NASA Health and Air Quality Applications: The Intersection with Water Quality

John A. Haynes, MS
Program Manager, Health and Air Quality

Applied Sciences Program
Earth Science Division
Science Mission Directorate
NASA
Washington, DC USA

jhaynes@nasa.gov
NASA Earth Science: Current Operating Missions
Launch of GPM on February 28, 2014, from Tanegashima Space Center, Japan.
Launch of SMAP on January 31, 2015, from VAFB.
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.
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
Why Health & Air Quality?

Potential Health Effects of Climate Variability and Change

CLIMATE CHANGE (Natural and Human-Caused)
- Regional Weather Changes
  - Extreme Heat Waves
  - Extreme Weather
  - Temperature
  - Precipitation

Air Pollution Levels
- Contamination Pathways
- Transmission Dynamics

Moderating Influences
- Heat-related Illnesses and Deaths
- Extreme Weather Events
- Related Health Effects
- Air Pollution-related Health Effects
- Water- and Food-borne Diseases
- Vector- and Rodent-borne Diseases

Research

Adaptation Measures

Source: GEO, 2003
Global Emerging Diseases

★ ZOONOTIC
★ VECTOR-BORNE

* 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.
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.
Enhanced Oil Spill Detection

PI: Sonia Gallegos, Ph.D., SSC
Collaborators: NOAA, NRL

- **Goal:** Develop an algorithm to identify thick oil in MODIS non-glinted satellite imagery.
- **Data Used:** MODIS-Aqua NIR/FIR imagery, and *in-situ* measurements collected during DWAS oil spill.
- **Methods:** 1) Separate oil pixels from low-level cloud pixels using VIS/FIR channels, 2) Identify oil pixels by spectral thresholds, 3) Test other methods.
- **Validate** algorithm with NOAA products and *in-situ* data.

**Accomplishments**
- Continued efforts to remove the noise in the texture algorithm resulting from high loads of sediment in the coastal areas.
- Completed developing the ensemble model set across the 412nm to 2130nm range to extend detection of dispersed oil.
- Completed the analyses for single channel data in the ensemble model.
- Completed the analyses for the slope of two bands in the ensemble model.
- MODIS products were computed for NW Australia for the period from 2002 until 2009 to help develop techniques to enhance detection of oil slicks in sediment-rich coastal waters.
Sargassum Early Advisory System App

PI: Tom Linton, Ph.D., TAMU-Galveston
Collaborators: SSC, NRL

- **Goal:** Automate the process of providing Sargassum landing alerts to coastal stakeholders
- **Data Used:** Landsat-7 and -8, HYCOM, and buoy data
- **Methods:** 1) Automate detection of Sargassum in satellite imagery, 2) Use ocean circulation and wind data to forecast landings, 3) Provide landing alerts via app, email and/or SMS
- **Validate** predictions with observations from coastal managers.

**Accomplishments**

- SSC and TAMU-Galveston organized and hosted the 2015 Sargassum Symposium held in Galveston, TX on April 2-3, 2015.
- Released version 1.1 of the Sargassum web application that featured refinements to the forecasting engine and the Sargassum identification algorithm.
- Began testing an approach to automate the retrieval of Landsat images from the DAAC.
- NRL delivered another version of the Landsat-8 Sargassum detection algorithm.
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, PLoS ONE)

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. 2014).

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).

Email from Ohio EPA, 04 Aug 2014

“[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.”

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.

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
Glenn Research Center’s Twin Otter continued to make ~weekly flights over Lake Erie to study algae concentrations and their contributions to Harmful Algal Blooms that may affect drinking water quality and availability. Additional coverage included Ohio River, etc. where significant blooms occurred.

- Total flight hours accrued: 80 hours
- All instruments & systems have functioned properly

Relevant MODIS and LANDSAT satellite data were referenced and in-situ calibration were collected on ground and water by partners: Michigan Tech Research Institute, NOAA, University of Toledo, Kent State University, Bowling Green State University, Ohio State University, and University of Cincinnati, with calibration support from MSFC and South Dakota State Univ.

Data have been shared within 2 business days with regional entities and archived for public access.

- Coordinated a coincidental flight with the NOAA hyperspectral sensor flight
- NASA Flights are now put on standby as the blooms subside
- First campaign data workshop November 12-13 @ Lake Erie Center, Oregon, Ohio
- Draft of first NASA TM scheduled for February 2016

Severe blooms in Ohio River this year

Collaborate with University of Cincinnati to develop algorithm
Cyanobacteria Assessment Network (CyAN)

- Five year consortium of NASA, EPA, USGS, and NOAA.
- Create a uniform and systematic approach for identifying cyanobacteria blooms through remote sensing across the CONUS.
- Estimate exposure and human health effects in drinking and recreational waters.
- Assess behavioral responses and economic value of the early warning system.
- Utilize data from Landsat, Sentinel 2, Sentinel 3, NPP/VIIRS, and MODIS.
- POC: Blake Schaeffer, EPA
Prototype Model for Improved Forecasts of Respiratory Illness Hazard from GOM Red Tide
PI: Richard Stumpf, NOAA

- Visual products of potential risk provided routinely to the CO-OPS forecasters
- Python, JavaScript and Google Maps uses basis forecast analysis
- Report respiratory forecast each beach every day on FL Gulf Coast
- Satellite based assessment for offshore exposure (MODIS/VIIRS ocean color)
- Forecasts disseminated:
  - NOAA HAB Operational Forecast System
  - Motes Marine Lab Beach Conditions Reporting System® (BCRS)
  - NWS Beach Hazards site

Prototype forecast tool combining NDFD wind with *K. brevis* cell concentrations. Shapefiles allow selection of information at individual points or regions.
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.

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.”
Cholera Prediction Model

Epidemic Cholera
- Sporadic outbreak
- Usually occurs following floods or inundation of large landscapes
- Warm temperatures may increase growth of bacteria in aquatic bodies.

Mixed-mode Cholera
- Usually two seasonal peaks
- One peak related to seawater intrusion; Second peak associated with widespread inundation
- Specific to Bengal Delta region

Endemic Cholera
- Cholera persists throughout year in coastal regions
- Seawater Intrusion from coasts to inland
- Cholera outbreaks occur during low river flow season

Background image: Bangladesh and Bay of Bengal

Jutla et al., 2015 (AJTMH-Accepted)
Publicly Available Modules
Case Studies
Water Resources Training also available!

Upcoming trainings

ARSET: Air Quality

The goal of the NASA Applied Remote Sensing Education and Training (ARSET) air quality project is to increase the utility of NASA earth science and model data for policy makers, regulatory agencies, and other applied science professionals in the area of air quality applications. The two main activities of this project are:

- Provide in-person and on-line courses, workshops and other capacity building activities throughout the year.
- Disseminate via this web page course materials and other information to enable training in applied air quality remote sensing.

Project courses are a combination of lectures and computer hands-on activities that teach professionals how to access, interpret, and apply NASA aerosol and trace gas data at regional and global scales with an emphasis on case studies. Course topics include:

- Case Studies in air quality analysis tailored to end-user needs, such as urban air pollution, dust, and fires.
- Satellite aerosol and trace gas products, their application and relationship to in-situ monitor data.

Upcoming trainings also available!
Questions:
John Haynes, Program Manager
Health & Air Quality Applications
NASA Headquarters / Earth Science
JHaynes@nasa.gov

http://AppliedSciences.NASA.gov