	Poor rural & urban slums	27	17.8% (46.9%)
Ascariasis	84 million	514 million	Poor rural & urban slums	27	15.0% (39.4%)
Hookworm	50 million	346 million	Poor rural	26	8.9% (23.5%)
Chagas disease	8–9 million	25–90 million	Poor rural & urban slums	13	1.6% (4.1%)
Schistosomiasis	1.8 million	36 million	Poor rural	4 with >1,000 cases	0.3% (0.8%)
Blinding trachoma	1.1 million	ND	Poor rural	3	0.2% (0.5%)
Lymphatic filariasis	720,000	8.9 million	Urban slums & poor rural	7	0.1% (0.3%)
Dengue	552,141 reported in 2006	ND	Urban slums	23	0.1% (0.2%)
Cysticercosis	400,000	75 million	Poor rural	15	<0.1% (0.2%)
Cutaneous (CL) and visceral (VL) leishmaniasis	62,000 CL	ND	Urban slums & poor rural	18	ND
	5,000 VL				
Leprosy	47,612 new cases	ND	Poor rural & urban slums	22	<0.1% (<0.1%)
Onchocerciasis	64 new cases in 2004	515,675	Poor rural	6	<0.1% (<0.1%)
Jungle yellow fever	86 new cases in 2004	ND	Jungle & urban slums	4	<0.1% (<0.1%)

P. J. Hotez, M. E. Bottazzi, C. Franco-Paredes, S. K. Ault, and M. R. Periago. 2008
The Neglected Tropical Diseases of Latin America and the Caribbean: A Review of Disease Burden and Distribution and a Roadmap for Control and Elimination. PLoS Negl Trop Dis. 2008 September; 2(9): e300.

Major NTD Target Sub-Regions and Unique Ecologies.

Scenario	Sub-Region	NTDs	Indigenous Populations	Co-Factors[a]
1	Southern cone of South America	Chagas, leishmaniasis, cysticercosis, echinococcosis, hemorrhagic fevers	+	Cattle ranching, minifundios, urban migration
2	Chaco (Bolivia, Paraguay, Argentina)	Chagas, leishmaniasis, STH	+++	Cattle ranching, minifundios, animal husbandry
3	Andean region (Altiplano or Highland)	Fascioliasis, Chagas, leishmaniasis, plague, bartonellosis, STH, cysticercosis, echinococcosis, ectoparasites	++++	Minifundios, urban migration
4	Amazonian basin	Chagas, leishmaniasis, STH, onchocerciasis, leprosy, trachoma, ectoparasites	++	Deforestation, mining, guerillas, urban migration, indiscriminant colonization
5	Eastern Brazil	STH (esp. hookworm) schistosomiasis, Chagas disease, leishmaniasis, LF (NE only), echinococcosis, leprosy, leptospirosis	++	Cattle ranching, deforestation, minifundios, urban migration, monoculture
6	North Pacific of South America	STH, cystiercosis, leishmaniasis, onchocerciasis, echinococcosis	++	Deforestation, gold mining, guerillas
7	Caribbean basin	STH, schistosomiasis, LF, leprosy, leptospirosis, fascioliasis	+	Economic dependence on tourism, deforestation, urban migration
8	Central America and Panama	STH, leishmaniasis, Chagas, onchocerciasis, cysticercosis, leptospirosis	+++	Deforestation, desertification, migration
10	South and Central Mexico	STH, Chagas, cystiercosis, leishmaniasis, trachoma, onchocerciasis	+++	Deforestation, migration
11	Northern Mexico	STH, Chagas, cysticercosis, leishmaniasis	++	Desertification, migration

P. J. Hotez, M. E. Bottazzi, C. Franco-Paredes, S. K. Ault, and M. R. Periago. 2008
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Strengths of satellite observations:

1. Measure environmental variables important to vector life cycles- ppt, soil moisture, temperature.
2. Land use/cover mapping
3. Ecological variables
4. large spacial coverage
5. Temperature

Precipitation
Relative humidity
Wind
Solar radiation
Topography
Fresh water rivers, ponds, lakes

models

Benjamin Zaitchik is also looking to better warn the public of health risks in his project, **Develop… of a Detection and Early Warning System for Malaria Risk in the Amazon**

Land Data Assimilation System (LDAS)
http://ldas.gsfc.nasa.gov/

Land Data Assimilation System (LDAS) that will be used to drive spatially-explicit ecological models of *Anop…*
Precipitation from TRMM, and GPM
Land Cover Type from MODIS, Landsat, ASTER, LDCM
Soil Moisture from AMSR-E (where applicable) and SMAP
Terrestrial Water Storage from GRACE and GRACE II
Surface Temperature form MODIS, Landsat, ASTER, LDCM
Vegetation Fraction/ Leaf Area Index from MODIS, Landsat, ASTER, LDCM
Topography from SRTM

MODIS (Terra & Aqua)

Orbit:	705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), sun-synchronous, near-polar, circular
Scan Rate:	20.3 rpm, cross track
Swath Dimensions:	2330 km (cross track) by 10 km (along track at nadir)
Telescope:	17.78 cm diam. off-axis, afocal (collimated), with intermediate field stop
Size:	1.0 x 1.6 x 1.0 m
Weight:	228.7 kg
Power:	162.5 W (single orbit average)
Data Rate:	10.6 Mbps (peak daytime); 6.1 Mbps (orbital average)
Quantization:	12 bits
Spatial Resolution:	250 m (bands 1-2) 500 m (bands 3-7) 1000 m (bands 8-36)
Design Life:	6 years

Environmental Tracking for Public Health Surveillance. Stan Morain, Taylor & Francis Group/Balkema Press in summer, 2012

Calibration
(see also: http://mcst.gsfc.nasa.gov/**)**

- MOD 01 - Level-1A Radiance Counts
- MOD 02 - Level-1B Calibrated Geolocated Radiances
- MOD 03 - Geolocation Data Set

Atmosphere
(see also: http://modis-atmos.gsfc.nasa.gov/**)**

- MOD 04 - Aerosol Product
- MOD 05 - Total Precipitable Water (Water Vapor)
- MOD 06 - Cloud Product
- MOD 07 - Atmospheric Profiles
- MOD 08 - Gridded Atmospheric Product
- MOD 35 - Cloud Mask

Land
(see also: http://edcdaac.usgs.gov/dataproducts.asp **and** http://modis-land.gsfc.nasa.gov/**)**

- MOD 09 - Surface Reflectance
- MOD 11 - Land Surface Temperature & Emissivity
- MOD 12 - Land Cover/Land Cover Change
- MOD 13 - Gridded Vegetation Indices (Max NDVI & Integrated MVI)
- MOD 14 - Thermail Anomalies, Fires & Biomass Burning
- MOD 15 - Leaf Area Index & FPAR
- MOD 16 - Evapotranspiration
- MOD 17 - Net Photosynthesis and Primary Productivity
- MOD 43 - Surface Reflectance
- MOD 44 - Vegetation Cover Conversion

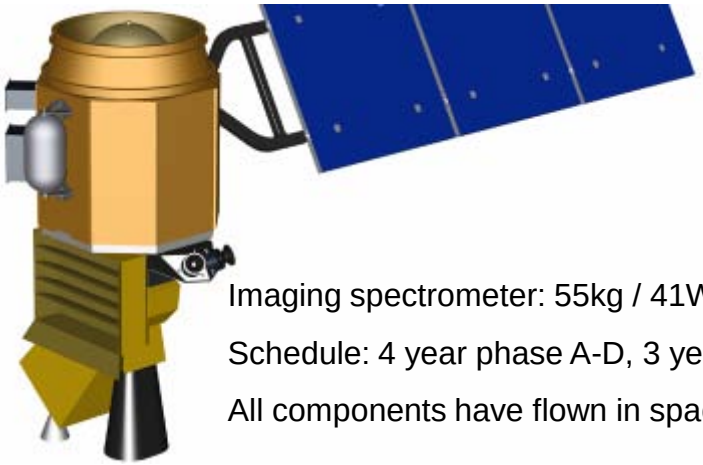
Cryosphere
(see also: http://nsidc.org/daac/modis/index.html**)**

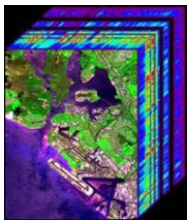
- MOD 10 - Snow Cover
- MOD 29 - Sea Ice Cover

Ocean
(Details about ocean products are best obtained by going to: http://oceancolor.gsfc.nasa.gov/**)**

- Angstrom Exponent
- Aerosol Optical Thickness
- Chlorophyll a
- Downwelling diffuse attenuation coefficient at 490 nm
- Level 2 Flags
- Photosynthetically Available Radiation
- Particulate Inorganic Carbon
- Particulate Organic Carbon
- Sea Surface Temperature Quality
- Sea Surface Temperature Quality - 4um
- Remote Sensing Reflectance
- Sea Surface Temperature
- Sea Surface Temperature 4um

HyspIRI Visible Shortwave Infrared (VSWIR) Science Measurements





Imaging spectrometer: 55kg / 41W

Schedule: 4 year phase A-D, 3 years operations

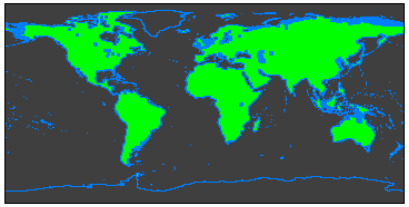
All components have flown in space

Science Questions:

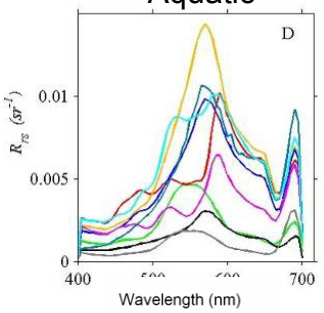
- *What is the composition, function, and health of land and water ecosystems?*
- *How are these ecosystems being altered by human activities and natural causes?*
- *How do these changes affect fundamental ecosystem processes upon which life on Earth depends?*

Measurement:

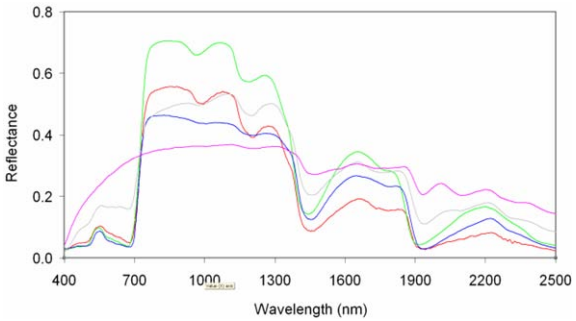
- 380 to 2500 nm in 10nm channels
- Accurate 60 m sampling
- 19 days revisit mapping mission
- Global land and shallow water



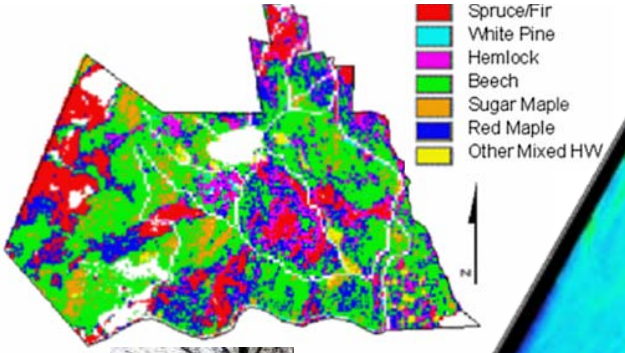
Aquatic

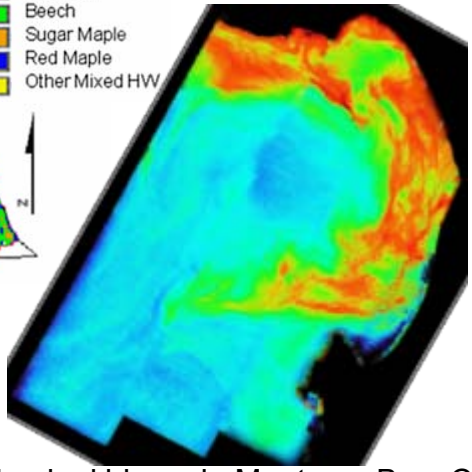


Terrestrial



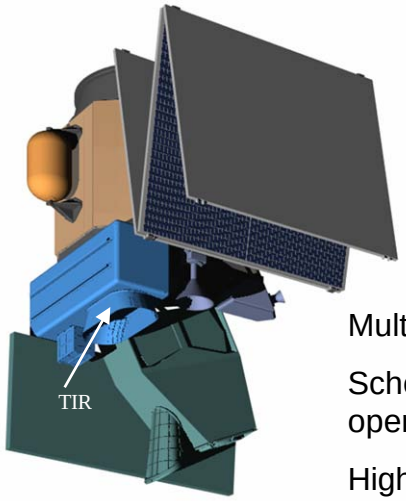
Map of dominant tree species, Bartlett Forest, NH

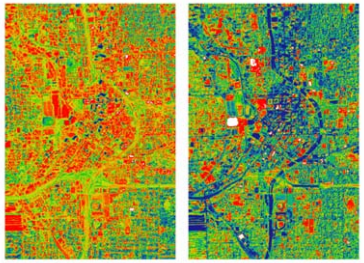




Red tide algal bloom in Monterey Bay, CA

HysplRI Thermal Infrared Multispectral (TIR) Science Measurements





Multispectral Scanner: 60kg / 103W

Schedule: 4 year phase A-D, 3 years operations

High Heritage

Science Questions:

TQ1. Volcanoes/Earthquakes (MA,FF)

– How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

• TQ2. Wildfires (LG,DR)

– What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

• TQ3. Water Use and Availability, (MA,RA)

– How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

• TQ4. Urbanization/Human Health, (DQ,GG)

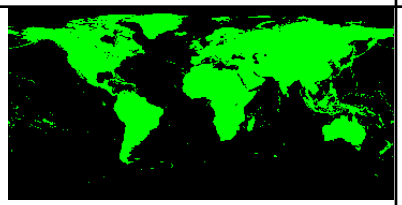
– How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

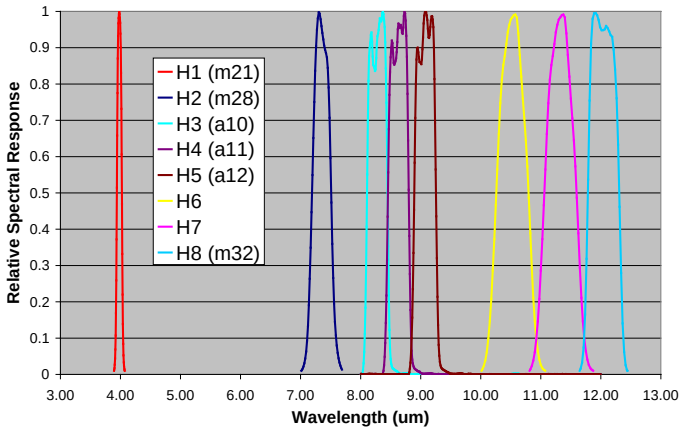
• TQ5. Earth surface composition and change, (AP,JC)

– What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

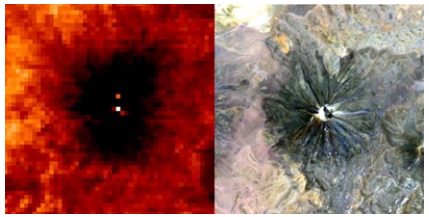
Measurement:

- 7 bands between 7.5-12 µm and 1 band at 4 µm
- 60 m resolution, 5 days revisit
- Global land and shallow water

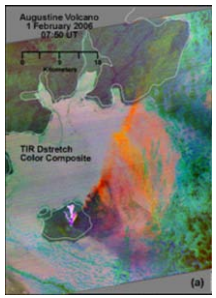




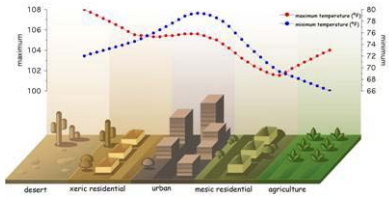
Andean volcano heats up



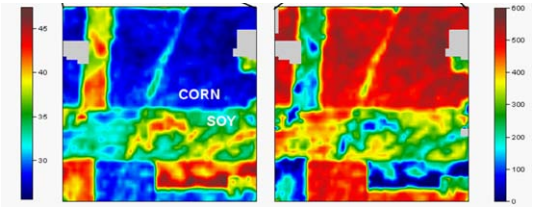
Volcanoes



Urbanization



Water Use and Availability

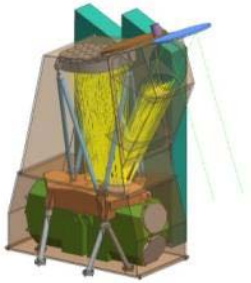


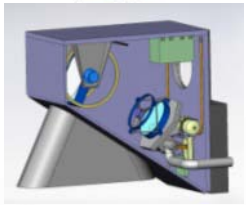
Surface Temperature

Evapotranspiration

HyspIRI Mission Concept - 2010

Payload





Science Instruments:

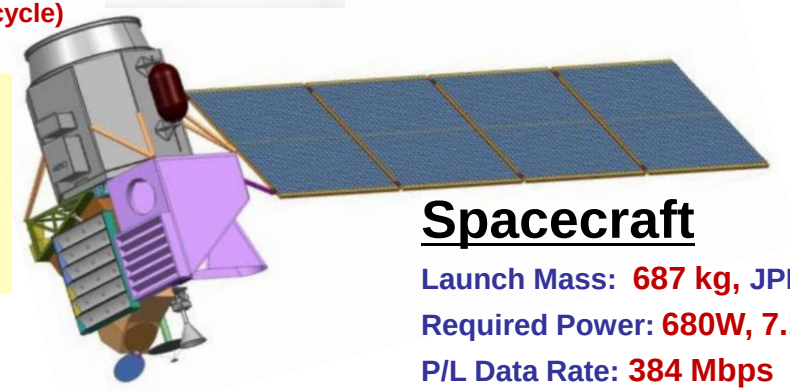
- VSWIR: Imaging Spectrometer
  - 380-2500 nm in 10 nm bands
  - 60m spatial resolution
  - Day-side (23% duty cycle)
  - 55 Kg, 41 W
- TIR: Thermal Infrared Scanner
  - 8 bands between 3-12 µm
  - 60m spatial resolution
  - Day and night-side (100% duty cycle)
  - 60 Kg, 103 W

Intelligent Payload Module (IPM)

- 24/7 Direct Broadcast capability
- subset of science data
- X-band @ 20 Mbps
- 11 Kg, 86 W

Mission Architecture

- Orbit: 626 km Sun-Synchronous, 10:30am LTDN
- Repeat: 19 day VSWIR / 5 day TIR
- Downlink: Contacts nearly every orbit to Svalbard (North) and Troll (Antarctica)
- Science Data: 5.7 Tbits/day
- Launch Vehicle: Taurus 3210, 2m fairing, 790 kg capability



Spacecraft

Launch Mass: 687 kg, JPL DP Margin: 30%

Required Power: 680W, 7.1 m^2 array (965 W capability)

P/L Data Rate: 384 Mbps

Downlink Data Rate: 800 Mbps Dual-pol X-band

Stabilization: 3-axis

Pointing: Control =720 arcsec (per axis 3σ)
Knowledge = 5.6 arcsec (Pitch/Roll axis 3σ);
15 arcsec (Yaw axis 3σ)
Stability = 5 arcsec/sec (per axis 3σ)

Implementation

Launch Date: 2014 - 2020

Lifetime: 3 years, with consumables for 5

Cost : Low to Moderate cost Mission

Partners: JPL, GSFC

Mission Class: C, with selected redundancy

Hardware Model: Protoflight

MODIS Data Sources

Atmosphere http://modis-atmos.gsfc.nasa.gov/

Land

http://edcdaac.usgs.gov/dataproducts.asp & http://modis-land.gsfc.nasa.gov/

Ocean

http://oceancolor.gsfc.nasa.gov

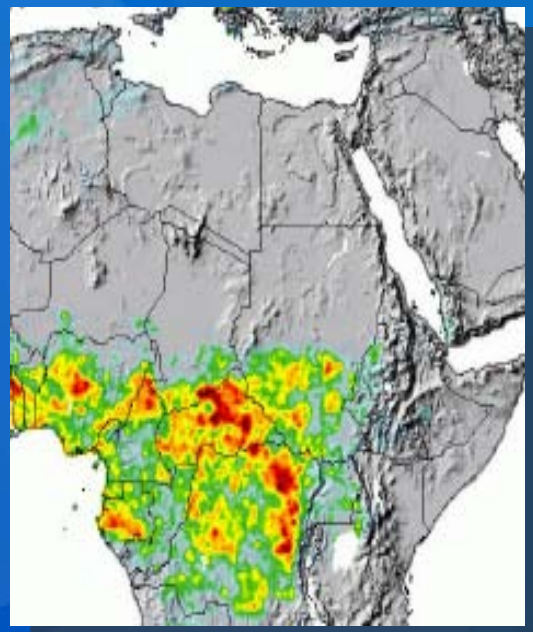
Landsat Data Products

http://landsat.usgs.gov/products_productinformation.php/

SERVIR

Regional Platform for Science and Policy in the Americas, Africa, and Asia

Using earth observations and predictive models for environmental management, disaster response, and climate change adaptation.



Flood Forecasting in Africa

Training and Capacity Building

Tracking Fires in Guatemala Mexico

- Data and Models
- Online Maps
- Visualizations
- Decision Support
- Training
- Partnerships

NASA's Public Health Partners

.gov/ph

.gov/rs

.org

.edu

.int

.mil

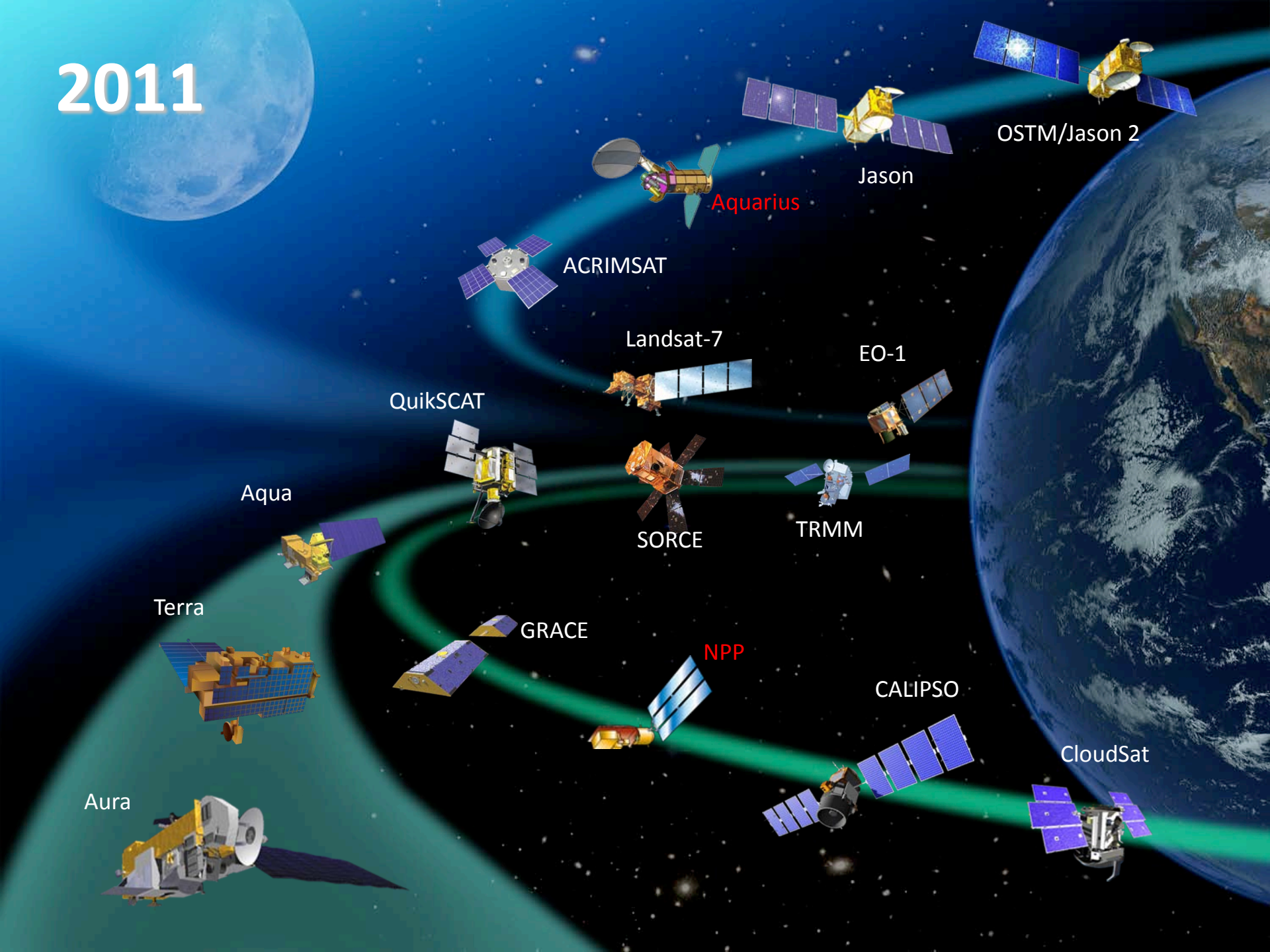
Future Observations for Health – Near Term

- **NPOESS Preparatory Mission (NPP)** -- 2011
  - NPP will serve as a bridge mission between the NASA Earth-observing research satellites Terra, Aura, and Aqua and the operational Joint Polar Satellite System (JPSS) constellation.
- **Landsat Data Continuity Mission (LDCM)** -- 2012
- **Global Precipitation Mission (GPM)** – 2013
  - Will provide accurate observations of the intensity and distribution of global precipitation. GPM builds on the heritage of the TRMM mission and is in partnership with JAXA.

Future Observations for Health – Decadal Survey

- **Hyperspectral Infrared Imager (HyspIRI)** – 2020s
  - HyspIRI will employ a hyperspectral imager and a thermal infrared scanner to monitor a variety of ecological and geological features at a wide range of wavelengths, including data on changes in vegetation type and deforestation for ecosystem management .

- **Soil Moisture Active Passive (SMAP)** – 2014
  - SMAP will use a combined radiometer and high-resolution radar to measure surface soil moisture and freeze-thaw state.

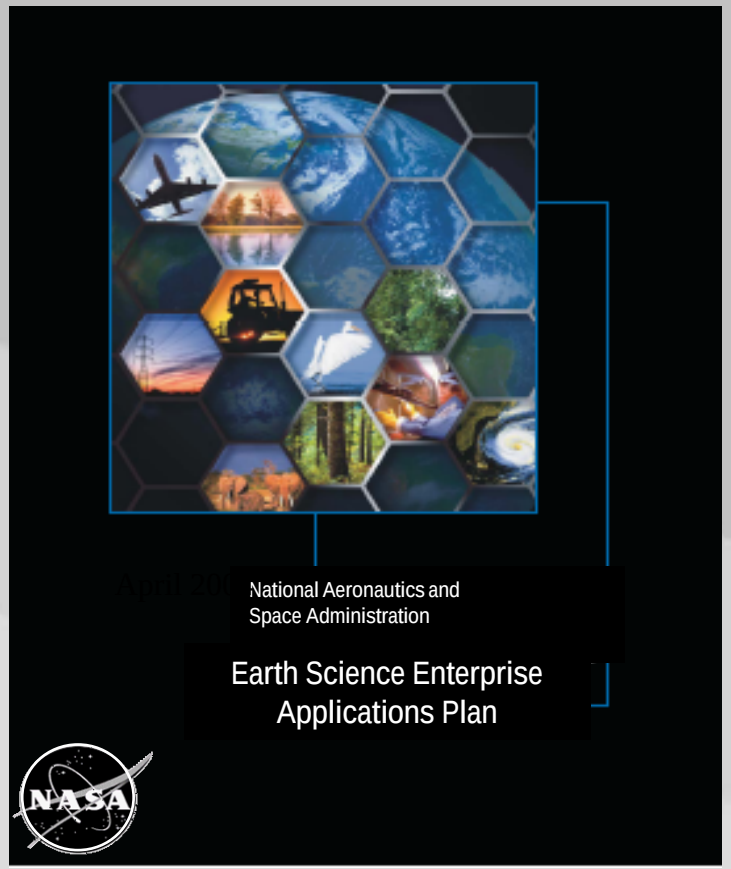

2011
OSTM/Jason 2
Jason
Aquarius
ACRIMSAT
Landsat-7
EO-1
QuikSCAT
Aqua
SORCE
TRMM
Terra
GRACE
NPP
CALIPSO
CloudSat
Aura

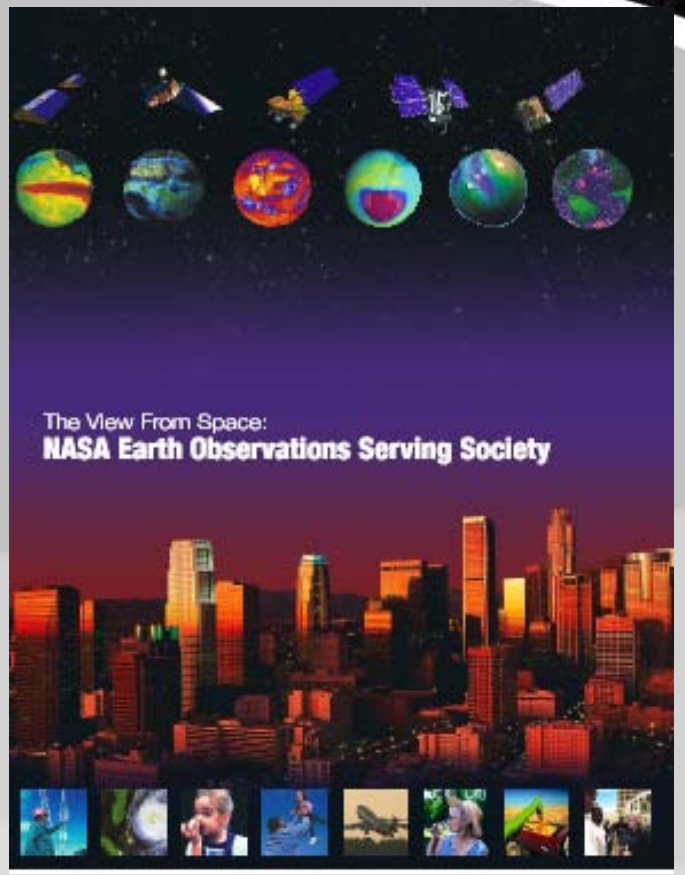

2012
OSTM/Jason 2
Jason
Aquarius
Landsat-7
LDCM
Aqua
SORCE
TRMM
Terra
GRACE
NPP
CALIPSO
CloudSat
Aura


2013
OSTM/Jason 2
OCO-2
Aquarius
GPM
Landsat-7
Aqua
SORCE
TRMM
Terra
NPP
LDCM
CALIPSO
CloudSat
Aura


2014
OCO-2
Aquarius
OSTM/Jason 2
Landsat-7
Aqua
SORCE
NPP
LDCM
SMAP
GPM

Applied Sciences Program





http://appliedsciences.nasa.gov

http://weather.msfc.nasa.gov/conference/phconference_home_sa.html

Epidemiology in the 21st Century