NASA Earth Observation Systems and Applications for Health and Air Quality

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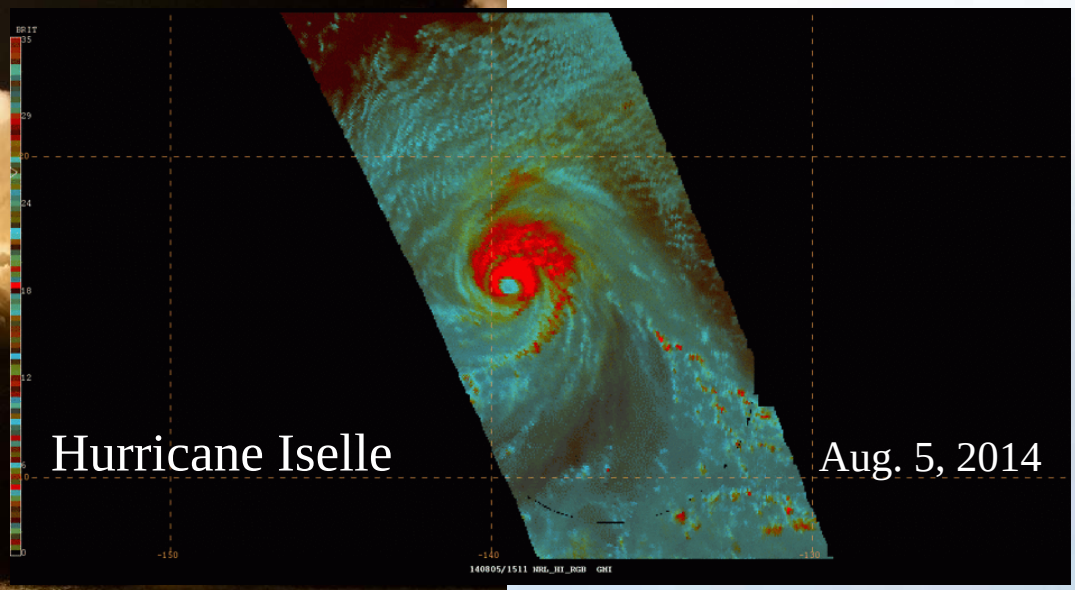
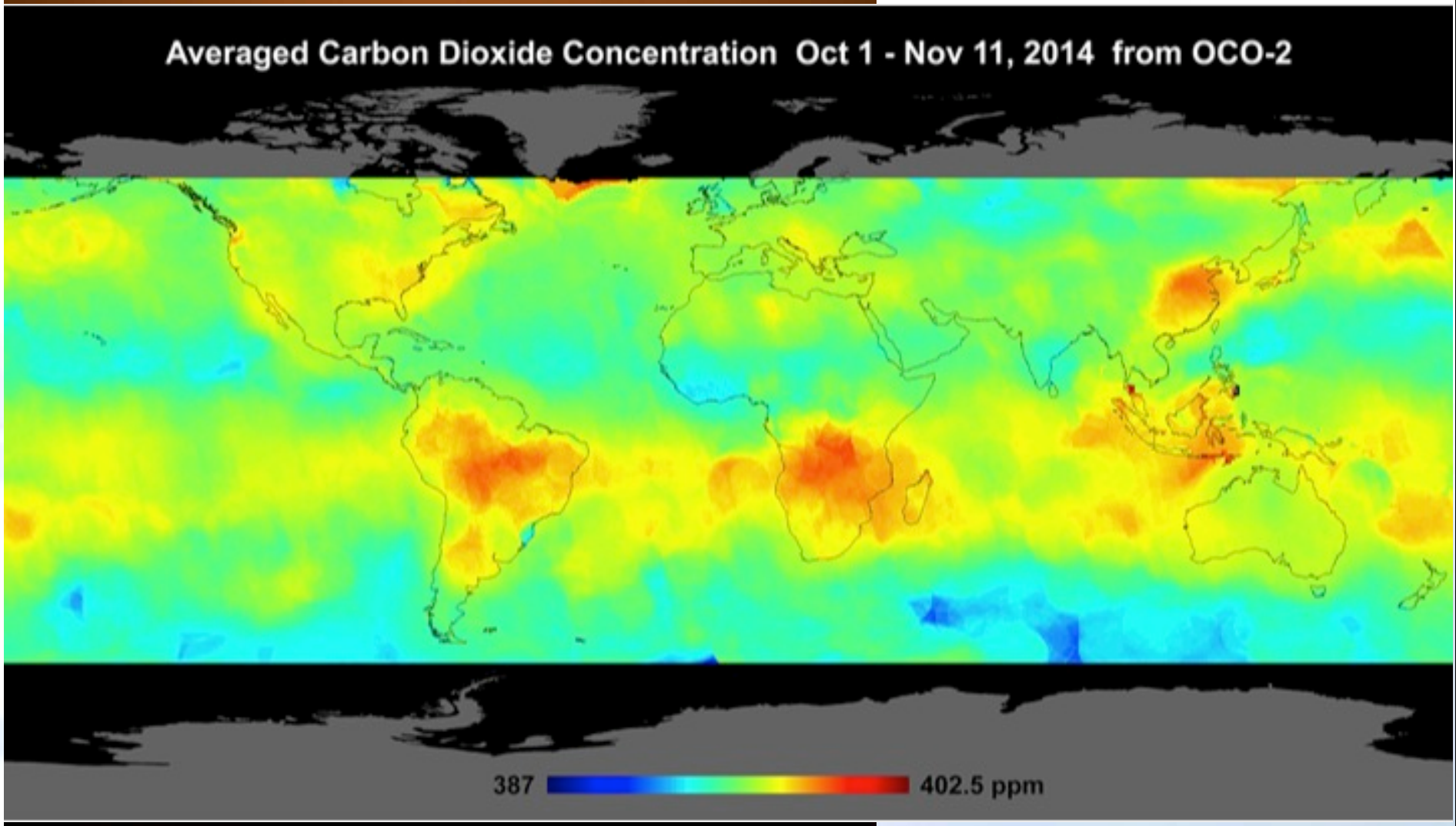
University of Illinois EES Symposium“One Environment. One World.”
April 9, 2015

Launch of GPM on February 28, 2014



Hurricane Iselle

Aug. 5, 2014

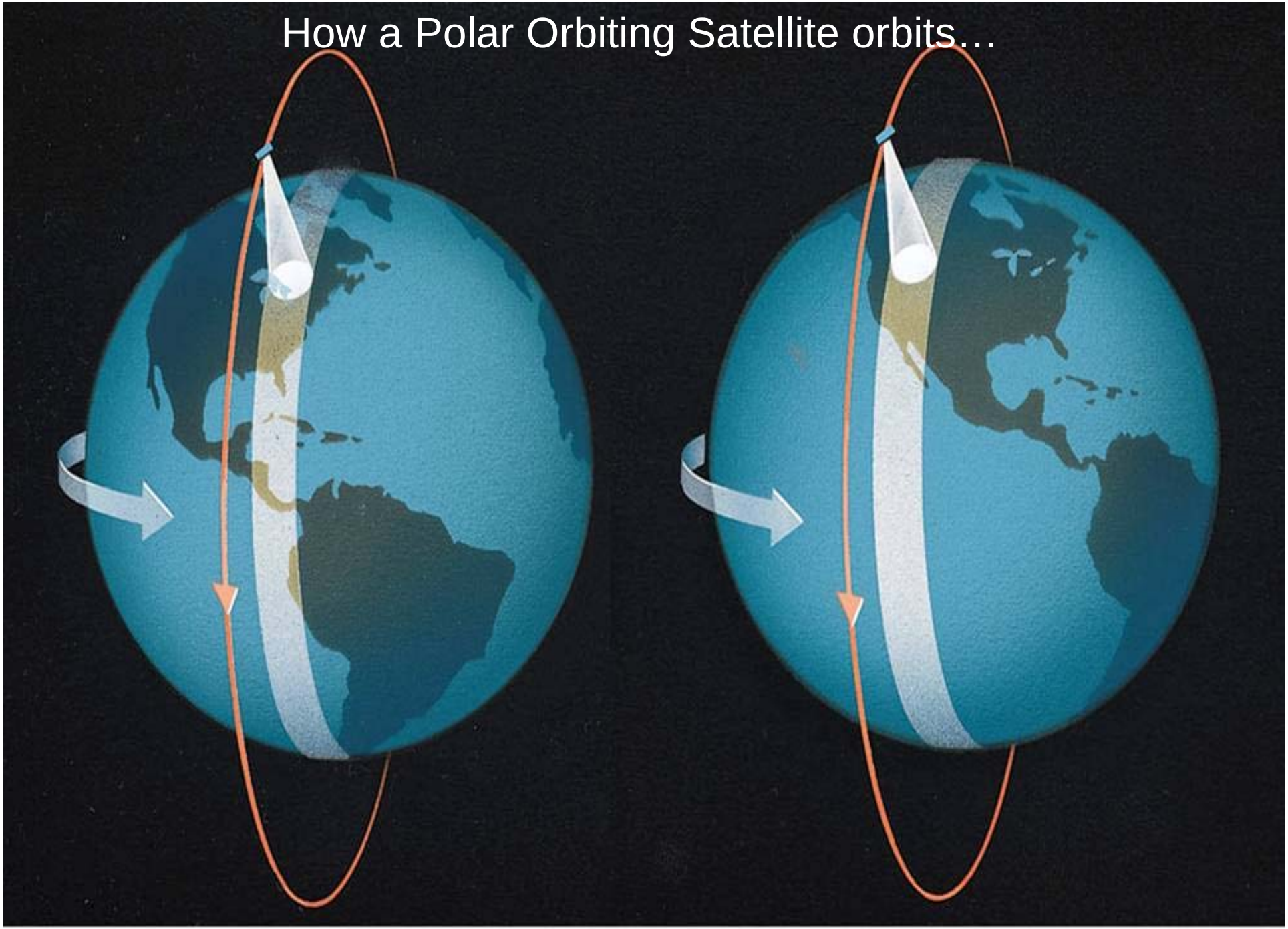

Averaged Carbon Dioxide Concentration Oct 1 - Nov 11, 2014 from OCO-2
387
402.5 ppm

With the successful lift-off of SMAP on Jan. 31, for the first time in more than a decade five NASA Earth science missions have been launched in a single year to help us all better understand our home planet.

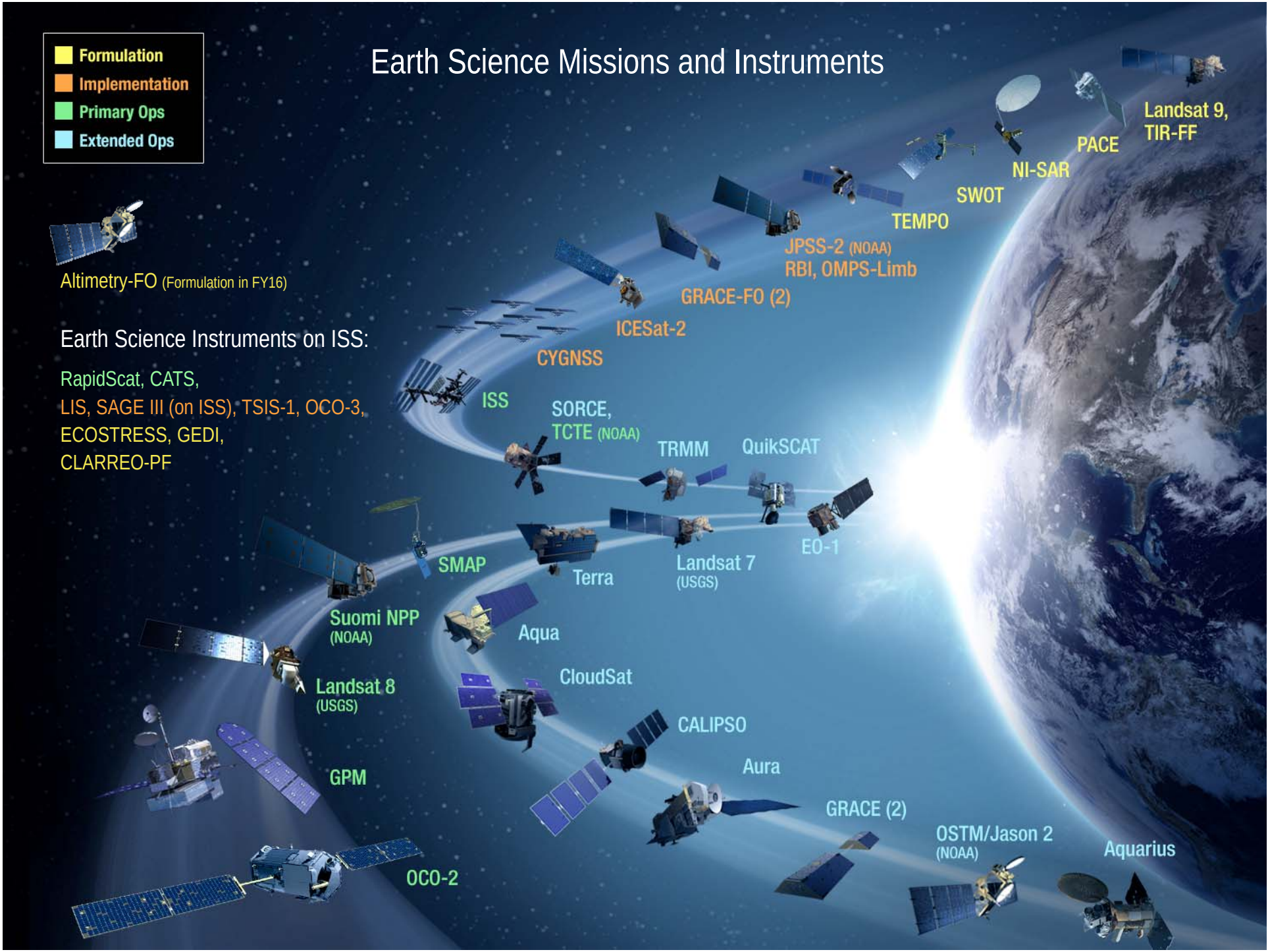
EARTH *RIGHT* NOW

www.nasa.gov/earthrightnow

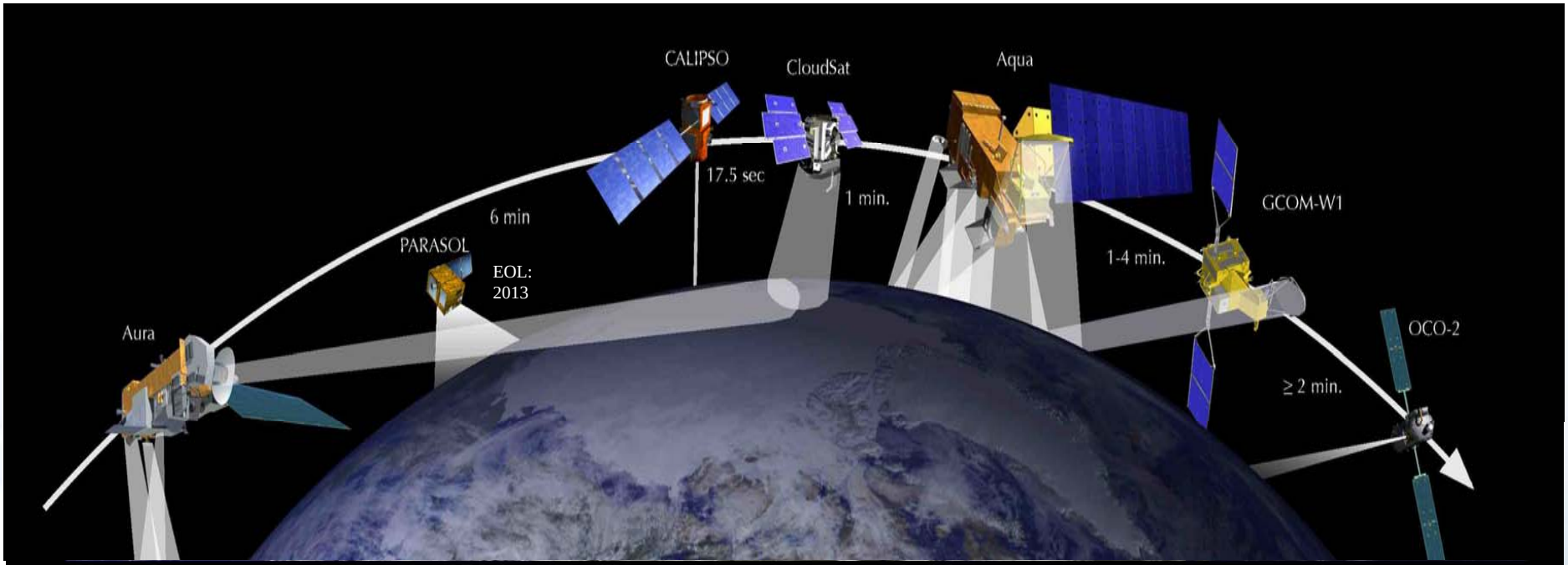
How a Polar Orbiting Satellite orbits…



Earth Science Missions and Instruments



OCO-2 and International A-Train



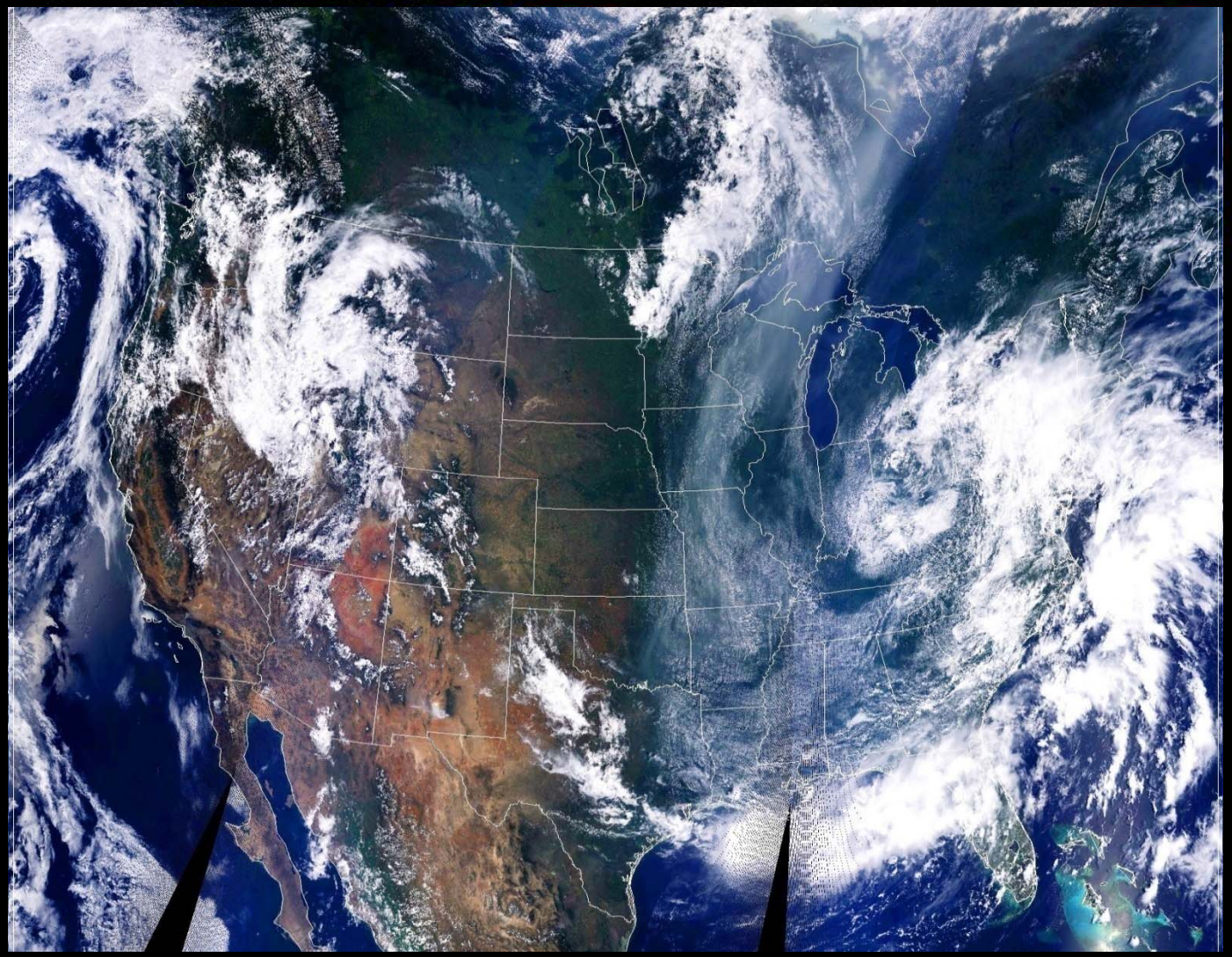
The Afternoon Constellation consists of six U.S. and international Earth Science satellites that fly within approximately ten minutes of each other to enable concurrent science. The joint measurements provide an unprecedented sensor system for Earth Observations.

04/06/10

United States Brazil Canada Finland France Japan Netherlands United Kingdom

www.nasa.gov

Smoke from Alaskan/Yukon Fires
18 July 2004



ESD/Applied Sciences Program

Discovering and demonstrating innovative and practical uses of Earth observations in organizations' policy, business, and management decisions.

http://AppliedSciences.NASA.gov

Applications

Prove-out, develop, and transition applications ideas for sustained uses of Earth obs. in decision making.

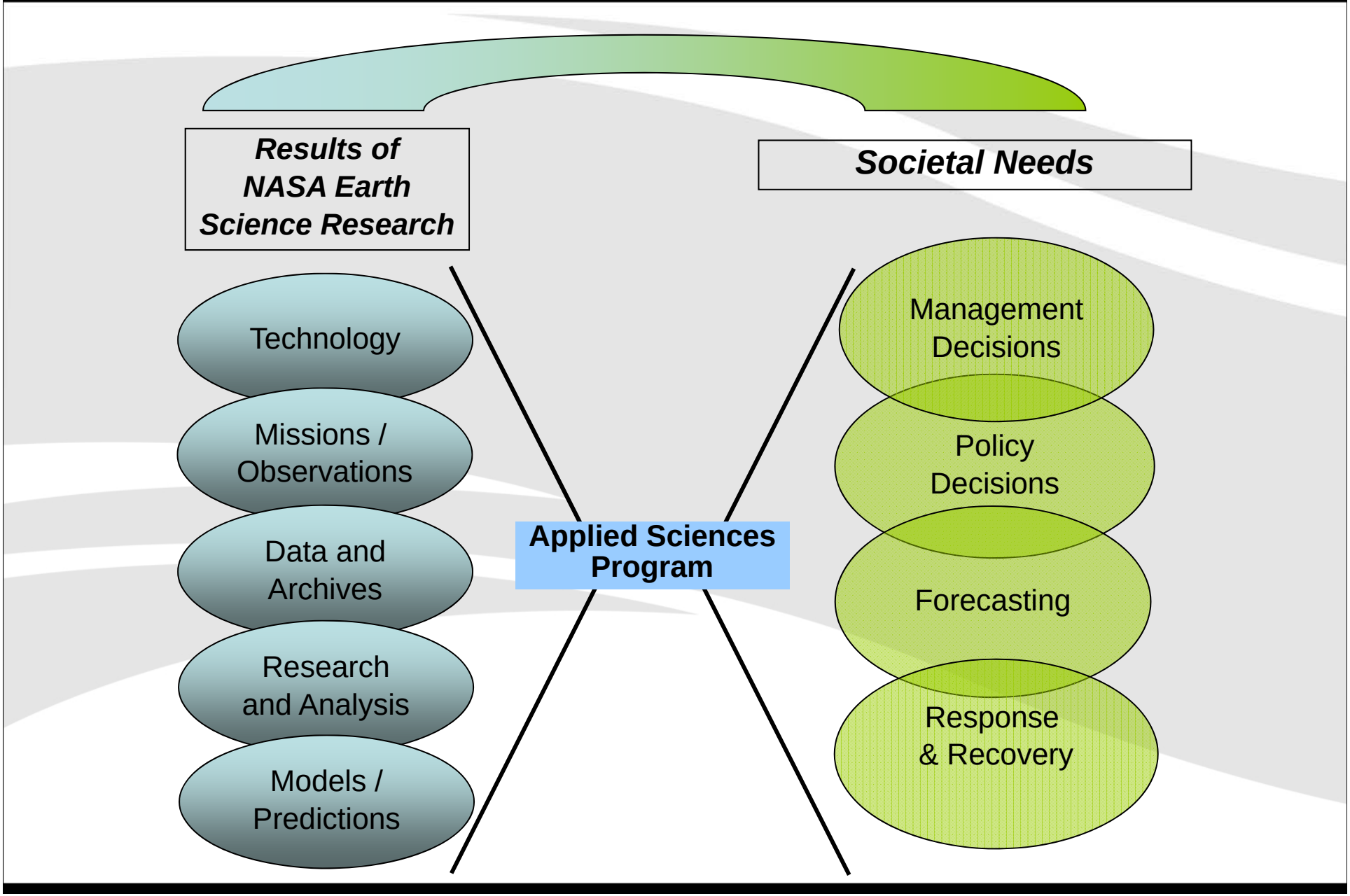
Capacity Building

Build skills and capabilities in US and developing countries to access Earth observations to benefit society.

Mission Planning

Identify applications early in mission lifecycle and integrate end-user needs in mission design and development.

NASA Applied Sciences Architecture



Applications Areas

Emphasis in 4 Applications Areas

Health & Air Quality

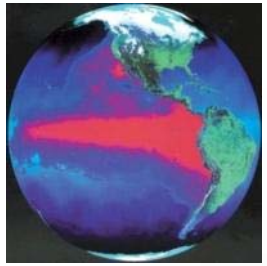
Water Resources

Disasters

Ecological Forecasting

Support opportunities in 5 additional areas

Agriculture



Climate

Weather

Energy

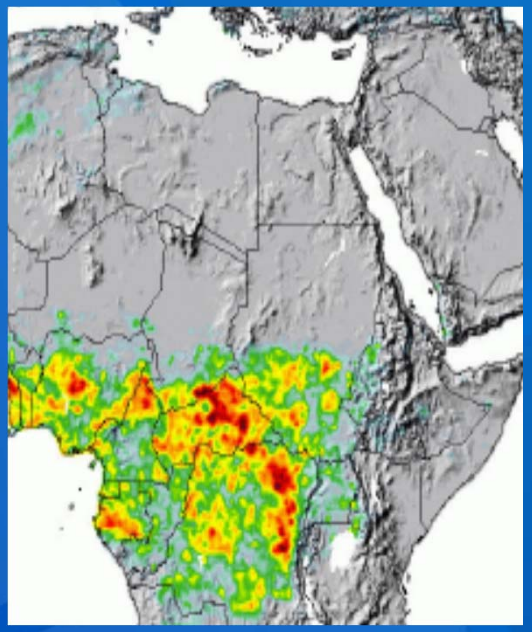
Oceans

SERVIR

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

https://www.servirglobal.net

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



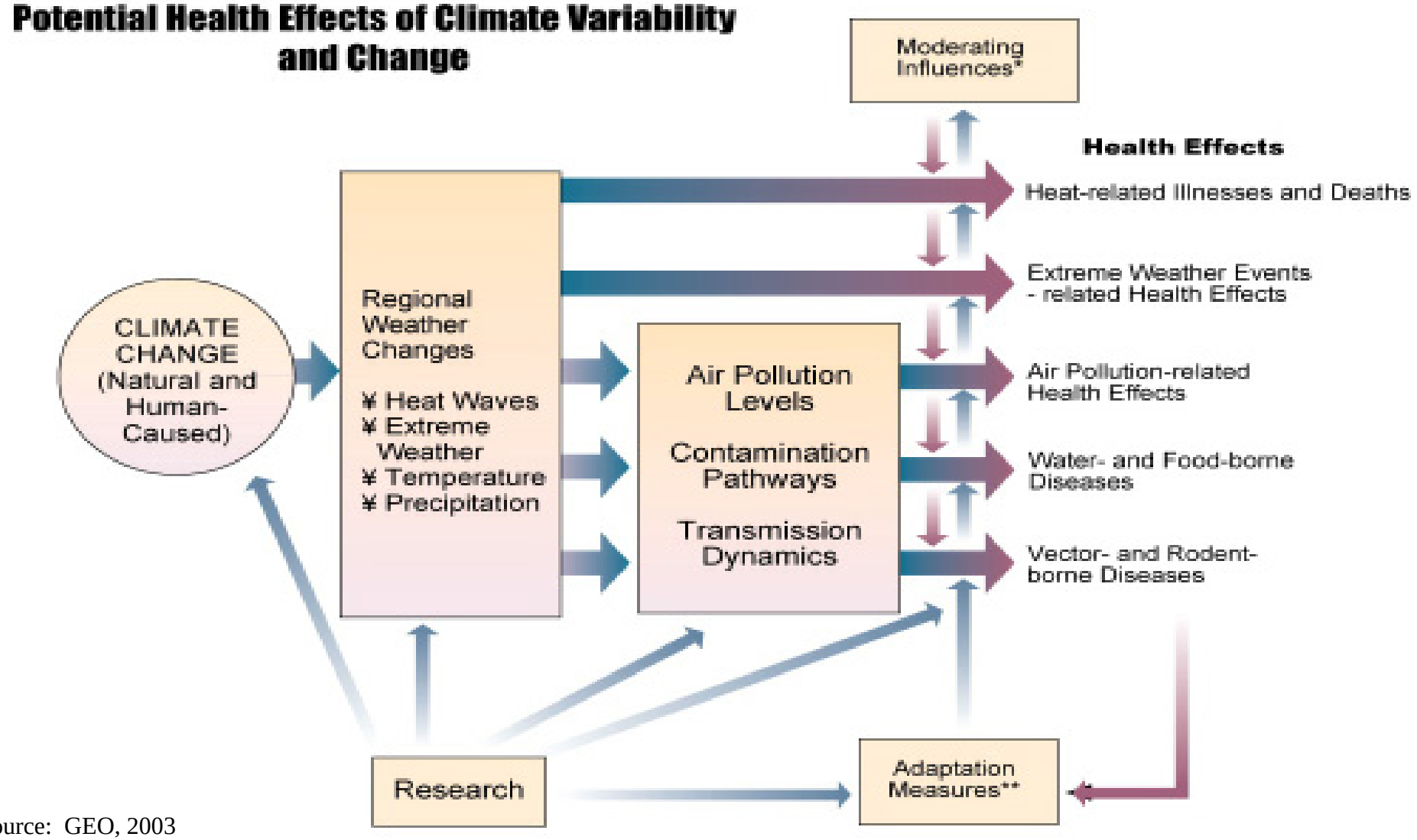
Flood Forecasting in Africa

Training and Capacity Building

Tracking Fires in Guatemala Mexico

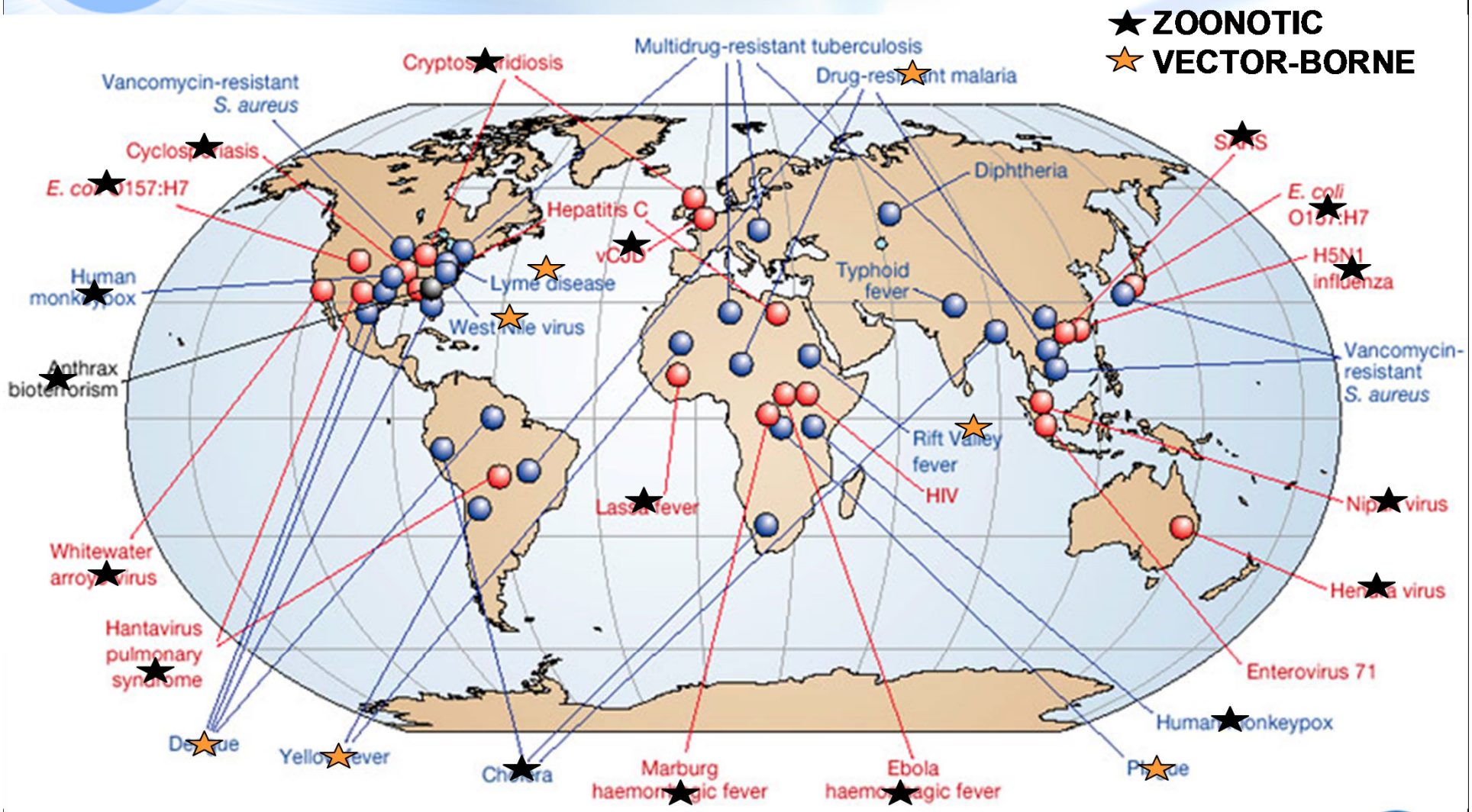
- Data and Models
- Online Maps
- Visualizations
- Decision Support
- Training
- Partnerships

Why Health & Air Quality?



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, 2010, 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.

Health & Air Quality

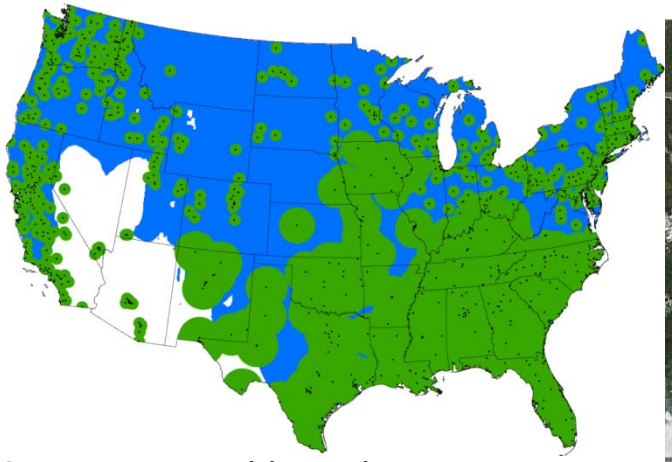
Objectives:

- NASA's Health & Air Quality Applications Area supports the use of Earth observations in air quality management and public health, particularly regarding **infectious disease and environmental health** issues.
- The area addresses issues of toxic and pathogenic exposure and health-related hazards and their effects for risk characterization and mitigation.
- The area promotes uses of Earth observing data and models regarding **implementation of air quality standards, policy, and regulations** for economic and human welfare.
- The Health & Air Quality Applications Area also addresses **effects of climate change on public health and air quality** to support managers and policy makers in their planning and preparations.

Improving Air Quality Maps with Satellite Data

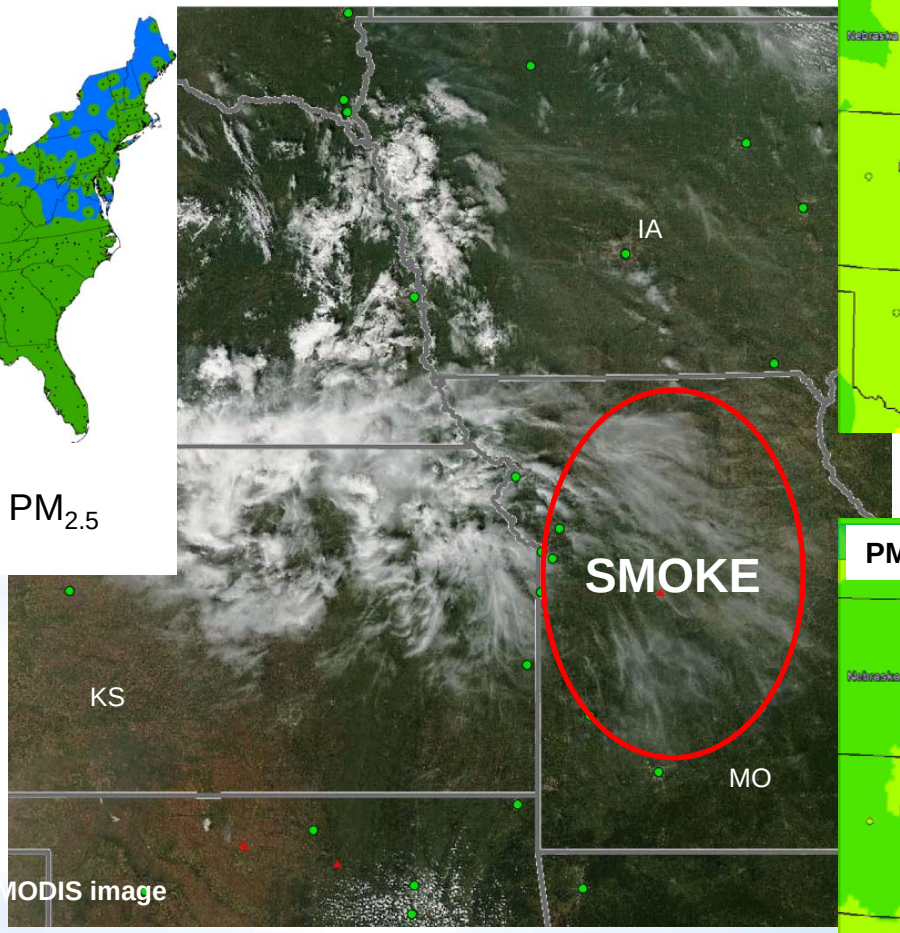
PI: Phil Dickerson, EPA

GROUND-BASED + SATELLITE COVERAGE OF AIR QUALITY

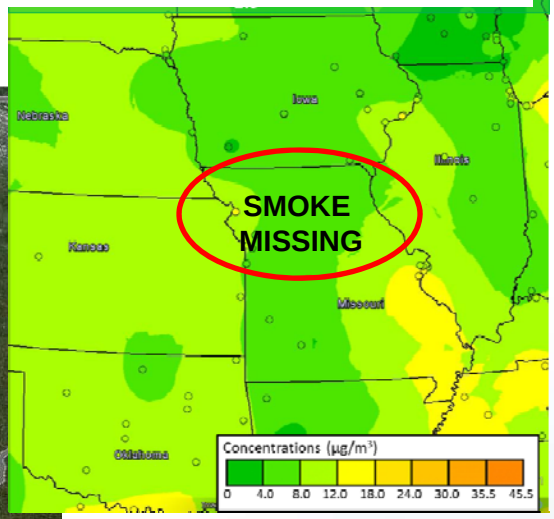


Green = ground-based $PM_{2.5}$
Blue = AirNow Satellite-based $PM_{2.5}$
White = no coverage

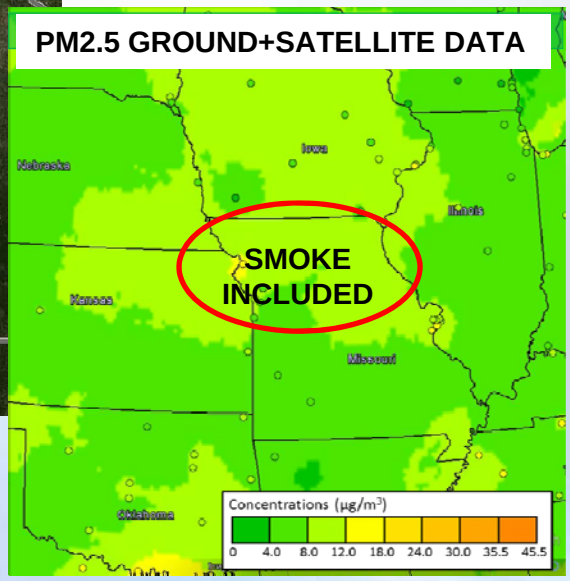
Northern Missouri fires - Sept. 4, 2013



PM2.5 FROM GROUND BASED DATA



PM2.5 GROUND+SATELLITE DATA

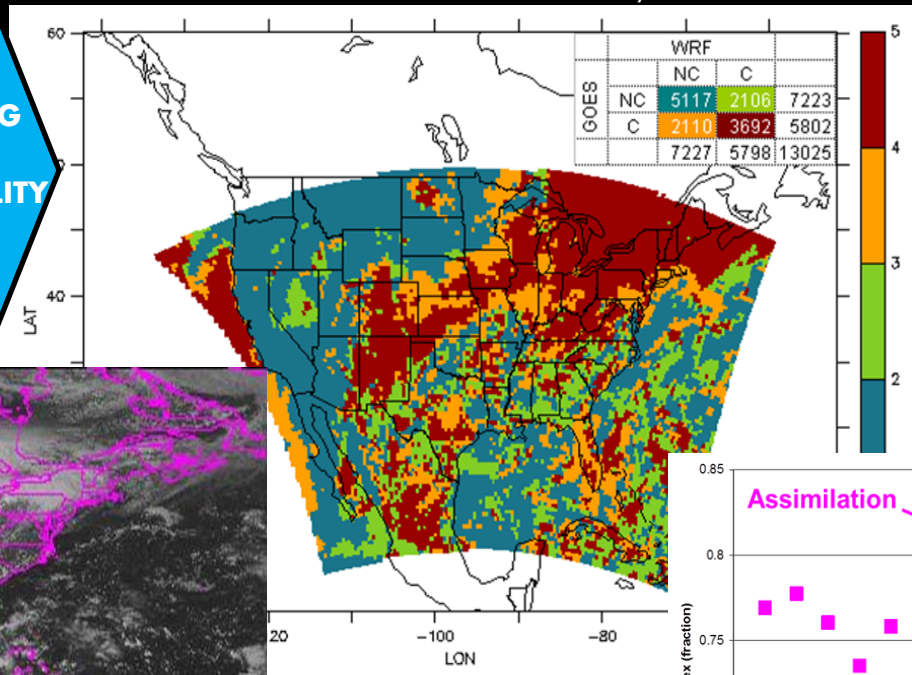


"This is the best tool I have seen so far that integrates satellite data with information from ground monitors."
Cassie McMahon, Minnesota Pollution Control Agency

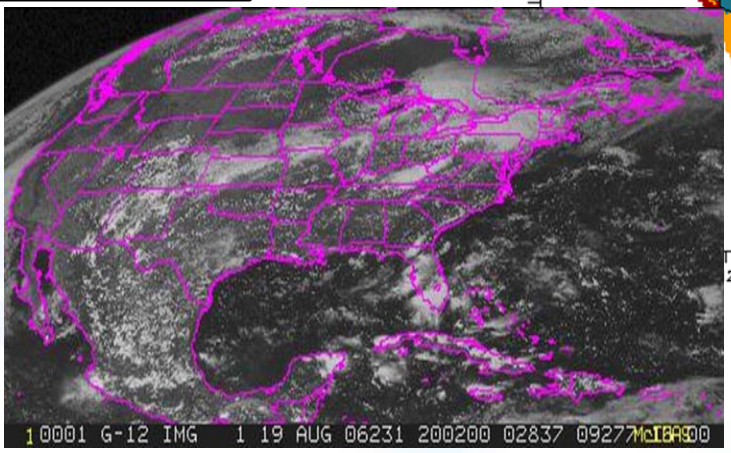
Incorporating Space-borne Measurements to Improve Air Quality Decision Support Systems for Texas

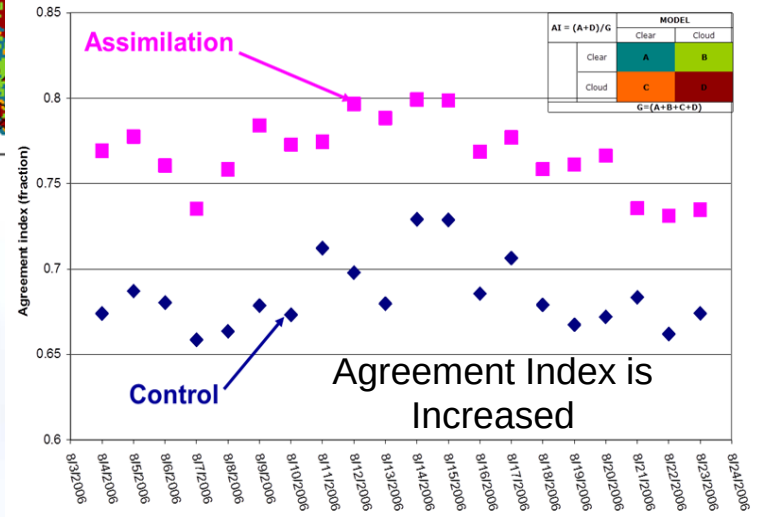
PI: Arastoo Pour Biazar, UAH

CLOUD LOCATIONS & TIMING FROM SATELLITE INGESTED INTO THE AIR QUALITY MODEL USED TO PLAN ACCEPTABLE EMISSIONS



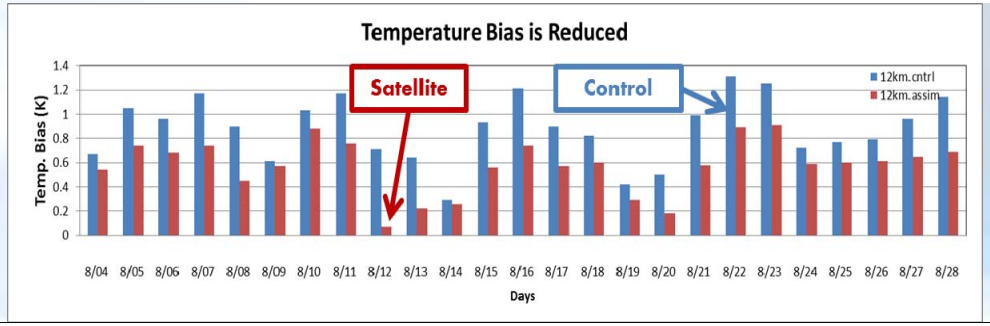
IMPROVED AIR QUALITY PLANNING AND REGULATORY DECISIONS





Agreement Index is Increased

- The temporal and spatial location of clouds have a large impact on the projected air quality given a set of emissions. This tool is designed to provide accurate cloud information.
- Texas Commission for Environmental Quality (TCEQ) used this tool in their latest State Implementation Plans (SIPs)
- The State of Texas joined NASA Applied Sciences in providing $500k of additional funding.



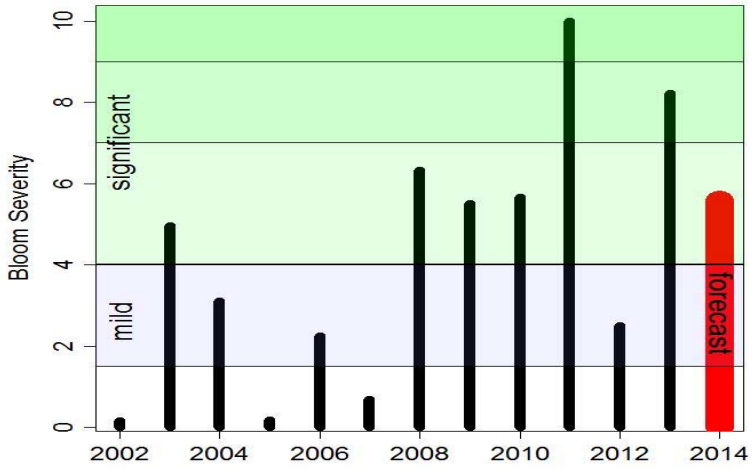
Monitoring and Forecasting Harmful Cyanobacterial Blooms in Lake Erie

Rick Stumpf, NOAA, PI

On Aug 02, 2014, City of Toledo issued "do-not-drink" for 400,000 people.

This project gave Toledo advance warning to monitor for toxic drinking water.

Seasonal forecast for 2014, warning of a significant bloom (models developed in Stumpf et al., 2012, PLoSONE)

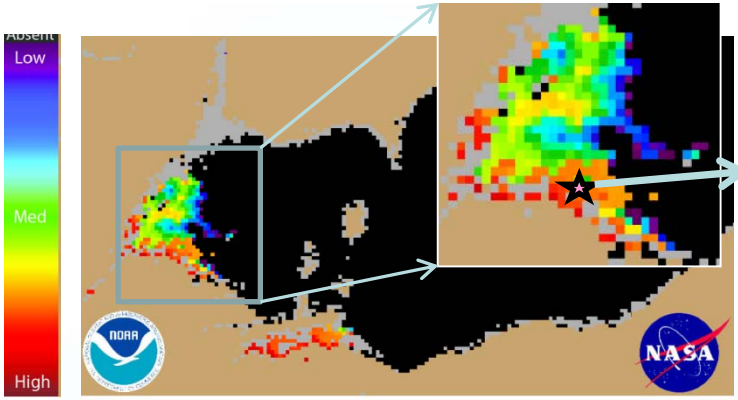


Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

1 August 2014, Bulletin 09

The bloom near the Maumee River has expanded since last weeks bulletin. Low winds (<10 knots) are forecast for the weekend, which may lead to scum formation in the Western basin near the Maumee River.
A slight eastern transport has been forecasted for the next few days.



Toledo water intake

"[The Aug 01 Bulletin] *put everyone on their toes. The extra vigilance is important for catching blooms in the vicinity of our intakes and beaches."*
Email from Ohio EPA, 04 Aug 2014

02 August 2014

Urgent water notice!

URGENT NOTICE TO RESIDENTS OF TOLEDO & LUCAS COUNTY WHO RECEIVE WATER FROM THE CITY OF TOLEDO

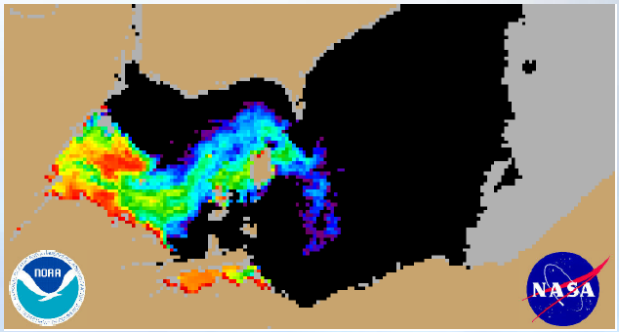
DO NOT DRINK THE WATER
DO NOT BOIL THE WATER

Timeline of 2014 events:

June 5 first bulletin (#1) this year
July 10 **Seasonal forecast issued**
July 17 #7 bloom first indicated in Maumee Bay
July 18 supplemental to Ohio EPA, bloom on Ohio coast.
July 21 EPA samples & posts Maumee Bay State Park
July 28 **#8 bloom identified along Ohio coast**
Aug 01 **#9 Bulletin reports intensification**
Aug 02 ***Toledo finds microcystin in finished water***
Aug 04 #10 Bulletin update of other areas at risk
Aug 05 Toledo cancels water notice.

Bulletins continued to be issued twice weekly until end of season (Oct).

4 August 2014, Bulletin 10
The microcystis bloom has intensified since last Thursday. . . Today and Tuesday expect slight northeast transport (away from the Maumee Bay area).



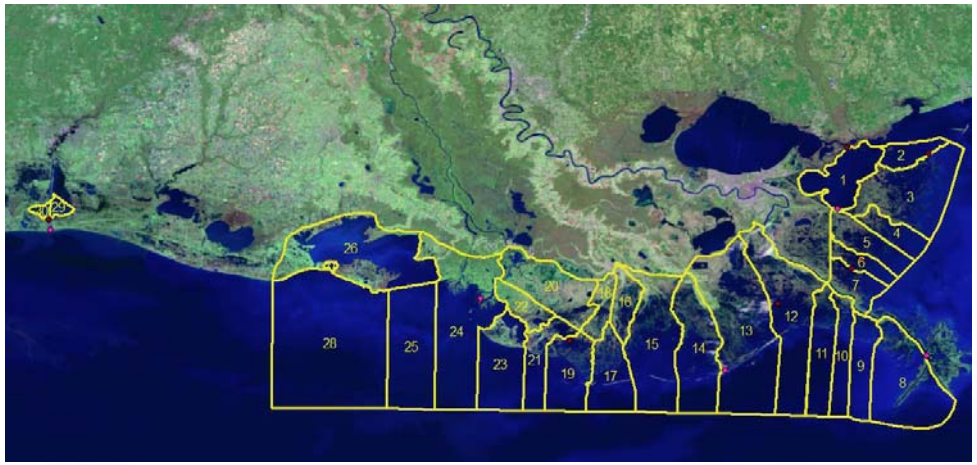
Feasibility Study of Satellite-Assisted Detection and Forecasting of Oyster Norovirus Outbreak

PI: Zhiqiang Deng, LSU

The goal of this project was to test and demonstrate the feasibility of utilizing Terra and Aqua MODIS observations (SST, salinity, solar radiation) in detection and forecasting of oyster norovirus outbreaks in coastal Louisiana. A Detection and Forecasting System (DAFS) for oyster norovirus outbreaks was developed by combining (1) environmental data from NASA Terra/Aqua MODIS sensors and in-situ sensors, (2) bacteriological data from field sampling and laboratory analysis of oysters and water, and (3) developing a predictive model.

The most sensitive environmental factors have been found to be SST and low tide or gauge height. The model successfully predicted the norovirus outbreak in coastal Louisiana in December 2012.

The primary partner is the Louisiana Department of Health and Hospitals (LDHH): Shellfish Program. Results are also shared with the Mississippi DOH.

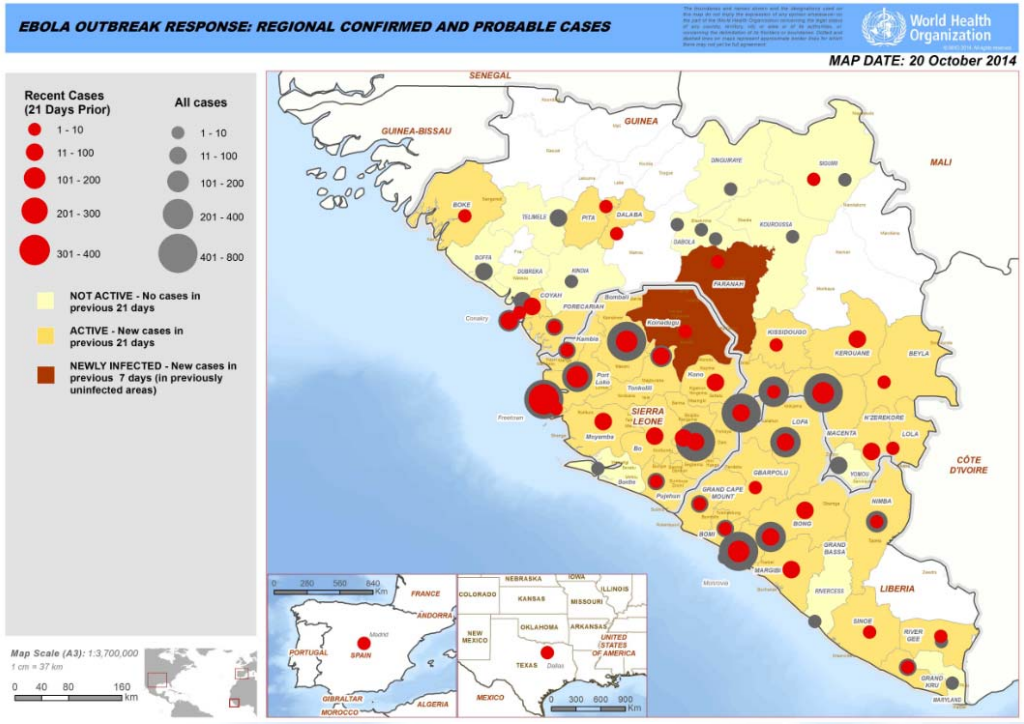


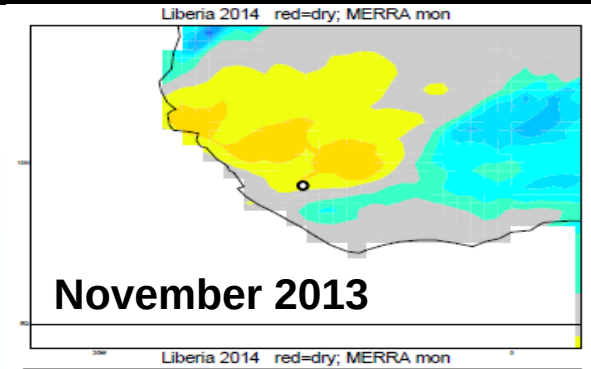
Map showing the 30 Louisiana oyster growing areas under study.

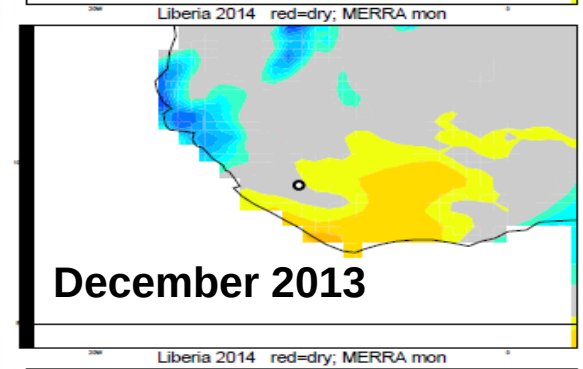
Mr. Glenn T. Cambre (P.H. Executive Director of LDHH) stated: “Such new insights will greatly enhance the usefulness of our program in helping detect and forecast infectious diseases within oysters and provide additional public health assurances to the citizens of Louisiana.”

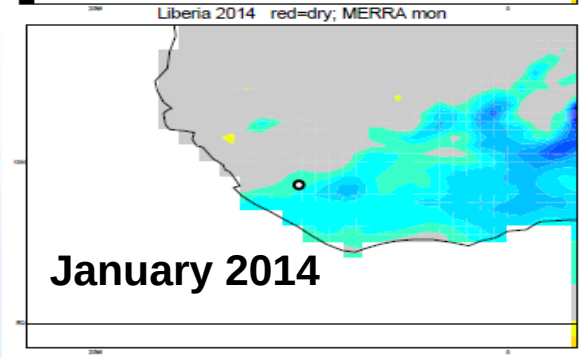
Predicting Zoonotic Hemorrhagic Fever Events using NASA Earth Science Data; Tucker & Pinzon, NASA GSFC

- The model makes operational predictions of Rift Valley Fever and Ebola based on NASA Earth science observations (MODIS, TRMM, Landsat) in sub-Saharan Africa.
- Sharply drier tropical forest conditions and hence lower NDVI values typically precede Ebola outbreaks by 1-3 months.
- Updating the model specifically for West Africa, using new datasets such as MERRA precipitation.
- Close partnership with the World Health Organization.
- SERVIR-Africa will take over the model by Summer 2015.
- Integrated with Google Maps http://rs4gzm.org/gzm.









MERRA precipitation reanalysis for the time period before the Ebola index case (noted by the small circle). Drier conditions are noted prior to the outbreak, as expected.

Investigating the Potential Range Expansion of the Vector Mosquito Aedes Aegypti in Mexico

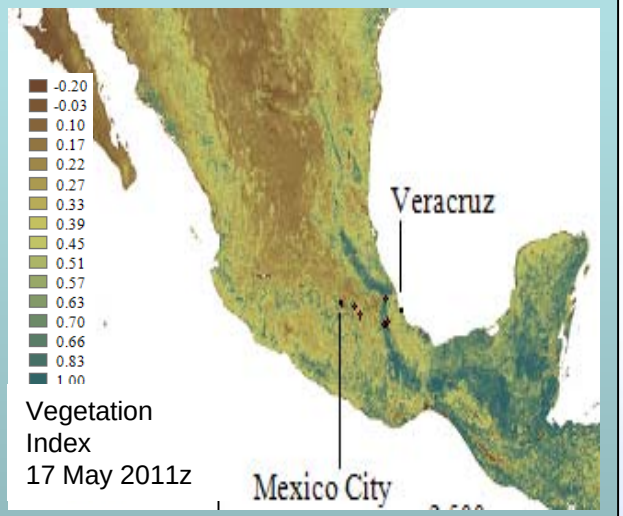
PI: William Crosson, USRA

Employ NASA remotely-sensed data to augment environmental monitoring and modeling. These data -- surface temperature, precipitation, land cover, vegetation indices, soil moisture and elevation -- are critical for understanding mosquito habitat needed for survival and abundance.

Land Cover (MODIS)

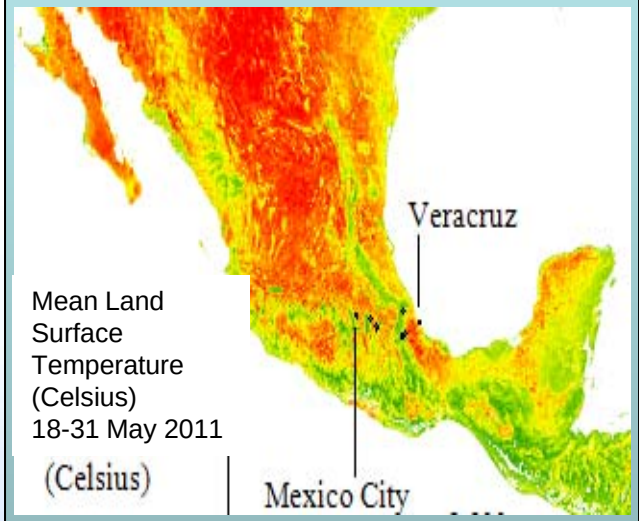
2009 Land Cover

Vegetation (MODIS)



Vegetation Index
17 May 2011z

Surface Temperature (MODIS)



Mean Land Surface Temperature (Celsius)
18-31 May 2011

Primary end user interest is dengue fever

NCAR — The National Center for Atmospheric Research, managed by UCAR to serve the community

CDC — SAFER • HEALTHIER • PEOPLE™

Investigating the Potential Range Expansion of the Vector Mosquito Aedes Aegypti in Mexico

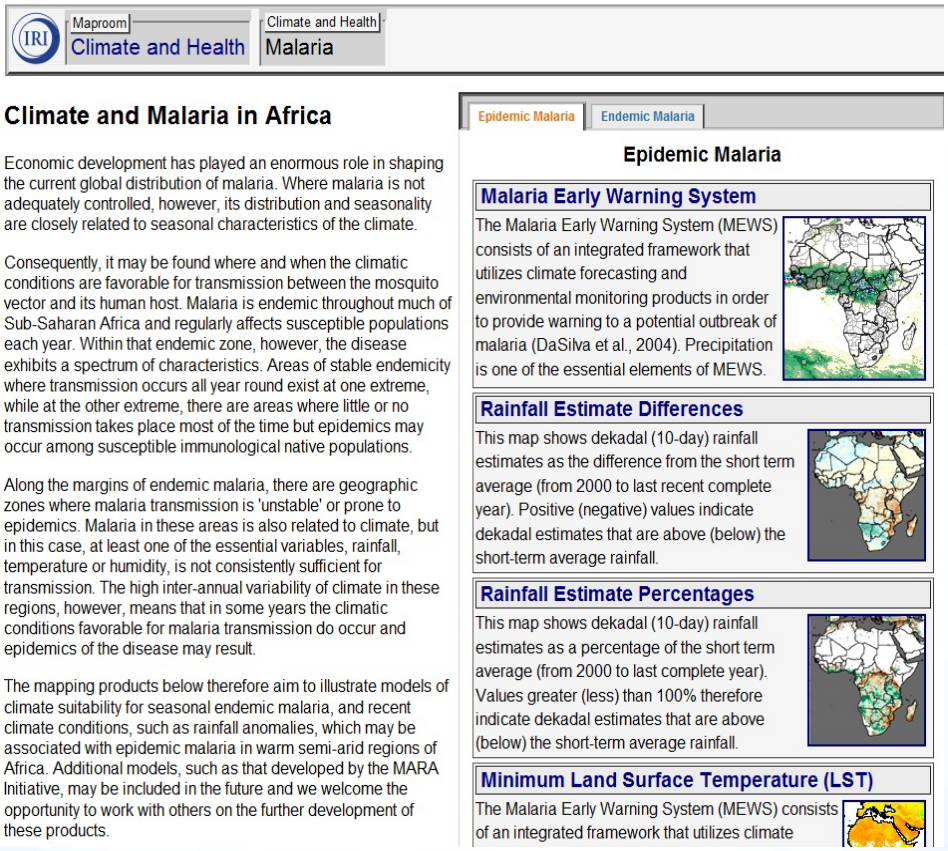
PI: William Crosson, USRA

Sampling and training sessions by USRA/UAH personnel to transfer remotely-sensed data products and habitat analyses to end users and to facilitate continued monitoring. Integrate/disseminate results through NASA SERVIR

Sampling Activities Summer, 2011 Mexico

Improving Decision-Making Activities for Malaria And Meningitis

PI: Pietro Ceccato, IRI/Columbia University



NASA and Columbia U. have developed a repository of data specifically relevant for decision making in malaria and meningitis control . Online ‘Maprooms’ have been created to provide public health officials with dynamic maps and tools to create time-series of disease status and relevant environmental factors. These tools are available as layers in NASA SERVIR, Google Earth and WHO OpenHealth. MODIS, OMI, and TRMM observations, among others, were used in the creation of the Maprooms.

A spokesman for the Ministry of Health in Eritrea thanked the project for its results and stated that the Maprooms “are always useful for malaria.”

http://iridl.ldeo.columbia.edu/maproom/

NASA Air Quality Applied Sciences Team (AQAST)

http://aqast.org

AQAST was created to serve the needs of US air quality management through the use of Earth Science satellite observations, models, and latest scientific knowledge.

AQAST consists of 19 members and is chaired by Daniel Jacob (Harvard). Members have expertise in the wide array of Earth Science tools and data sets available from NASA and other agencies.

Team Members:

- Work long-term applications projects
- Support short-term, quick-response efforts (Tiger Teams)

All AQAST projects are conducted in close partnership with air quality management partners.

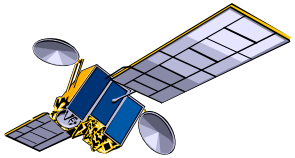
AQAST Membership: PIs and Co-Is

- **Daniel Jacob (leader),** Loretta Mickley (Harvard)
- **Greg Carmichael** (U. Iowa)
- **Dan Cohan** (Rice U.)
- **Russ Dickerson** (U. Maryland)
- **Bryan Duncan**, Yasuko Yoshida, Melanie Follette-Cook (NASA/GSFC); Jennifer Olson (NASA/LaRC)
- **David Edwards** (NCAR)
- **Arlene Fiore** (NOAA/GFDL); Meiyun Lin (Princeton)
- **Jack Fishman,** Ben de Foy (Saint Louis U.)
- **Daven Henze**, Jana Milford (U. Colorado)
- **Tracey Holloway,** Steve Ackerman (U. Wisconsin); Bart Sponseller (Wisconsin DRC)
- **Edward Hyer,** Jeff Reid, Doug Westphal, Kim Richardson (NRL)
- **Pius Lee,** Tianfeng Chai (NOAA/NESDIS)
- **Yang Liu**, Matthew Strickland (Emory U.), Bin Yu (UC Berkeley)
- **Richard McNider**, Arastoo Biazar (U. Alabama – Huntsville)
- **Brad Pierce** (NOAA/NESDIS)
- **Ted Russell,** Yongtao Hu, Talat Odman (Georgia Tech); Lorraine Remer (NASA/GSFC)
- **David Streets** (Argonne)
- **Jim Szykman** (EPA/ORD/NERL)
- **Anne Thompson**, William Ryan, Suellen Haupt (Penn State U.)

Air Quality Applied Sciences Team (AQAST)

EARTH SCIENCE SERVING AIR QUALITY MANAGEMENT NEEDS

Earth science resources



satellites

suborbital platforms

models

AQAST

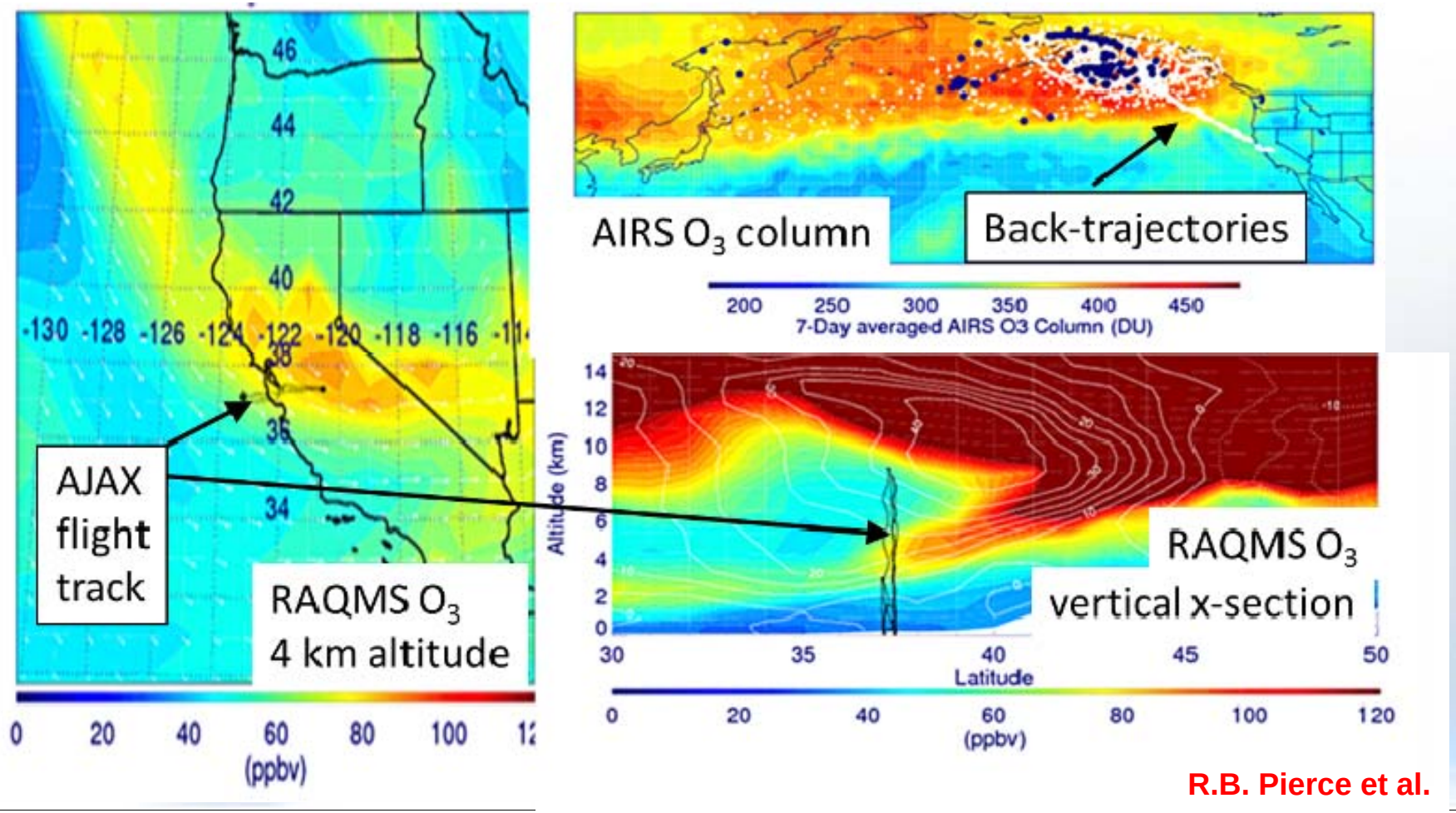
Air Quality Management Needs

- **Pollution monitoring**
- **Exposure assessment**
- **AQ forecasting**
- **Source attribution of events**
- **Quantifying emissions**
- **Assessment of natural and international influences**
- **Understanding of transport, chemistry, aerosol processes**
- **Understanding of climate-AQ interactions**

AQAST

AQAST: Wyoming Exceptional Event Demonstration

Wyoming DEQ/AQD used RAQMS ozone analyses utilizing Aqua/AIRS data to issue an exceptional event demonstration package to the EPA for an ozone exceedance at Thunder Basin, June 6, 2012. This ozone stratospheric intrusion event was documented by the NASA AJAX flight campaign. EPA accepted in Summer 2014!

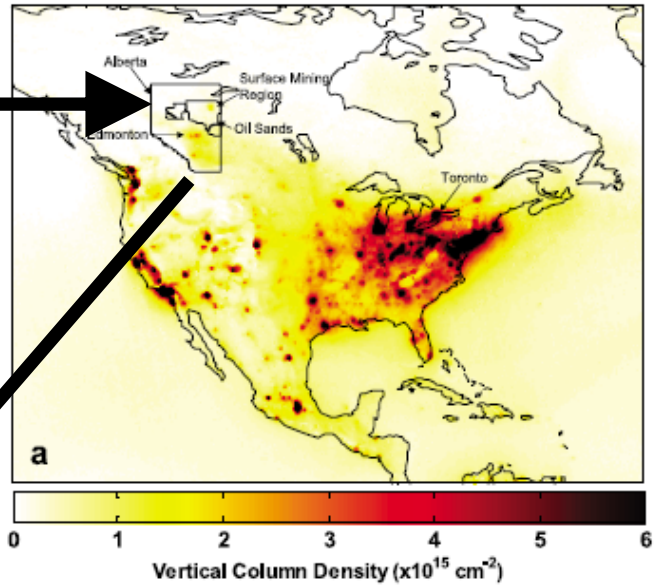


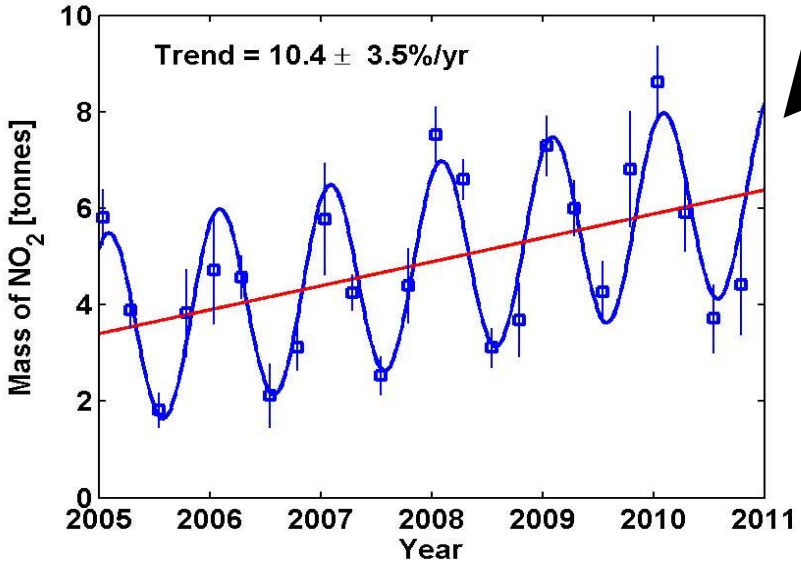
R.B. Pierce et al.

AQAST: Using satellite observations to monitor growth in emissions from Canadian oil sands

Oil sand recovery In Alberta

OMI NO_2 columns, 2004-2010





Oil sand extraction requires much energy to extract and upgrade the bitumen.

Observations show an increase in NO_2 columns of ~10% per year.

McLinden et al. [GRL 2012]

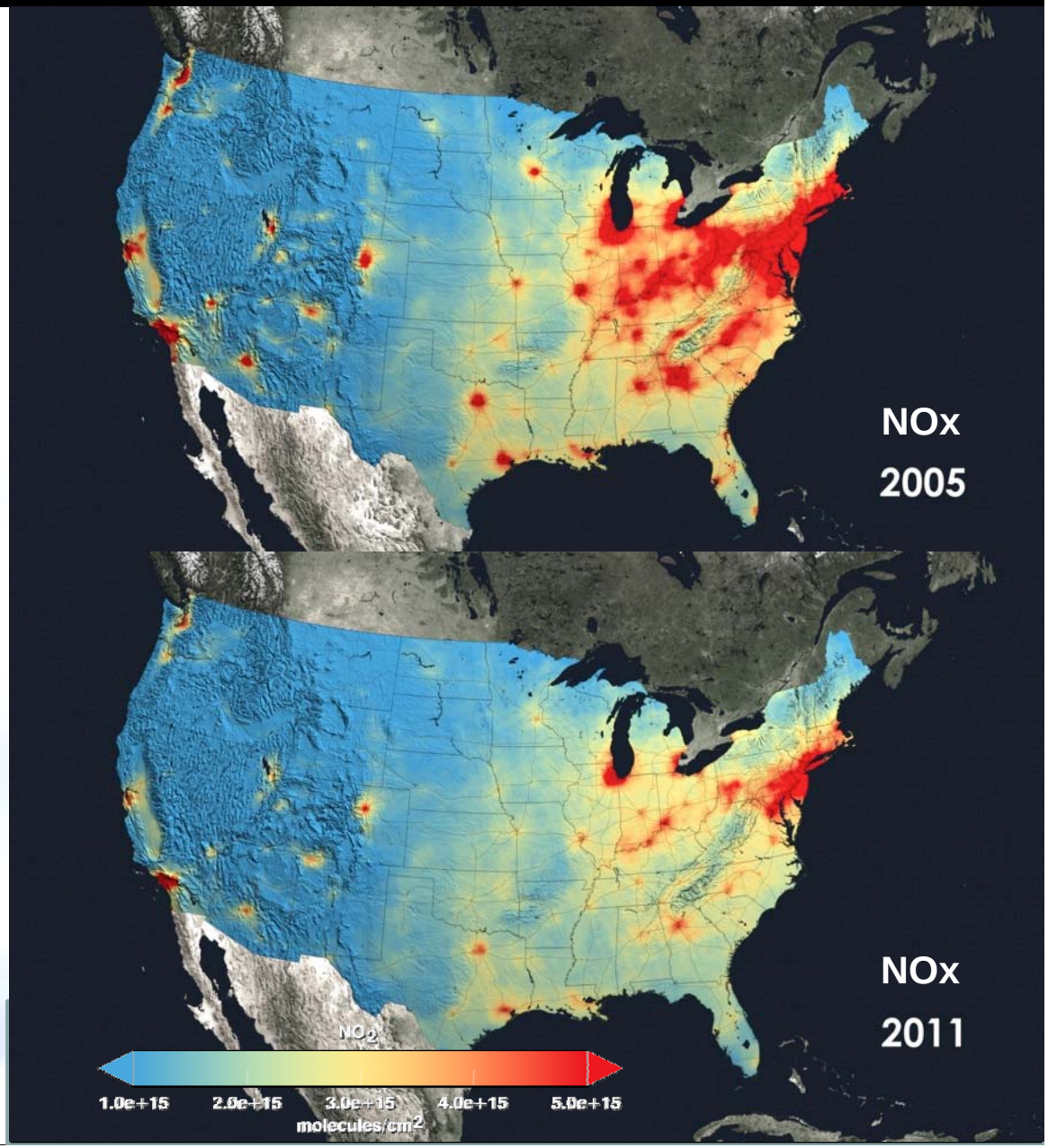
AQAST PI: R.R. Dickerson

AQAST: NASA *Aura* OMI Shows Air Quality is Improving

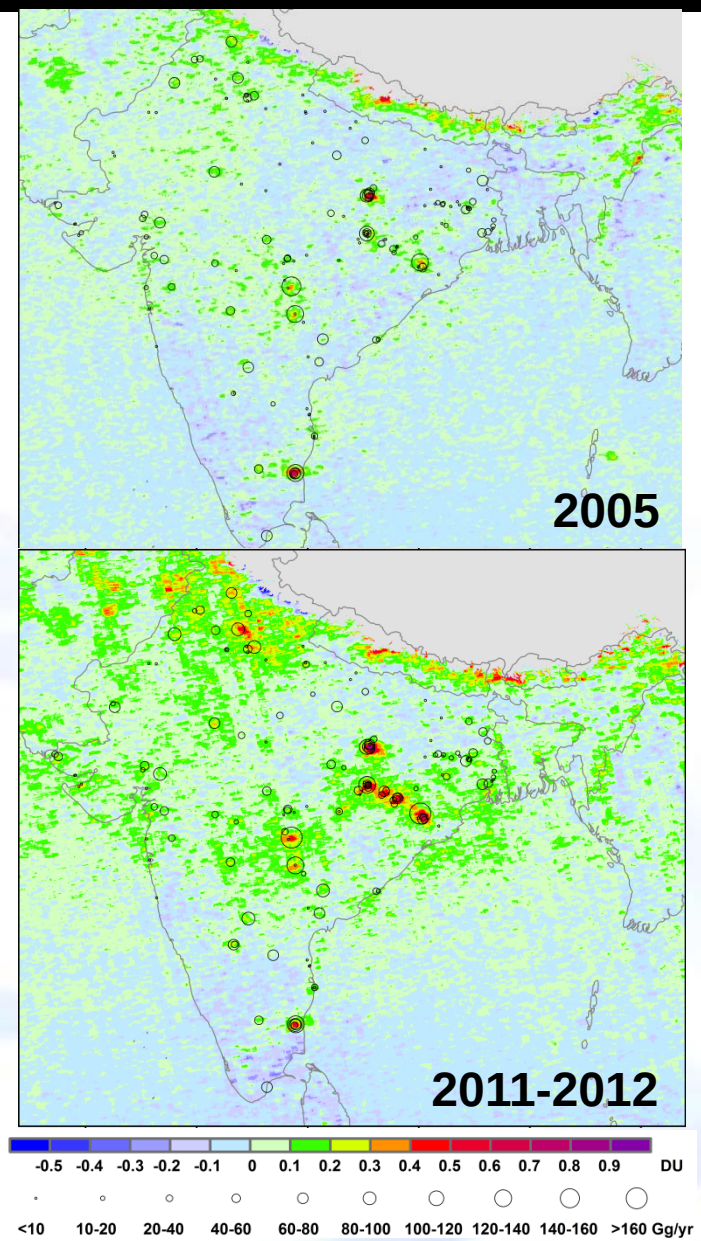
- OMI data show a 30-40% decrease in the pollutant nitrogen dioxide from 2005 to 2011.

- The NO_2 decrease is due to emission control devices on coal-burning power plants and more fuel-efficient cars.

- NASA AQAST members facilitate the use of satellite data by the air quality community, such as by demonstrating the effectiveness of state efforts to improve air quality.



AQAST: Aura/OMI Documents Increase of India's Sulfur Dioxide Emissions



- India has 361 ground-based urban monitoring stations
- Only 70 are in the industrial areas near power plants
- Analysis of these sparse ground station data suggests a decrease in SO_2 emissions

By filling gaps in the ground-based network, OMI data show:

- SO_2 emissions increased by >60% between 2005 and 2012
- India surpassed the U.S. in 2010 to become the world's second largest emitter of SO_2, after China

AQAST PI: D.G. Streets/ANL Dec 2013: *Env. Sci. and Tech*

Applied Remote Sensing Training Program (ARSET)

POC: Ana. I. Prados, NASA-GSFC

Objectives

- Provide end-users with **professional technical workshops**
- Build long term partnerships with communities and institutions in the public and private sectors.

Online and hands-on courses:

- **Who:** policy makers, environmental managers, modelers and other professionals in the public and private sectors.

  Where: U.S and internationally
- **When**: throughout the year. Check websites.
- Do NOT require prior remote- sensing background.
- Presentations and hands-on guided computer exercises on how to access, interpret and use NASA satellite images for decision-support.

NASA Training for California Air Resources Board, Sacramento, CA December 2011

NASA Earth Right Now Campaign

“Your planet is changing. We’re on it.”

2014-15 outreach campaign for NASA Earth Science

Five New Earth Science Missions in Just Over a Year:
An Opportunity NASA Hasn’t Had in Over a Decade!

http://www.nasa.gov/earthrightnow

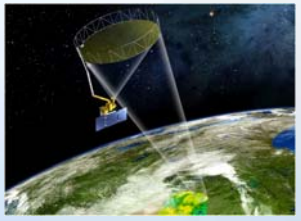
2014 **2015**

February — July — September — January

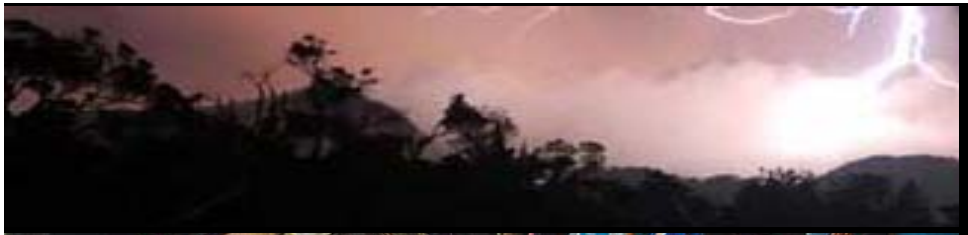
GPM

OCO-2

ISS RapidScat and CATS (Jan)



SMAP



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Space Administration

Questions:

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http://AppliedSciences.NASA.gov