National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

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Introduction to Remote Sensing for Public Health Applications

John A. Haynes, NASA

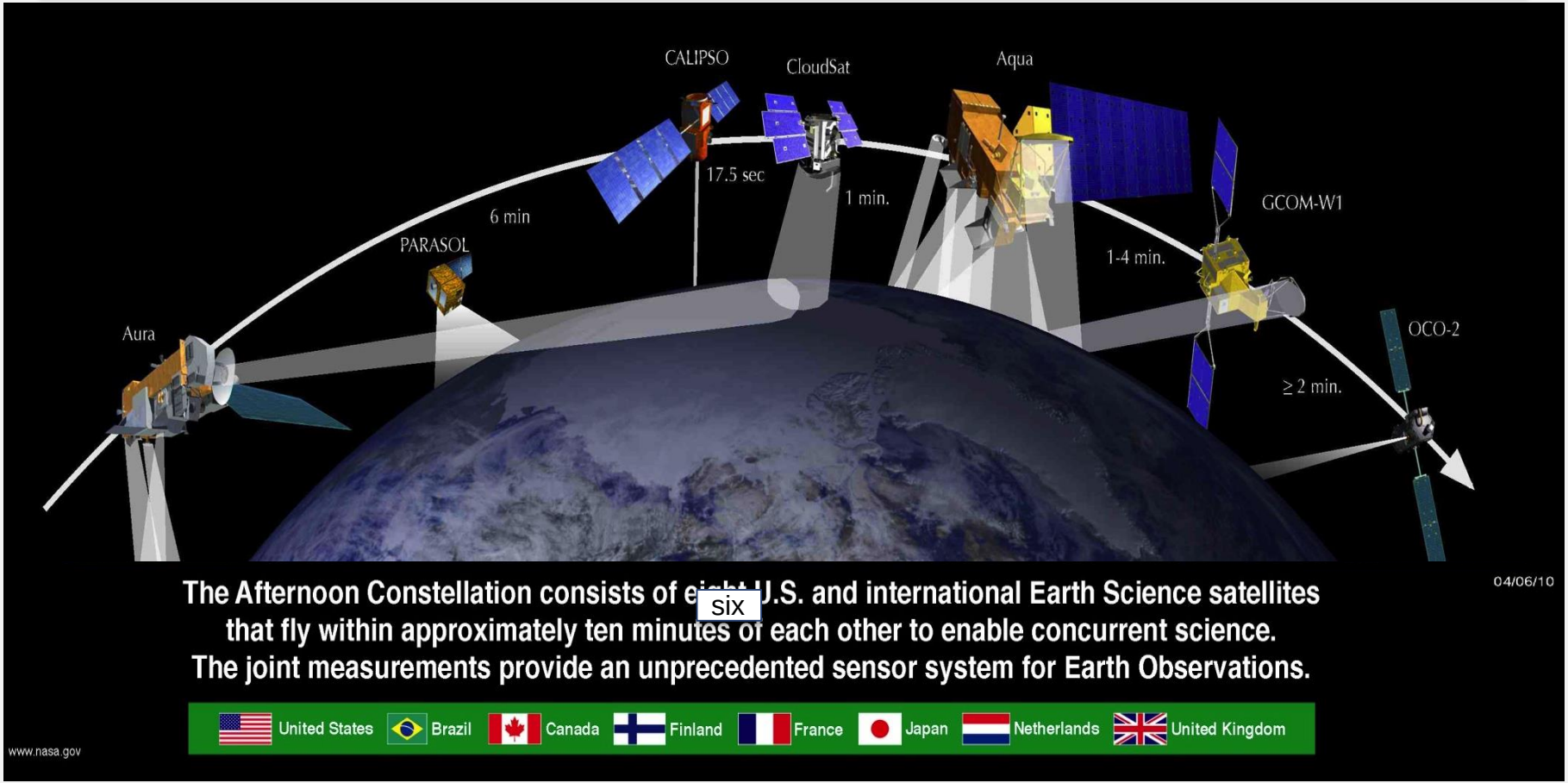
Week 2

Outline

- Brief overview of NASA satellite missions
- Health Focus Areas and Objectives
- What are Satellites That Collect Remotely Sensed Data?
- Examples of Satellites that collect Remotely Sensed Data for Health Applications
- Examples of Health Projects that Use Remotely Sensed Data


Formulation
Implementation
Primary Ops
Extended Ops
NASA Earth Science:
Current and Upcoming Missions
Landsat 9,
TIR-FF
PACE
NI-SAR
SWOT
TEMPO
JPSS-2 (NOAA)
RBI, OMPS-Limb
GRACE-FO (2)
ICESat-2
CYGNSS
ISS
SORCE,
TCTE (NOAA)
NISTAR, EPIC
(NOAA's DSCOVR)
QuikSCAT
EO-1
SMAP
Landsat 7
(USGS)
Terra
Suomi NPP
(NOAA)
Aqua
Landsat 8
(USGS)
CloudSat
CALIPSO
GPM
Aura
GRACE (2)
OSTM/Jason 2
(NOAA)
OCO-2

International A-Train

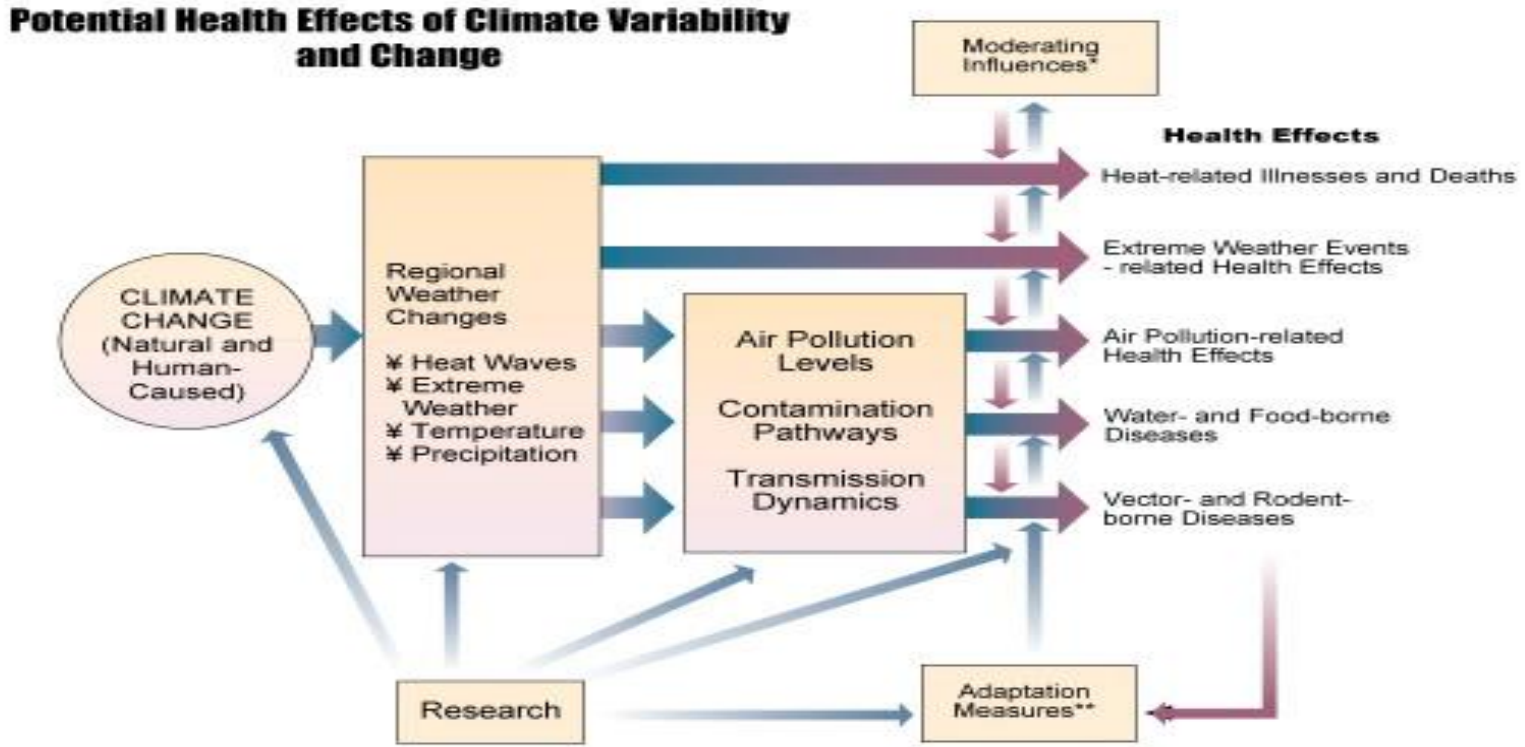


Focus Areas of Health and AQ

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.
- implementation of **air quality standards, policy, and regulations** for economic and human welfare.
- **effects of climate change on public health and air quality** to support managers and policy makers in their planning and preparations

How Can Remotely Sensed Data Aid Health

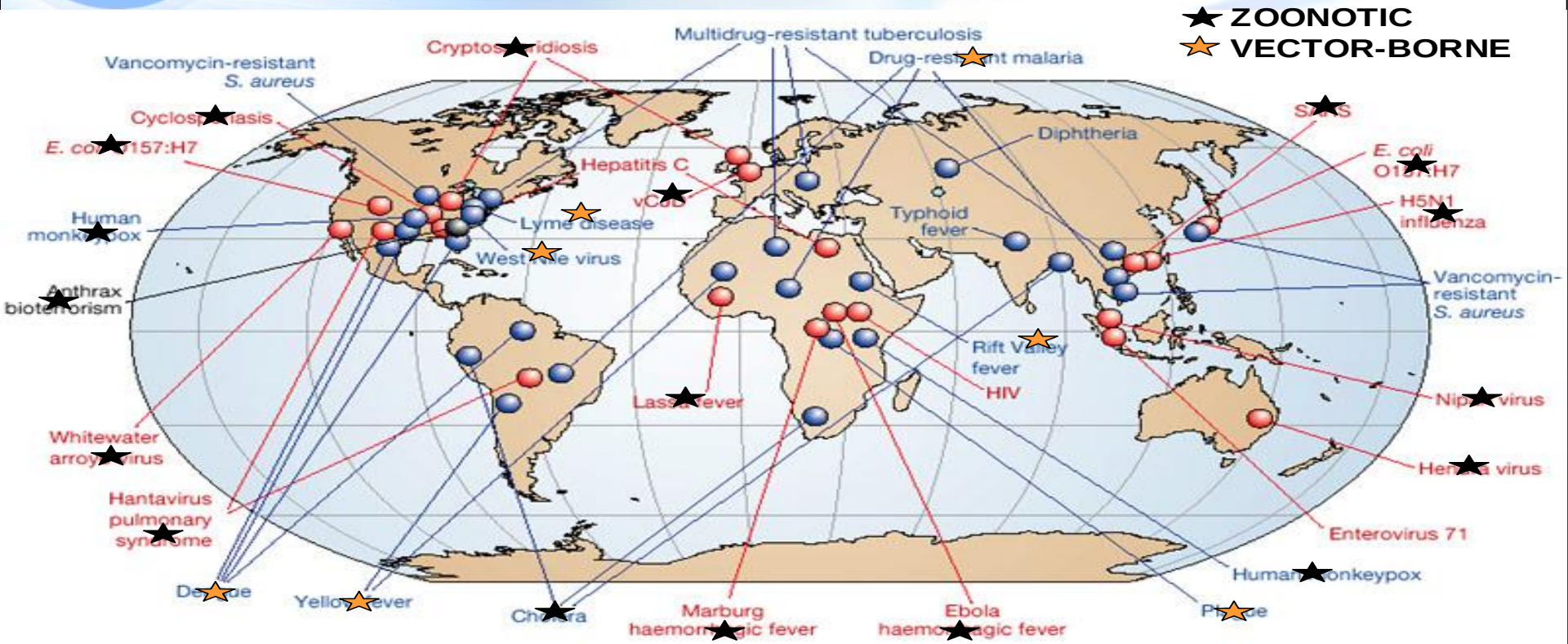


Patz et al., 2000

Source: GEO, 2003

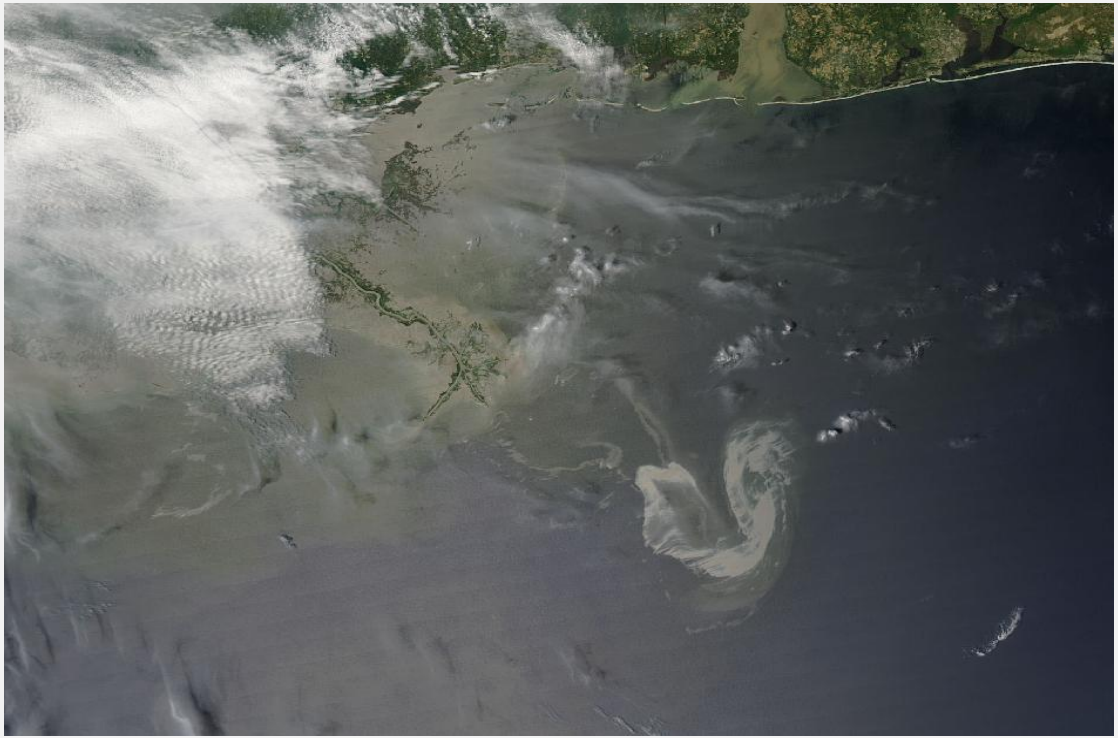
http://www.usgcrp.gov/usgcrp/Library/nationalassessment/healthimages.htm

Global Emerging Diseases*

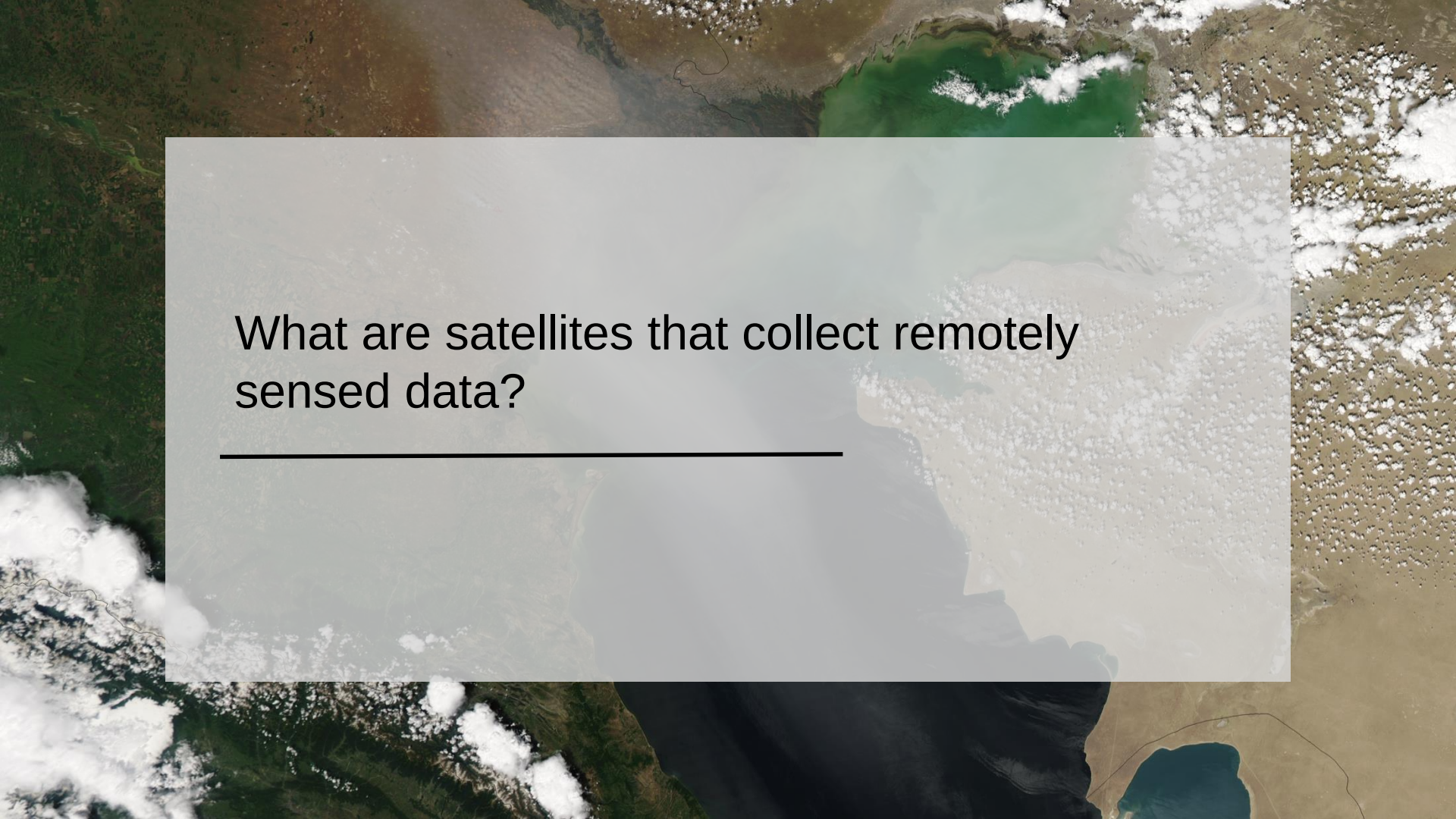


* Modified from Morens et al. 2004 *Nature* 430:242

New Emerging 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.



What are satellites that collect remotely sensed data?

_____

What are the satellites that collect remotely sensed data?

- A satellite is a machine launched into space that moves around the Earth (or another body in space)
- Some take pictures of Earth, other planets, the sun, black holes, dark matter, or faraway galaxies

Why are satellites important?

- They provide a birds-eye view of Earth that sees large areas
- See into space better than surface-level telescopes

What are the parts of a satellite?

- Two common parts: an antenna and a power source
  - Many carry scientific sensors

What are the satellites that collect remotely sensed data?

How do satellites orbit Earth?

- Most are launched into space on rockets
- Its speed is balanced by the pull of Earth's gravity
- Satellites orbit at different heights, speeds, and along different paths

Why don't satellites crash into each other?

- They can, but collisions are rare

What was the first satellite in space?

- Sputnik 1: the Soviet Union launched it in 1957

What is the history of NASA satellites?

- First launch: Explorer 1 in 1958
- First satellite image of Earth: Explorer 6 launched in 1959
- First TV image of Earth from Space: TIROS-1 launched in 1960

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- Monitored by NASA, other U.S. and international organizations

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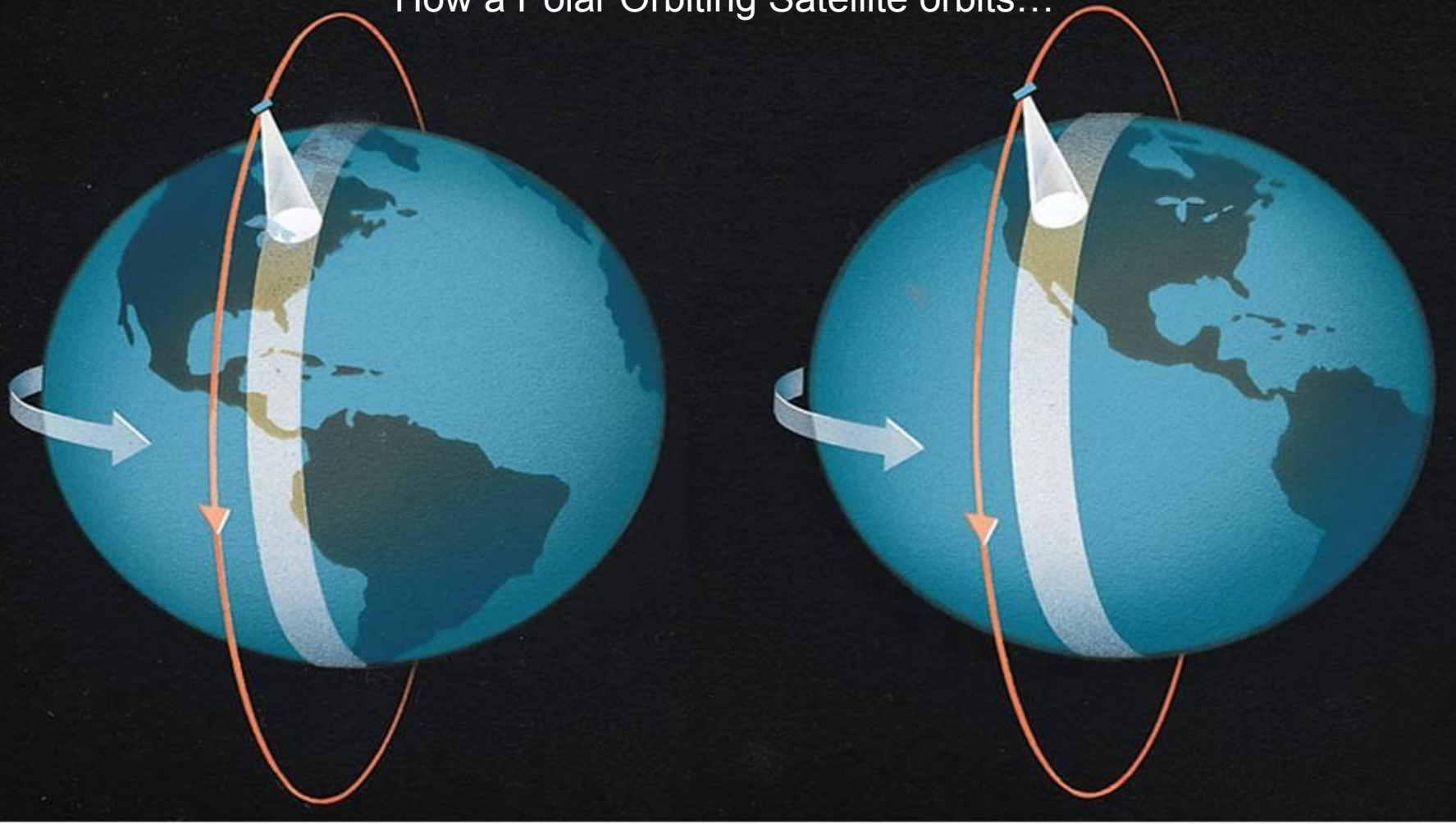
How a Polar Orbiting Satellite orbits…

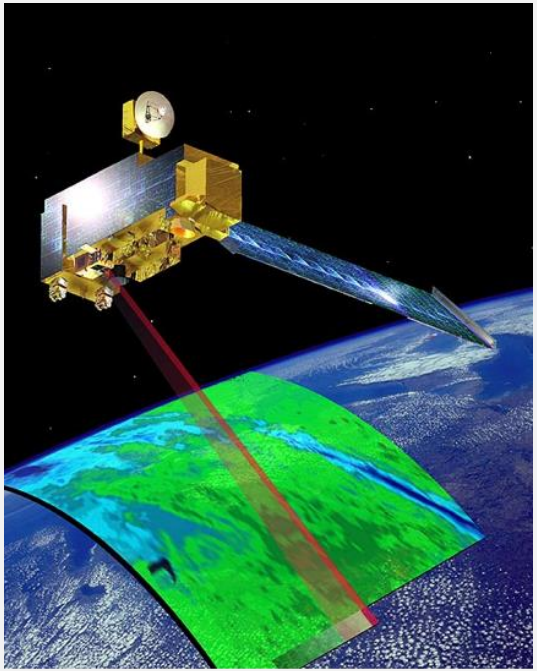


Examples of satellites that collect remotely sensed data for health applications

Satellites Used to Study Health

Moderate Resolution Imaging Spectroradiometer (MODIS)

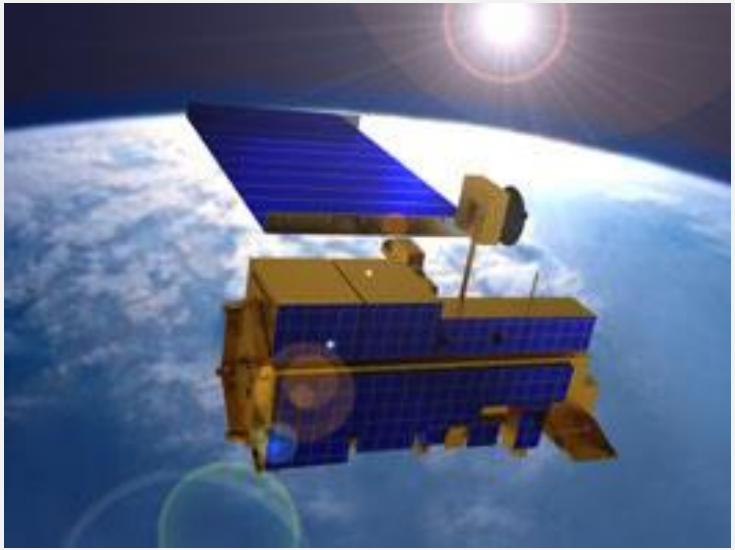
- Aboard Terra and Aqua
- Measures
  - Atmosphere
  - Land
  - Ocean characteristics
- Views the entire surface of Earth every 1-2 days
- 250-100m resolution



Satellites Used to Study Health

Terra

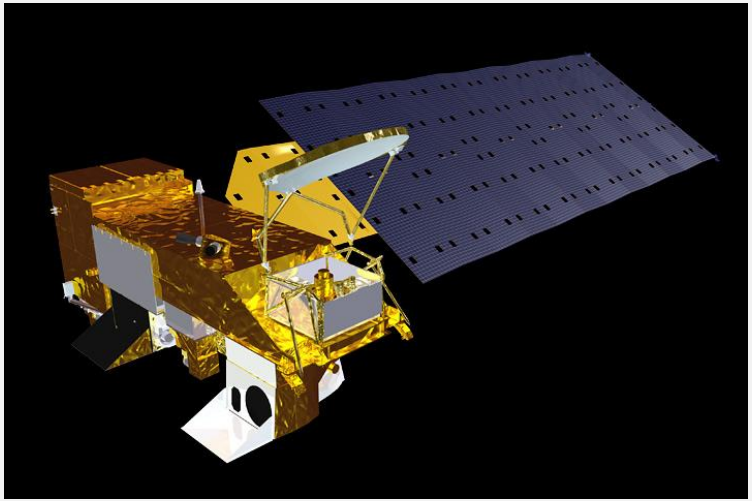
- Flagship satellite of NASA's Earth Observing System (EOS)
- First EOS platform
- Launched in 1999
- Provides global data on
  - Atmosphere
  - Land
  - Oceans
  - Interactions with solar radiation & each other
- Five instruments on board
  - CERES, MISR, MODIS, MOPITT, and ASTER



Satellites Used to Study Health

Aqua

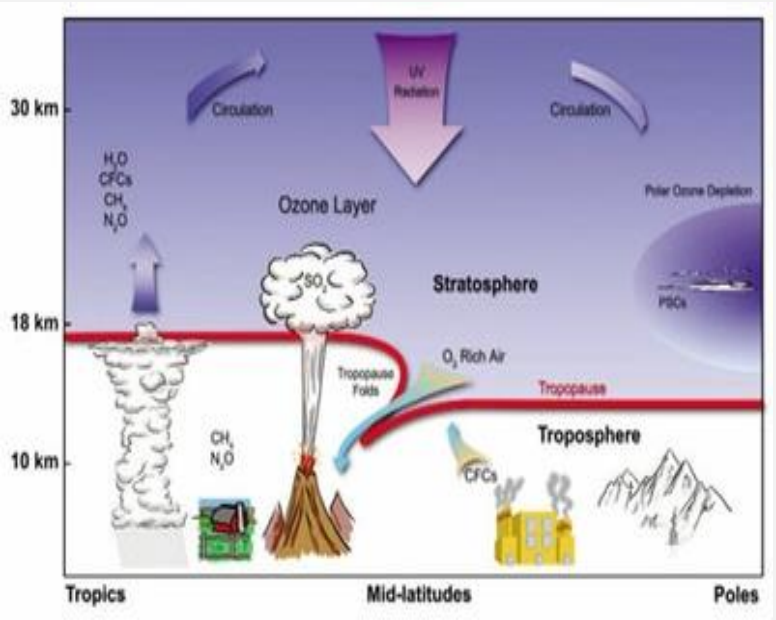
- Launched in 2002
- Collects information about Earth's water cycle
  - Evaporation from oceans
  - Water vapor in the atmosphere
  - Clouds
  - Precipitation
  - Soil moisture
  - Sea and land ice
  - Snow cover
- Instruments: AIRS, AMSU, CERES, MODIS, AMSR-E



Satellites Used to Study Health

Aura

- Launched in 2004
- Studies chemistry and dynamics of Earth's atmosphere
  - Emphasis on upper troposphere and lower stratosphere
- Allows scientists to investigate:
  - Ozone trends
  - Air quality changes
  - Links to climate change
- Instruments
  - MLS, OMI, and TES



Satellites Used to Study Health

Suomi-National Polar-Orbiting Partnership (S-NPP)

- Launched in 2011
- Collects & distributes land, ocean, and atmospheric data
- Transition for Aqua, Terra, and Aura to Joint Polar Satellite System (JPSS)
- Provides
  - Atmospheric and sea surface temperatures
  - Humidity sounding
  - Land and ocean biological productivity
  - Cloud and aerosol properties
- Instruments
  - ATMS, VIIRS, CrIS, OMPS, and CERES

“Black Marble” Image of the Western Hemisphere from S-NPP

Satellites Used to Study Health

Global Precipitation Measurement (GPM) Mission

- Launched in 2014
- Provide next-generation observations of rain and snow worldwide, every 3 hours
- Joint project of NASA & the Japan Aerospace Exploration Agency (JAXA)
- Used to unify precipitation measurements
- Will help
  - Advance our understanding of Earth's water and energy cycles
  - Improve forecasting of extreme events
  - Extend current capabilities

Examples of health projects that use remotely sensed data

NASA Data & Models Support U.S. Coast Guard Search and Rescue Missions PI: Yi Chao, JPL

- Relevance
  - U.S. Coast Guard performs thousands of search & rescue missions, saving 5,000+ lives
  - Time is critical when deploying S&R operations
  - Enhancing predictions narrows the area and increases efficiency
- Accomplishments
  - Assimilated data from Aqua, OSTM/JASON-2, & others incorporated into SAROPS tool in 2011
  - Enhanced forecasts of ocean currents and winds for:
    - Targeting and sizing search areas
    - Estimating response times

This application is an “extraordinarily powerful technique that we will continue to use and incorporate”
- Arthur Allen, USCG Office of Search and Rescue

Figure 1: This image is of the observed drift trajectory in one test.

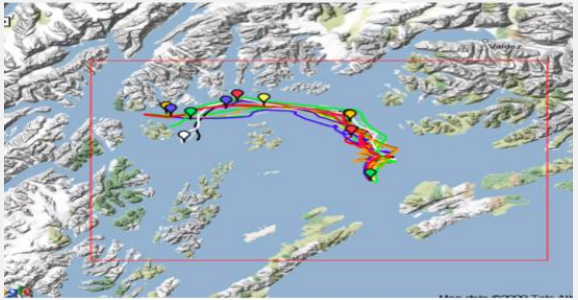
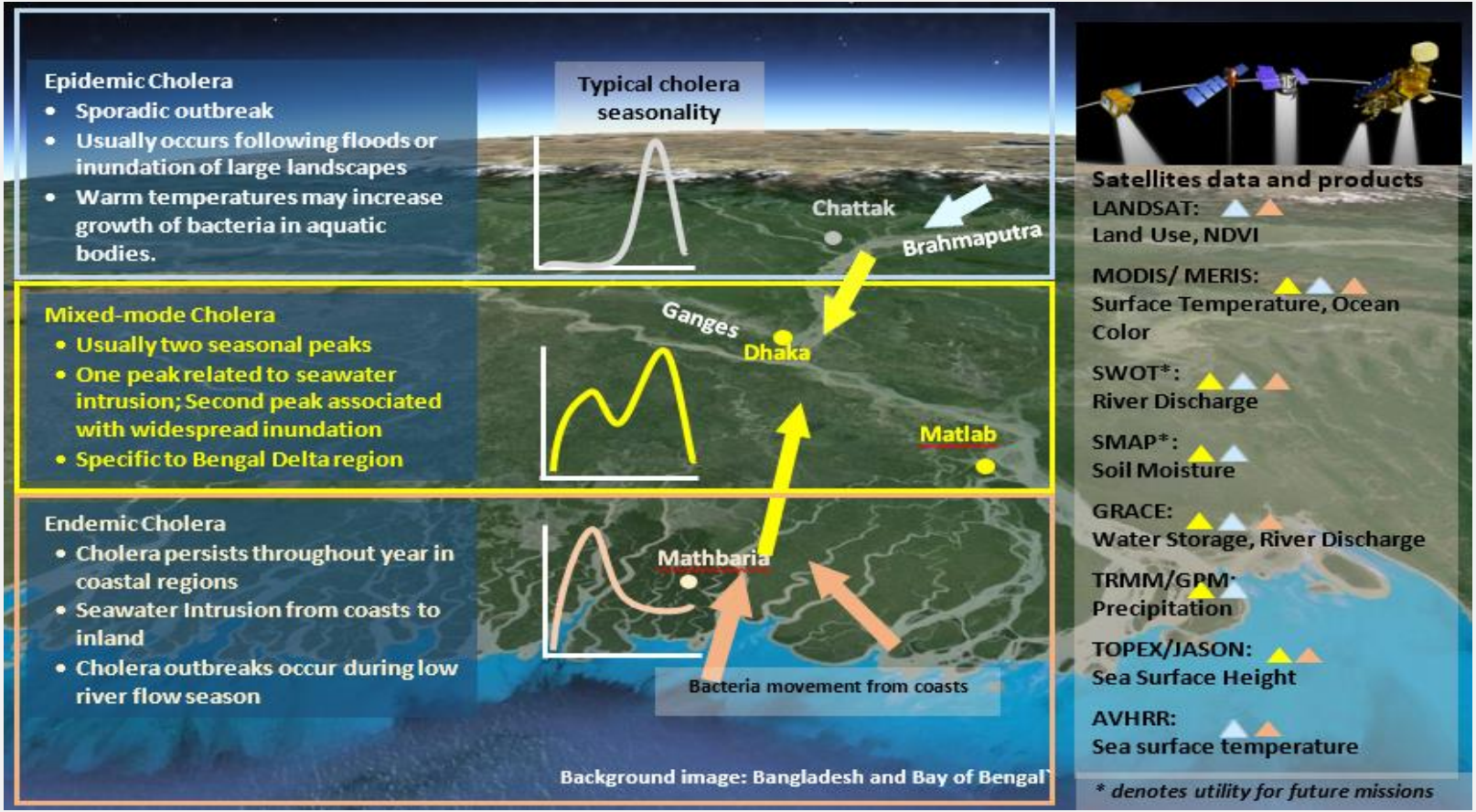


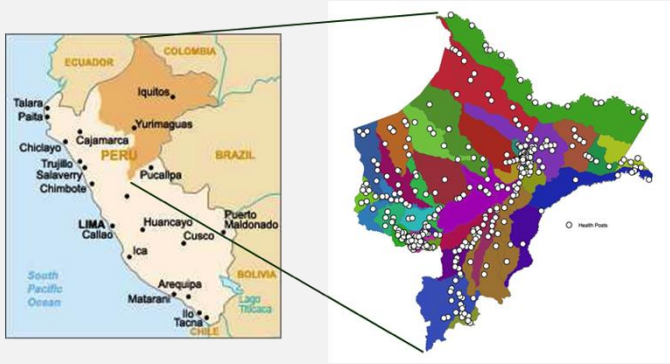
Figure 2: This image shows the forecasted drift trajectories based on the model including NASA data. Note points of correlation with observed trajectory

Cholera Prediction Model PI: Antar Jutla, West Virginia Univ.



Development of a Detection and Early Warning System for Malaria Risk in the Amazon; PIs: Ben Zaitchik, Johns Hopkins Univ; William Pan, Duke Univ.

- Over 90% of malaria in Western Hemisphere is in the Amazon
- In Peru: 75% of cases occur in Northern Amazonian Region
- Key factors:
  - Expansion of vector habitats
  - Social & ecological processes increasing human exposure to mosquito vector *Anopheles darlingi*



Geographic location of transmission risk modeling (Department of Loreto, Peru). Loreto districts are differentiated by color with local health clinics indicated by white circles.

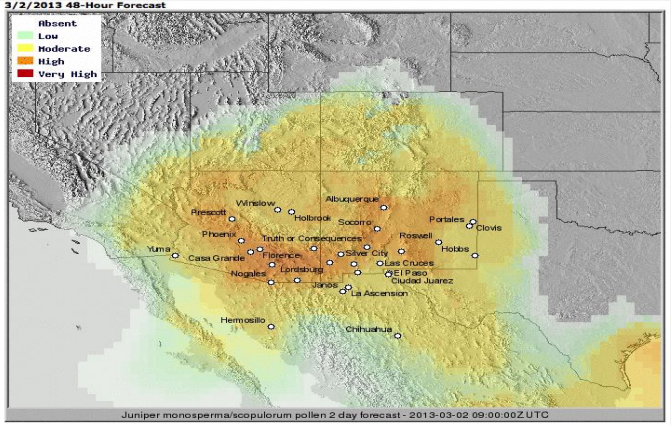
- Developed a spatially explicit model of malaria transmission based on
  - Mosquito density and human settlement/activity
- Key finding:
  - Climate and hydrological variability influence total mosquito abundance
  - Land cover influences relative density of vector NAMRU-6

Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems PI: Jeff Luvall, NASA MSFC

- Produces a pollen forecasting alert system with deterministic models for predicting & simulating pollen
- Use hi-res satellite data sets from MODIS & NPP-VIIRS
- Component of New Mexico Environmental Public Health Tracking System
  - Use models to predict increased risk of asthma

NEW MEXICO Environmental Public Health Tracking EPHT

CDC Centers for Disease Control and Prevention

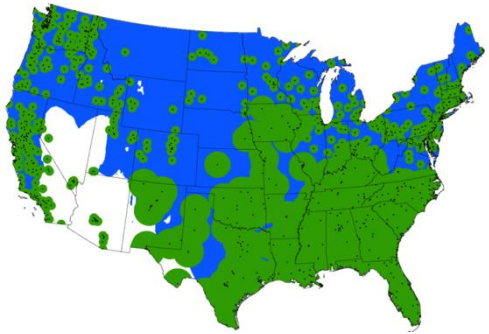


(Above) This figure shows how the data from NASA's MODIS sensor was used to develop a vegetation mask of Juniper pollen in New Mexico and then incorporated in the PREAM model for the prediction system.

(Left) *Juniper* pollen in New Mexico

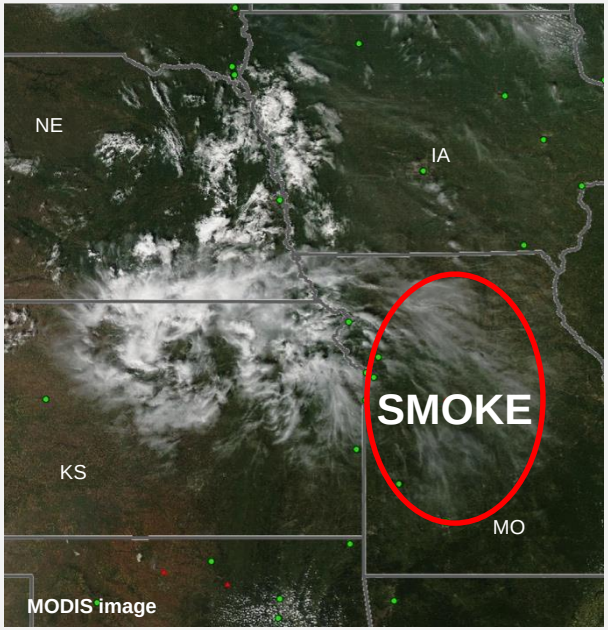
Improving Air Quality Maps with Satellite Data PI Phil Dickerson, EPA

GROUND-BASED + SATELLITE COVERAGE OF AIR QUALITY



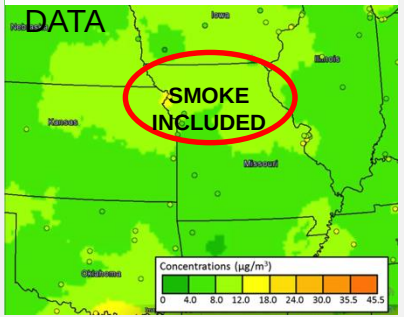
Green = ground-based $PM_{2.5}$
Blue = AirNow Satellite-based $PM_{2.5}$
White = no coverage

Northern Missouri fires - Sept. 4, 2013



PM2.5 FROM GROUND BASED DATA

PM2.5 GROUND+SATELLITE DATA

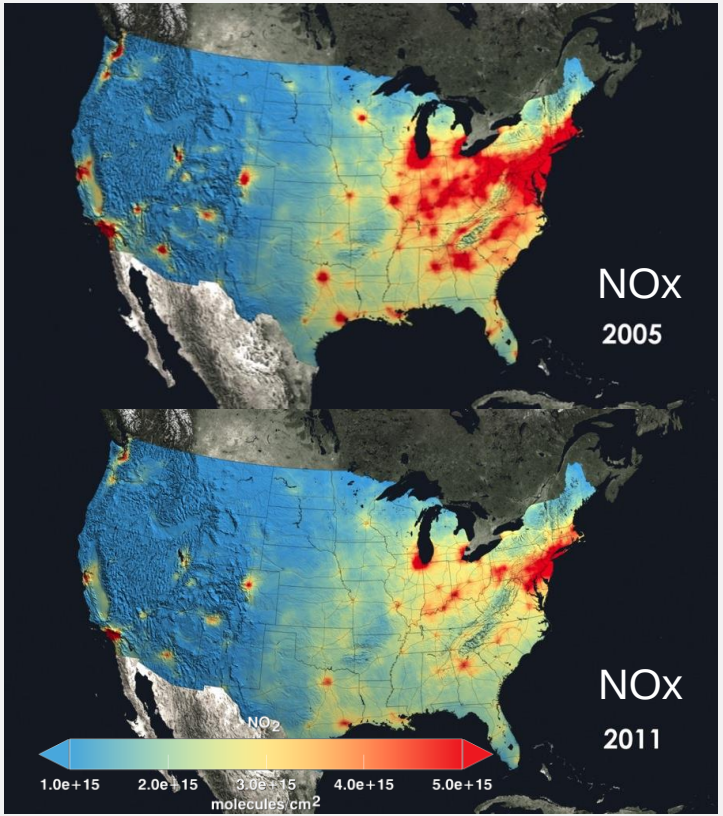


"This is the best tool I have seen so far that integrates satellite data with information from ground monitors."
Cassie McMahon, Minnesota Pollution Control Agency

NASA *Aura* OMI Shows NO_2 Air Quality is Improving

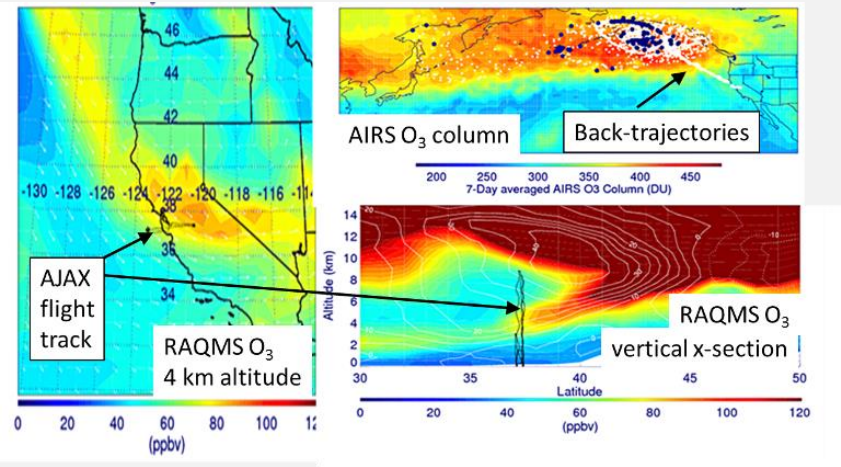
- OMI data show a 30-40% decrease in the pollutant Nitrogen Dioxide from 2005-2011
- The NO_2 decrease is due to emission control devices on coal-burning power plants and more fuel-efficient cars
- NASA Air Quality Applied Sciences Team (AQAST) members facilitate use of satellite data

On April 12, 2016, President Obama used OMI NO_2 data to explain how pollution affects our planet: https://www.youtube.com/watch?v=LKe5FdKInJs



AQAST: Wyoming Exceptional Event Demonstration

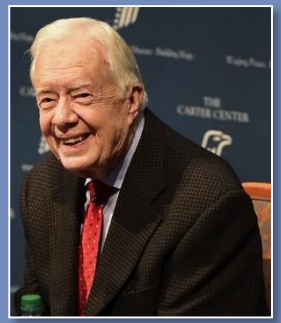
- Wyoming DEQ/AQD used Real-time Air Quality Modeling System (RAQMS) to issue an exceptional event demonstration package to the EPA
- June 6, 2012: Ozone exceedance at Thunder Basin
- This ozone stratospheric intrusion event was documented by the NASA Ames Alpha Jet Atmospheric eXperiment (AJAX)



DEVELOP Student Training National Program: The Partnership with the Carter Center

- President Carter contacted Administrator Bolden Spring 2015
  - Request NASA's help in locating Yanomami villages in the Amazon to support The Carter Center's *oncherciasis* ("river blindness") eradication efforts
- DEVELOP 2015 project found evidence of 167 potential villages
- The Carter Center will use these tools in their work to eradicate river blindness

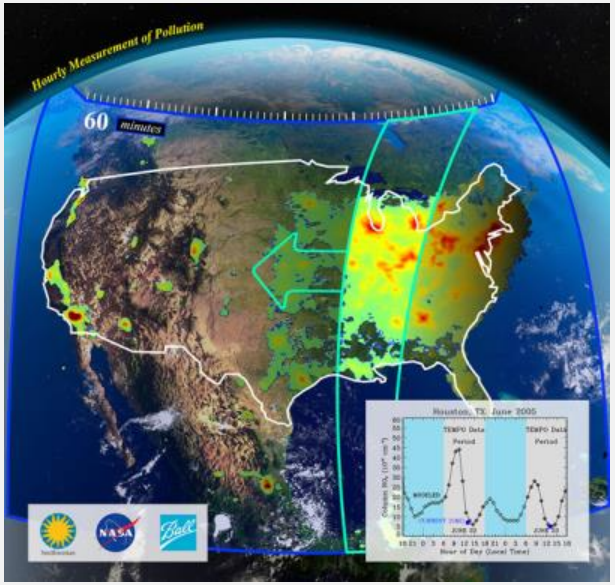
Commercial imagery of potential Yanomami village



During a 20 August 2015 press conference, President Carter remarked that eradicating of river blindness in the Americas is one of his top priorities before stepping down from The Carter Center

Earth Venture Instrument -1
Tropospheric Emissions: monitoring Pollution (TEMPO)

- TEMPO is a pathfinder to using hosted commercial payloads from GEO
- Tropospheric pollution observations from Geostationary orbit
  - Ozone, NO_2, and CH_2O
  - Forms a global Air Quality constellation in GEO with EU Sentinel 4 and Korean GEMS
- EPA and NOAA are part of the science team
- Instrument delivery in 2017; Launch NLT 2021



PI: Kelly Chance, Smithsonian Astrophysical Observatory
PE: Betsy Edwards; **PS:** Barry Lefer
Instrument Development: Ball Aerospace
Project Management: LaRC
RY$: 93.2M
Orbit requirements: ***Geostationary Orbit.*** Hosted on a commercial communication satellite

National Aeronautics and
Space Administration

Questions:

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Health & Air Quality Applications

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