Geospatial Monitoring of the SDGs

Sharing experiences on indicator 6.6.1 on freshwater related ecosystems, and exploring opportunities for better monitoring of the land-water-ocean nexus

INEGI Dirección Regional Centro
November 27, 2017

Dr. Argyro Kavvada,
NASA – BAH &
EO4SDG Exec. Sec.

UN-GGIM
UNITED NATIONS INITIATIVE ON GLOBAL GEOSPATIAL INFORMATION MANAGEMENT

GEO GROUP ON EARTH OBSERVATIONS

UN environment

INEGI
INSTITUTO NACIONAL DE ESTADÍSTICA Y GEOGRAFÍA

THE GLOBAL GOALS
For Sustainable Development

Social

Environmental

Economic

Everything happens somewhere.

- Nancy Tosta

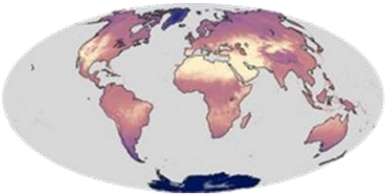
You manage what you measure.

- A. Nonymous

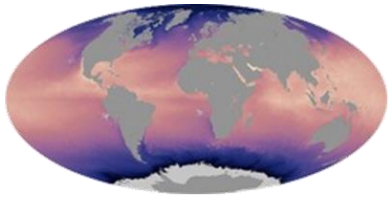
Outline

- The role of Earth observation and geospatial data in SDG monitoring
- NASA-UMD Pilot Effort for indicator 6.6.1
- Examples of use of Earth observations for monitoring water related ecosystems in the US
- Conclusions

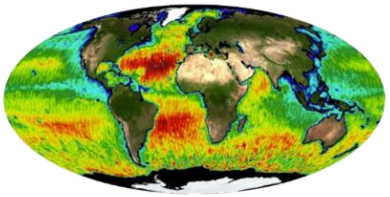
Some types of Earth observations . . .



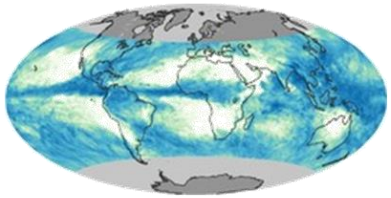
Land Temperature



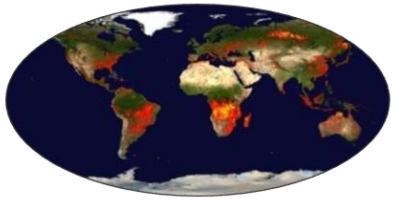
Sea Surface Temperature



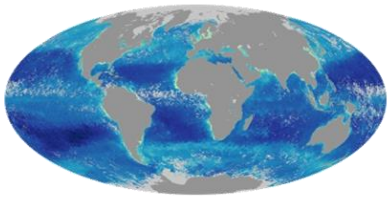
Sea Surface Salinity



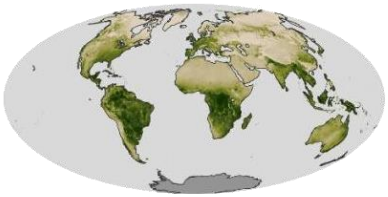
Total Rainfall



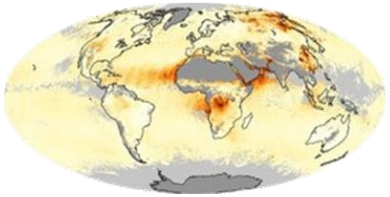
Fires & Thermal Anomalies



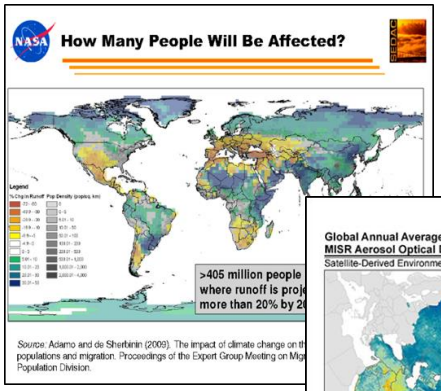
Chlorophyll

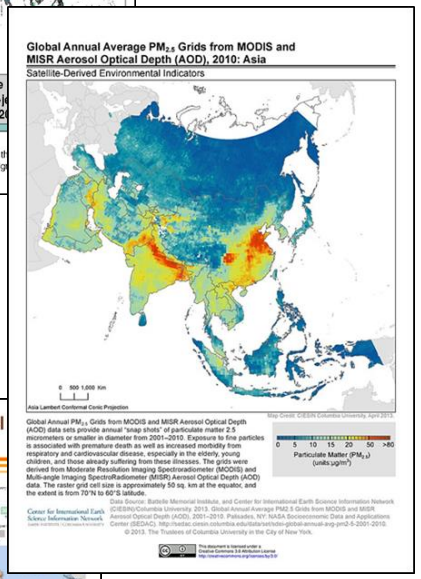


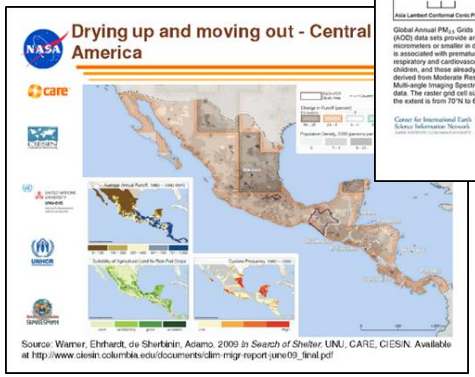
Vegetation



Aerosols







… data models that use gridded population data

Source: CIESIN Columbia University.

GROUP ON EARTH OBSERVATIONS

EO4SDG

Alignments of the Goals with specific types of Earth observations and geospatial information

Sustainable Development Goals

Earth Observations in Service of the *Agenda 2030*

Target — *Contribute to progress on the Target yet not the Indicator per se*								*Goal*	*Indicator* — *Direct measure or indirect support*				
						1.4	1.5	1	1.4.2				
					2.3	2.4	2.c	2	2.4.1				
				3.3	3.4	3.9	3.d	3	3.9.1				
								4					
							5.a	5	5.a.1				
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1
					7.2	7.3	7.a	7.b	7	7.1.1				
								8.4	8					
					9.1	9.4	9.5	9.a	9	9.1.1	9.4.1			
						10.6	10.7	10.a	10					
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1
				12.2	12.4	12.8	12.a	12.b	12	12.a.1				
					13.1	13.2	13.3	13.b	13	13.1.1				
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14	14.3.1	14.4.1	14.5.1		
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2
								16.8	16					
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17	17.6.1	17.18.1			

Alignment of Earth Obs. and GEO to the Goals, Targets, and Indicators

SDGs with most opportunities:

Earth Observations & Water

Potential Applications

- Drought & Food security
- Flood Warning & Mapping
- Water Allocation Planning
- Reservoir Operations
- Irrigation Water Management
- Crop Production
- Managed Aquifer Recharge
- Water Quality
- Land Use Planning and Policy
- …

Hydropower

Water, Environment, and Climate Change

Sanitation and Hygiene

Agricultural Water management

Water Supply

Credit: Noosha Tayebi, WBG

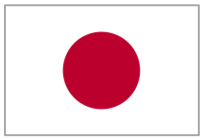
EO4SDG

EARTH OBSERVATIONS FOR THE SUSTAINABLE DEVELOPMENT GOALS

Initiative Co-Chairs

Eduardo De La Torre
Mexico/INEGI

Chu Ishida
Japan/JAXA



Lawrence Friedl
USA/NASA

Executive Secretary

Argyro Kavvada
USA/NASA-BAH

GROUP ON EARTH OBSERVATIONS

EARTH OBSERVATIONS FOR THE SUSTAINABLE DEVELOPMENT GOALS

EO4SDG Initiative: http://eo4sdg.org

Earth Observations in Service of the 2030 Agenda

Initiative Purpose:

Organize and realize the potential of Earth observations and geospatial information to advance the *2030 Agenda* and enable societal benefits through achievement of the SDGs.

Key Emphasis:

Collaborations with statistical community, national statistical offices, line ministries, custodian agencies. Also, communication role in federated approach to GEO community

- Projects
  Develop, validate and deploy uses of Earth observations to support SDG tracking and reporting
- Capacity Building
  Build skills for accessing and applying Earth observations data
- Data and Information Products
  Advance discoverability and accessibility of products
- Outreach and Engagement
  Promote the consideration and adoption of Earth obs. for the SDGs

Outline

- The role of Earth observation and geospatial data in SDG monitoring
- **NASA-UMD Pilot Effort for indicator 6.6.1**
- Examples of use of Earth observations for monitoring water related ecosystems in the US
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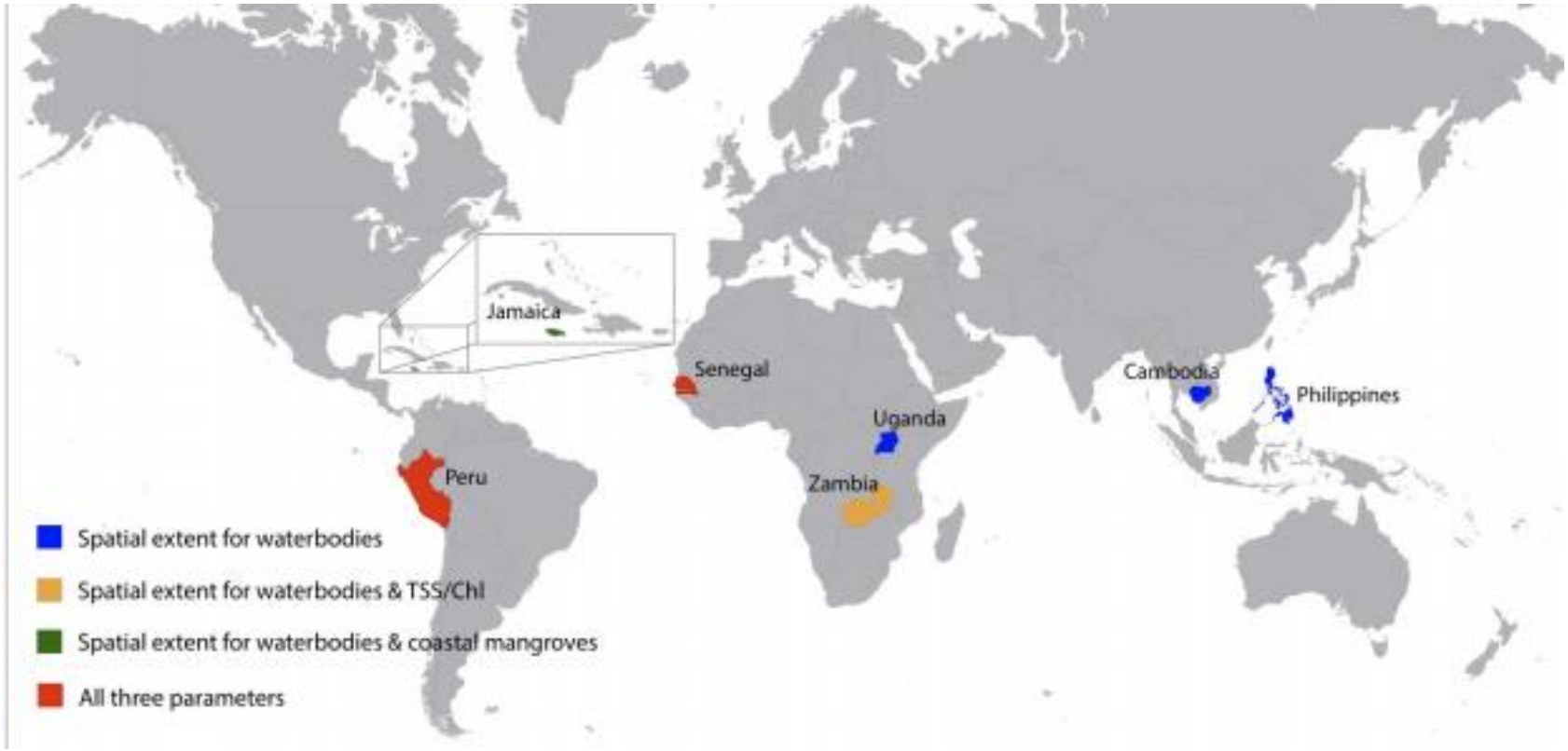
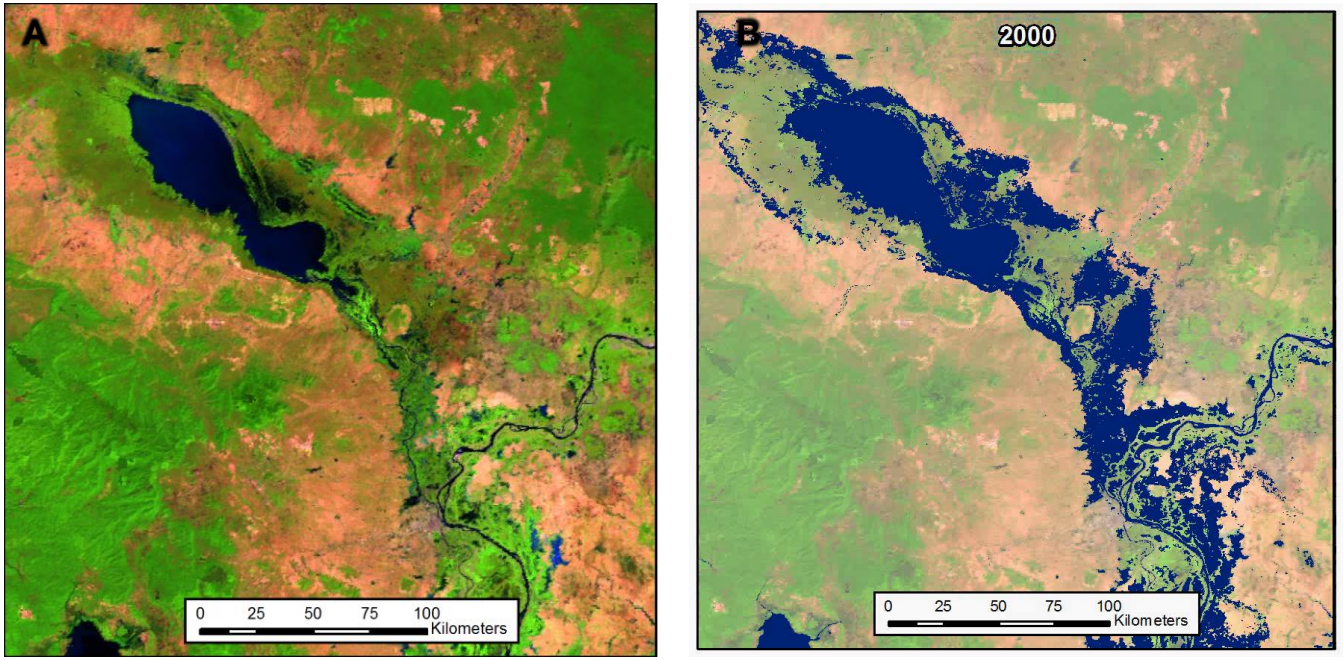
Piloting the Use of Earth Observations for Monitoring Extent of Water-Related Ecosystems



Water Ecosystem Measured	Sub-indicators Measured	Datasets	Spatial Resolution (m)
Open water	Spatial extent	MOD44W C6.1*	250
Open water	Spatial extent	Landsat-5, 7, and 8*†	30
Lakes & reservoir	TSS and Chlorophyll	Landsat-8*† and Sentinel-2A‡	20-30
Wetlands (coastal mangroves)	Spatial extent	Landsat 8 OLI*†, Sentinel-1C‡, SRTM*	30

*National Aeronautics and Space Administration (NASA) †US Geological Survey (USGS) ‡European Space Agency (ESA)

MEASURING SURFACE WATER WITH MODERATE RESOLUTION RASTER MAPS
TONLE SAP, CAMBODIA
ANNUAL VARIATION

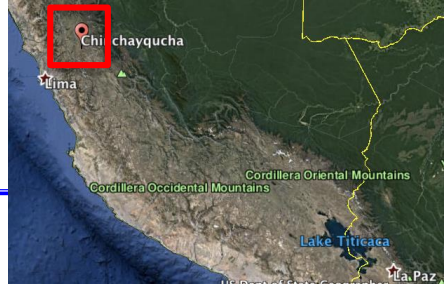


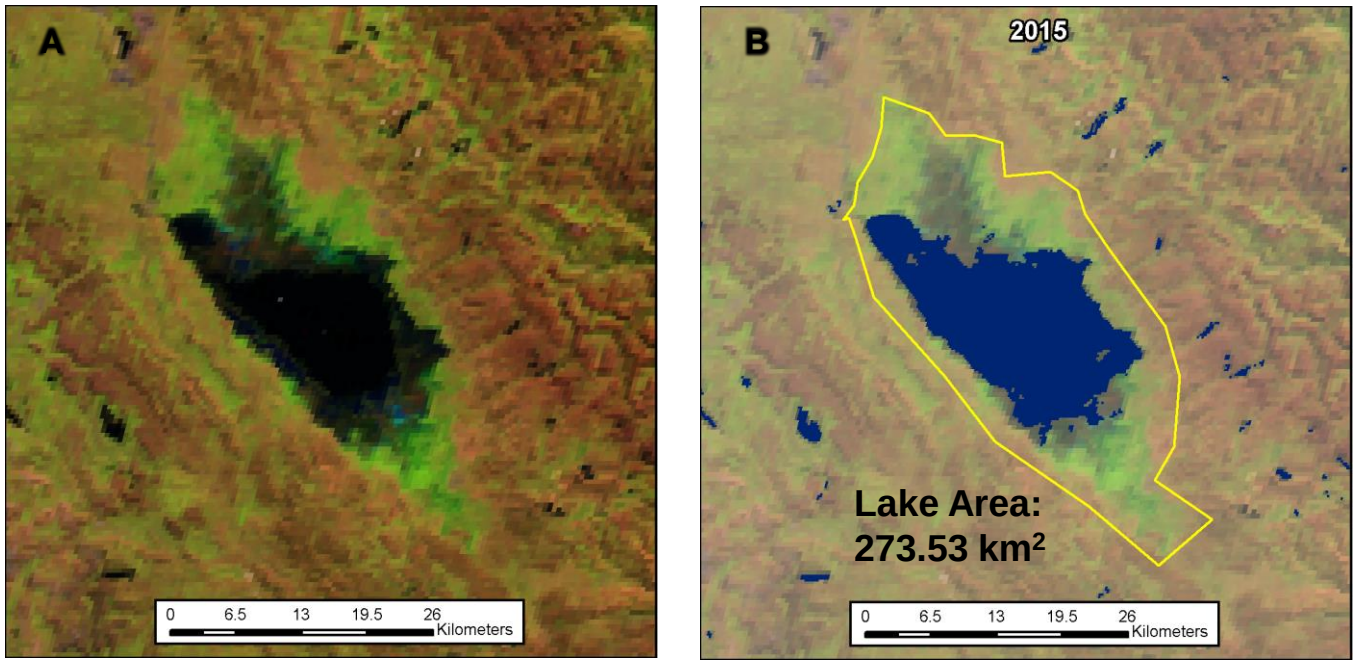
A) False color composite (6-2-1) MODIS surface reflectance image (MOD09A1) of the Tonle Sap Lake and Lower Mekong River in Cambodia. Imagery is an 8-day composite collected from a period beginning on 1/17/13. B) Animation of annual water dataset, MOD44W C6.1 (Carroll et al., 2017), overlain in blue, showing measured spatial extent of open water for the years 2000-2015.

MOD09A1 citation: Vermote, E., et al., 2015, MOD09A1: MODIS/Terra Surface Reflectance 8-Day L3 Global 500m SIN. Version 6. NASA EOSDIS Land Processes DAAC, USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota (https://lpdaac.usgs.gov), accessed 06 23, 2017, at http://dx.doi.org/10.5067/MODIS/MOD09A1.006

Chinchaycocha, Peru

Water body area extraction by polygon





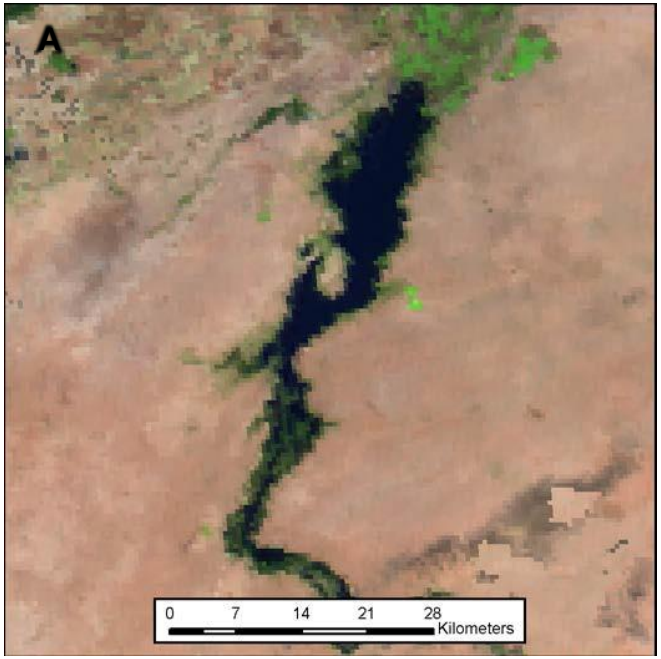
A) False color composite (6-2-1) MODIS surface reflectance image (MOD09A1) of Chinchaycocha, Peru. Imagery is an 8-day composite collected from a period beginning on 6/26/15. B) The area value shown corresponds to the area of water inside the polygon displayed in yellow.

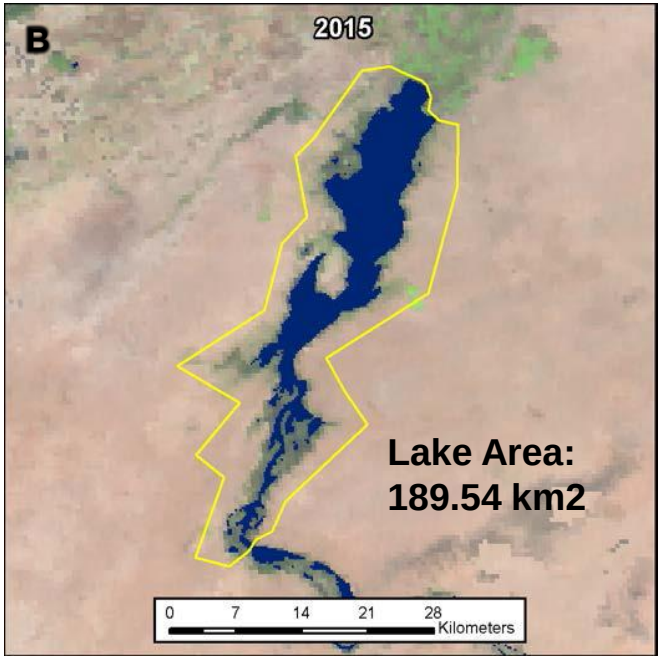
B) Note: Polygon was drawn arbitrarily as a demonstration of potential.

MOD09A1 citation: Vermote, E., et al., 2015, MOD09A1: MODIS/Terra Surface Reflectance 8-Day L3 Global 500m SIN. Version 6. NASA EOSDIS Land Processes DAAC, USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota (https://lpdaac.usgs.gov), accessed 06 23, 2017, at http://dx.doi.org/10.5067/MODIS/MOD09A1.006

Lac De Guiers, Senegal

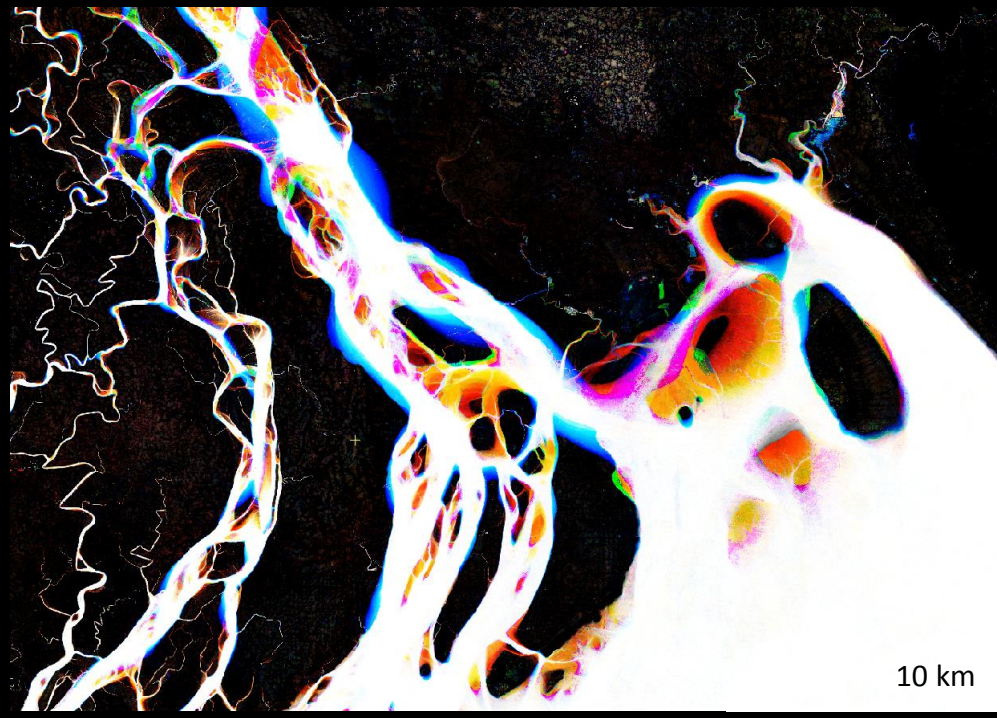
Water Body Area Extraction by polygon





A) False color composite (6-2-1) MODIS surface reflectance image (MOD09A1) of Lac de Guiers, Senegal. Imagery is an 8-day composite collected from a period beginning on 2/2/15. B) The annual water dataset, MOD44W C6.0 (Carroll et al., 2017), overlain in blue, showing measured spatial extent of open water for the year 2015. The area value shown corresponds to the total area of water inside the polygon displayed in yellow. **Note: Polygon was drawn arbitrarily as a demonstration of potential.**

Global surface water change: Landsat 5, 7, 8
Bay of Bengal, Bangladesh



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Google
GLAD
GLOBAL LAND ANALYSIS & DISCOVERY

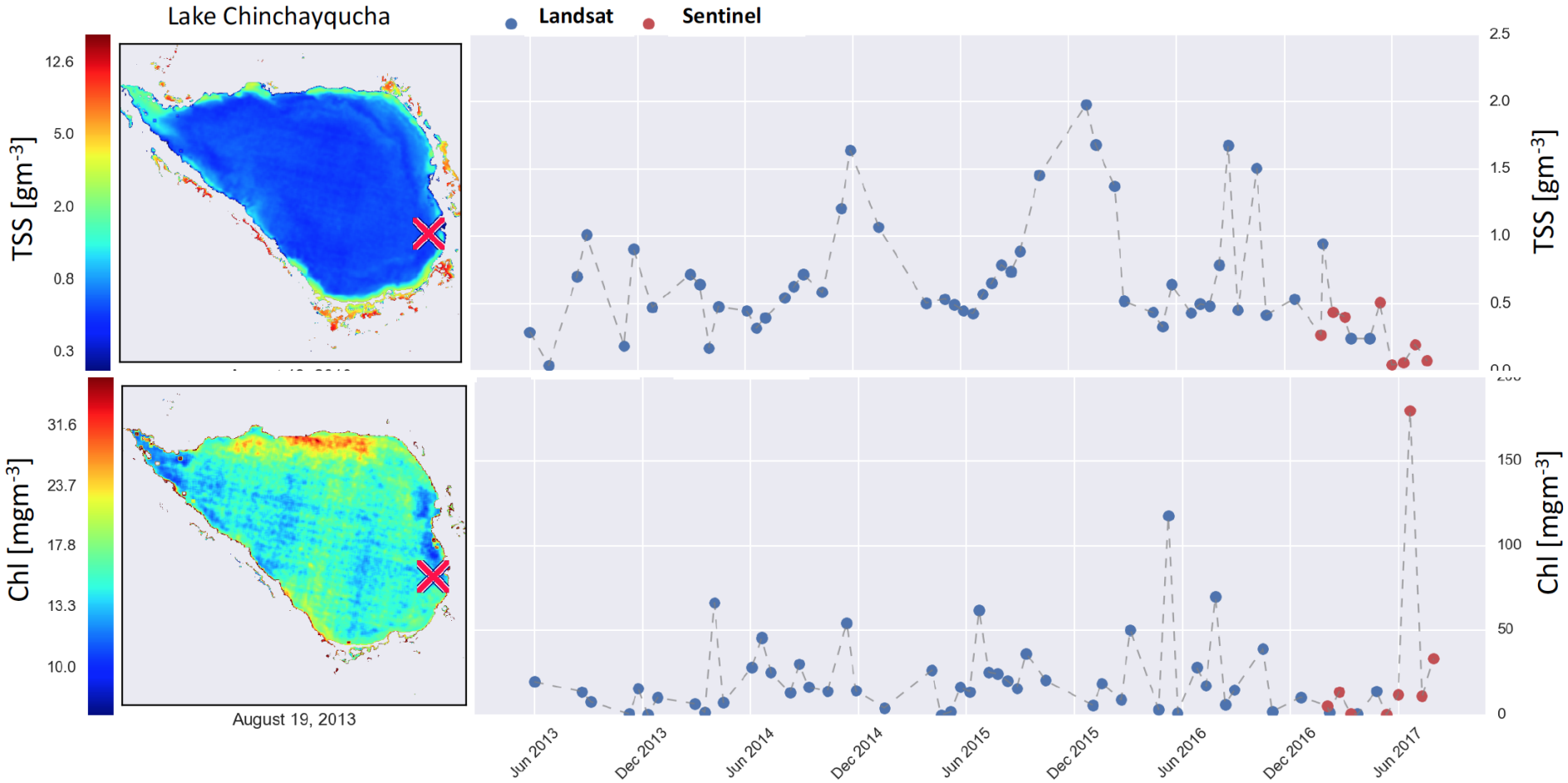
Surface water change
2000-2015

water to land
land to water
temporary land
temporary water

NASA

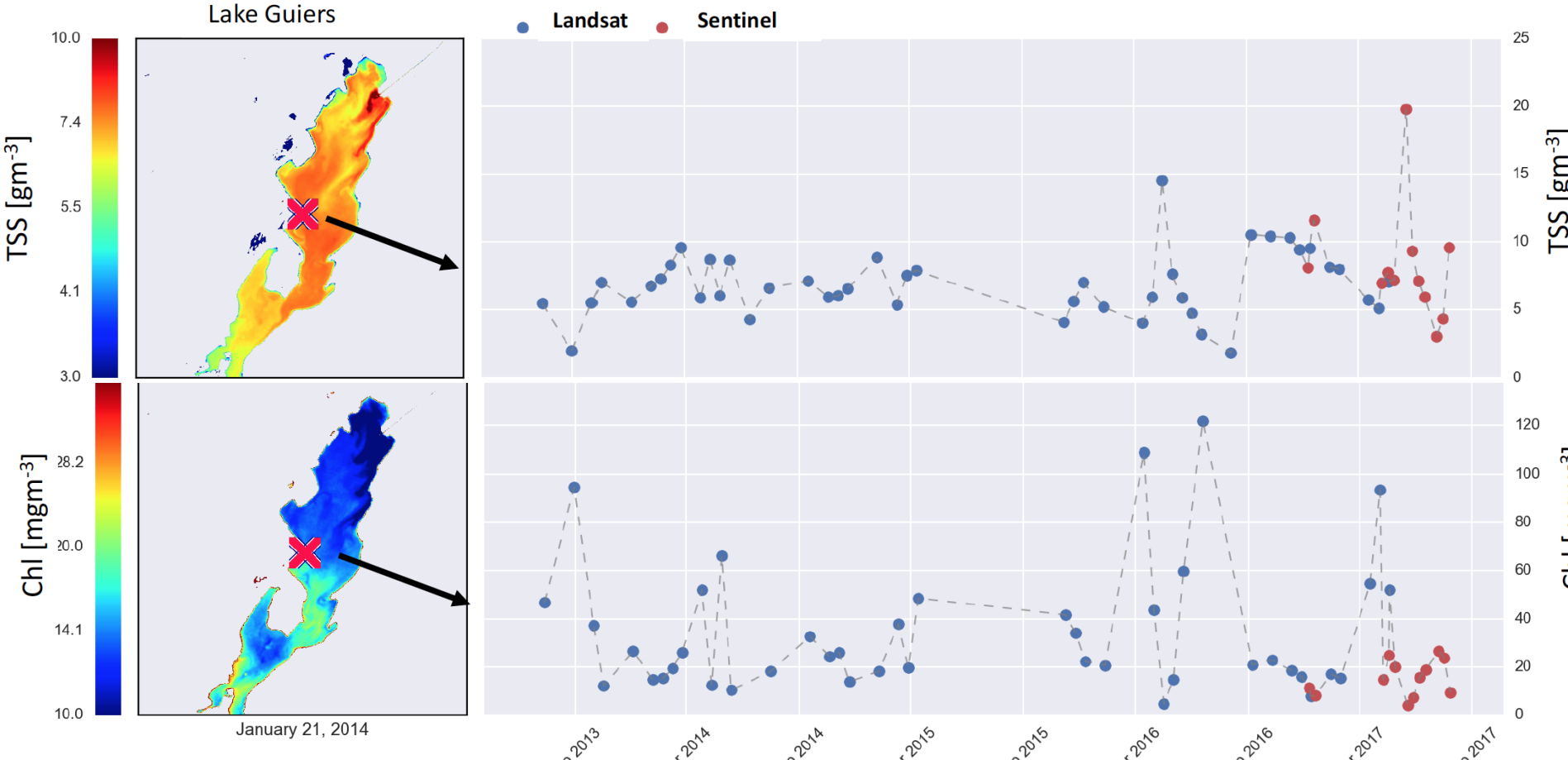
Time-series Analyses of Water Quality (WQ) Indicators

Lake Chinchayqucha – Peru



Time-series Analyses of Water Quality (WQ) Indicators

Lake Guiers – Senegal



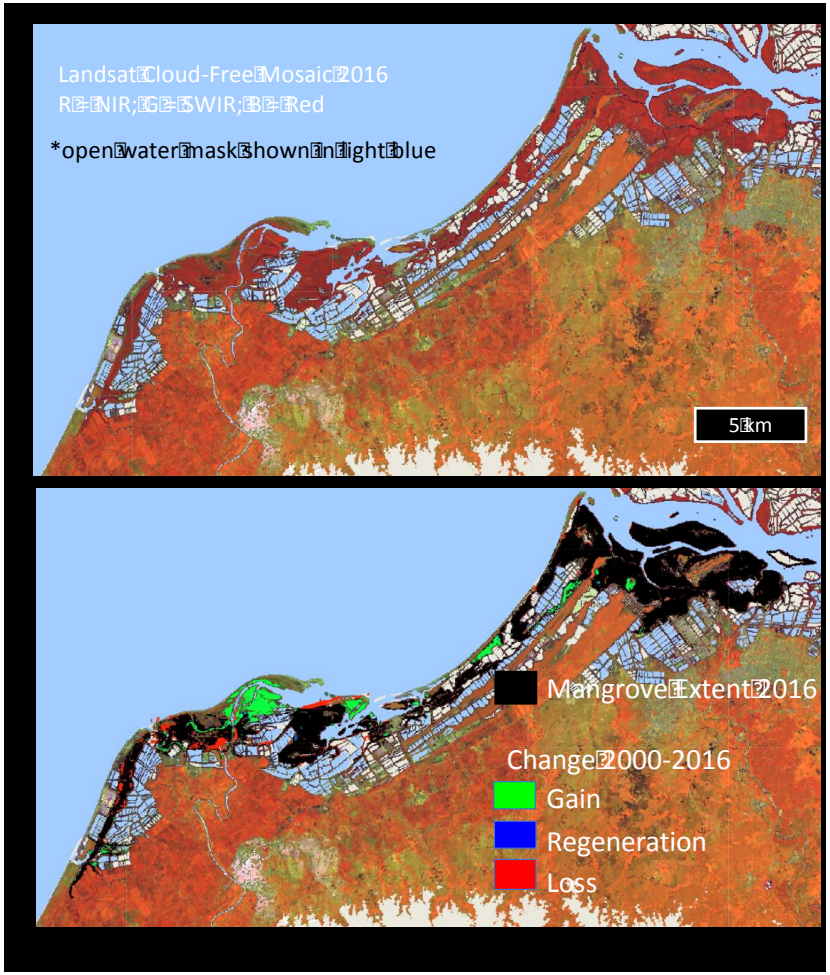
Coastal mangroves mapping: Landsat, Sentinel, SRTM

- An annual mosaic of cloud-free imagery from the Landsat 8 OLI was combined with spectral indices, radar backscatter from Sentinel 1, and elevation to semi-automatically detect the extent of mangrove wetlands.
- An additional analysis, using the Landsat imagery archive, can be used to detect areas of gain, loss, and regeneration in the mangrove ecosystems.
- The methods used capitalize on open-access imagery and open-source mapping tools (Google Earth Engine) to process large amounts of geospatial data (including satellite data).
- The mangrove extent dataset provides an average annual land cover information at a 30m x 30m resolution - can be sampled using geographic boundary files to determine country and district-wide extent estimates.
- The mangrove change dataset provides information on the long-term trends in mangrove change, where areas of excessive gain or excessive loss can be useful in determining key locations for future sustainable development projects.

Credit: *Lola Fatoyinbo, David Lagomasino*

Coastal mangroves mapping: Landsat, Sentinel, SRTM

Tumbes District, Peru



Summary

- NASA-UMD scientists quantified the spatial extent of open waterbodies, including coastal mangroves, for a group of pilot countries, and provided a proof of concept for the extraction of water quality indicators for select large open waterbodies.
- Opportunities: All of the Earth observation datasets that were used are of global coverage and freely available, making them a particularly attractive option for data-scarce regions.
- The availability of high-quality, relatively frequent satellite products together with existing algorithm/methodologies and validation using in-situ and ground based data enables reporting on relative changes from baseline values over time in a more systematic manner.
- This pilot effort does not intend to replace the country-owned process of SDG data collection and submission; rather, this initiative explores the applicability of Earth observation data to complement country-generated data.
- Challenges: All datasets will not have the same use everywhere, algorithms are not all operational, need country-specific information.

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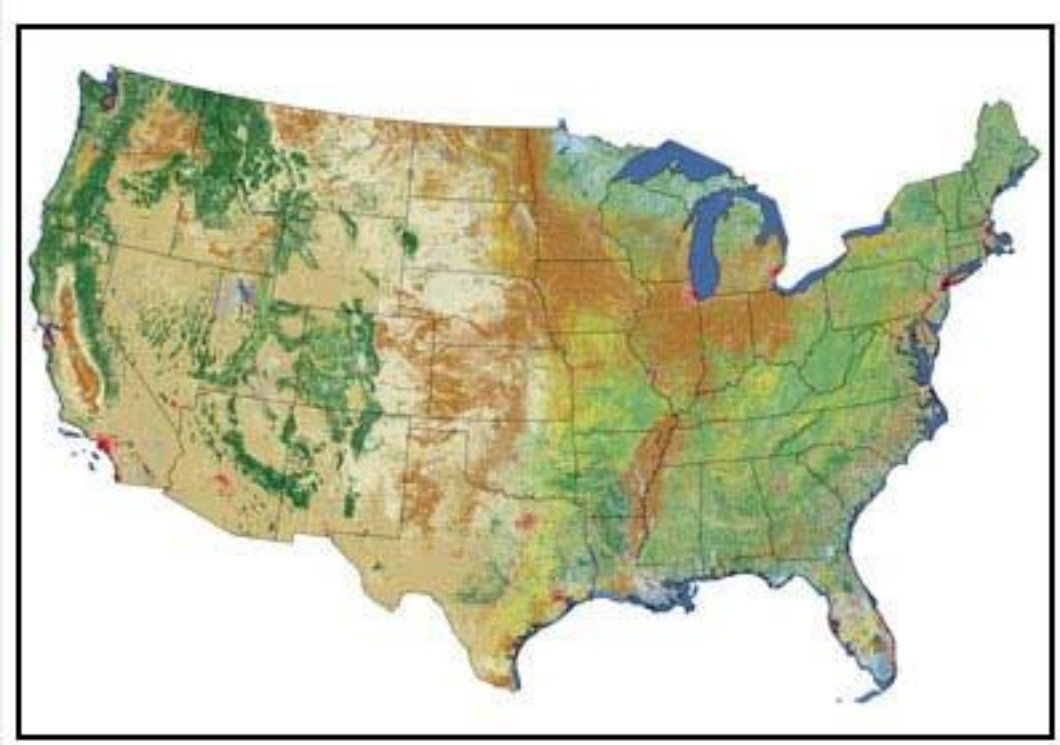
National Online Platform for the SDGs

sdg.data.gov

- Support Federal Interagency Working Group on Sustainable Development Goals Data (IWG-SDG Data) established by the Office of Management and Budget (OMB)

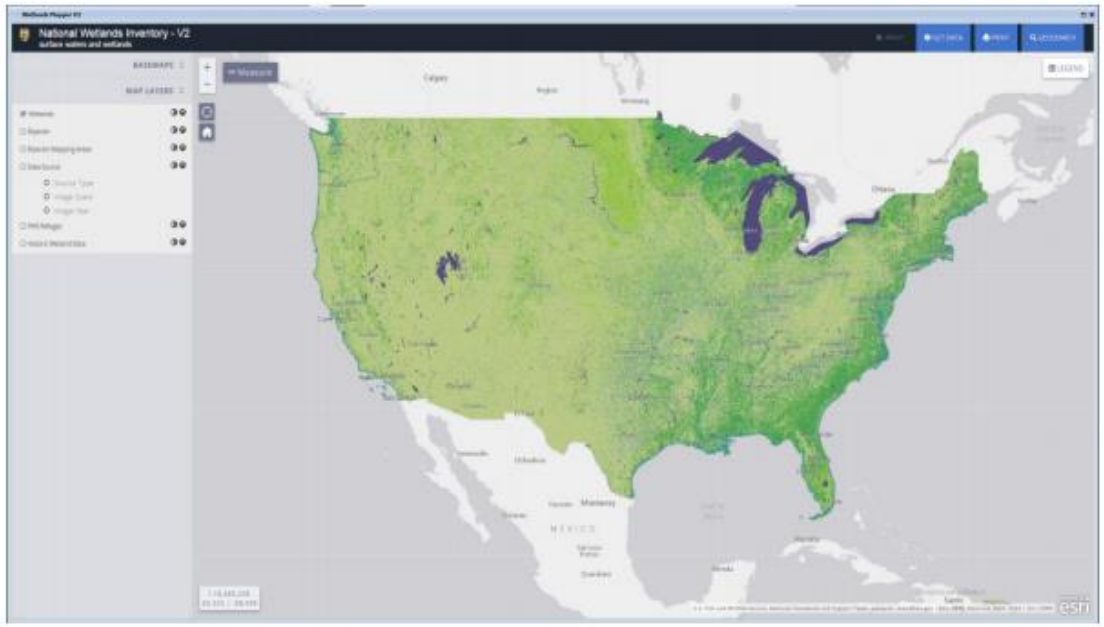
- The mission of the IWG-SDG Data is to advise OMB on 1) the quality of global, regional, and national statistical indicators and associated metadata; and 2) available national data sources that may be suitable for use in reporting of official national statistics for measuring the SDGs.

The National Land Cover Database (NLCD)



- NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of Federal agencies led by USGS
- NLCD supports a wide variety of Federal, State, local, and nongovernmental applications that seek to assess ecosystem health, understand the spatial patterns of biodiversity, predict climate change effects, and develop land management policy.

The US Fish and Wildlife Service (FWS) Wetlands Mapper



- The FWS's objective of mapping wetlands and deepwater habitats is to produce information on the location, type and size of these resources.

- The maps are prepared from the analysis of high altitude imagery.

- The Wetlands Mapper is a direct response to the need to integrate digital map data with other resource information to produce timely and relevant management and decision support tools.

Users of the mapper have seamless access to a suite of base map information including ESRI Maps and imagery, Open Street Map, National Geographic, USGS Topographical maps and the USGS National Ma

Utilizing Earth Observations to Monitor Marsh Health in the Chesapeake Bay to Support the Maryland Department of Natural Resources Coastal Resiliency Assessment

Term: Summer 2017

Project Partners: Maryland Department of Natural Resources and The Nature Conservancy (TNC)

Earth Observations: Landsat 5, TM Landsat 7, ETM+ Landsat 8, OLI Sentinel-2, MSI

Methods: Analyzed trends in marsh health on the Maryland coast of the Chesapeake Bay from 1984 - 2017 and to forecast changes in marsh health from 2017 – 2030. A change detection algorithm was used to detect changes in marsh elevation and location of high marsh and low marsh over the study period.

Results: The Maryland Department of Natural Resources and TNC will use these results to supplement their Coastal Resiliency Assessment and develop more informed decision-making plans regarding restoration and conservation in the Chesapeake Bay.

Conclusions

- Earth observations and geospatial information can compliment country generated statistics, facilitating the sustained monitoring of progress on the SDGs, and national priorities, over time

- The availability of high quality, relatively frequent satellite products together with existing algorithm / methodologies and validation using in-situ and ground based data enables reporting on relative changes from baseline values over time in a more consistent and systematic way

- Strengthening of institutional capacities and inter-institutional coordination is fundamental for achievement of the SDGs

- For a more robust use of Earth observations and geospatial data for the SDGs, a close collaboration between the EO /GI community, the national statistical offices, and other national, sub-national and regional authorities is needed.

- Effective Partnerships with the private and academic sectors, non-governmental institutions and civil society, and the development community is essential to help enhance our responsiveness to country needs, scale up efforts, and address issues of data disaggregation, meeting the ‘Leave No One Behind’ core principle of the 2030 Agenda.

Extra Slides

Measuring Surface Water with Moderate Resolution Raster Maps

- Data from the MODerate Spatial Resolution Imaging Spectrometer (MODIS), on board NASA's Terra satellite, was gathered for each year and processed to automatically classify water
  - The algorithm was originally described in Carroll et al. (2009):

  Carroll, M.L., Townshend, J.R., DiMiceli, C.M., Noojipady, P., & Sohlberg, R.A. (2009). A new global raster water mask at 250 m resolution. International Journal of Digital Earth, 2, 291-308
- The resulting **annual** datasets depict **normal surface water** extent for that entire year
- Only open water can be detected with this method – emergent vegetation is often not detected
- The dataset covers all global land masses, with the exception of Antarctica, for the years 2000 through 2015

Credit: *Alfred Hubbard, Mark Carroll, Frederick Policelli*

30m maps of inter-annual and seasonal surface water dynamics

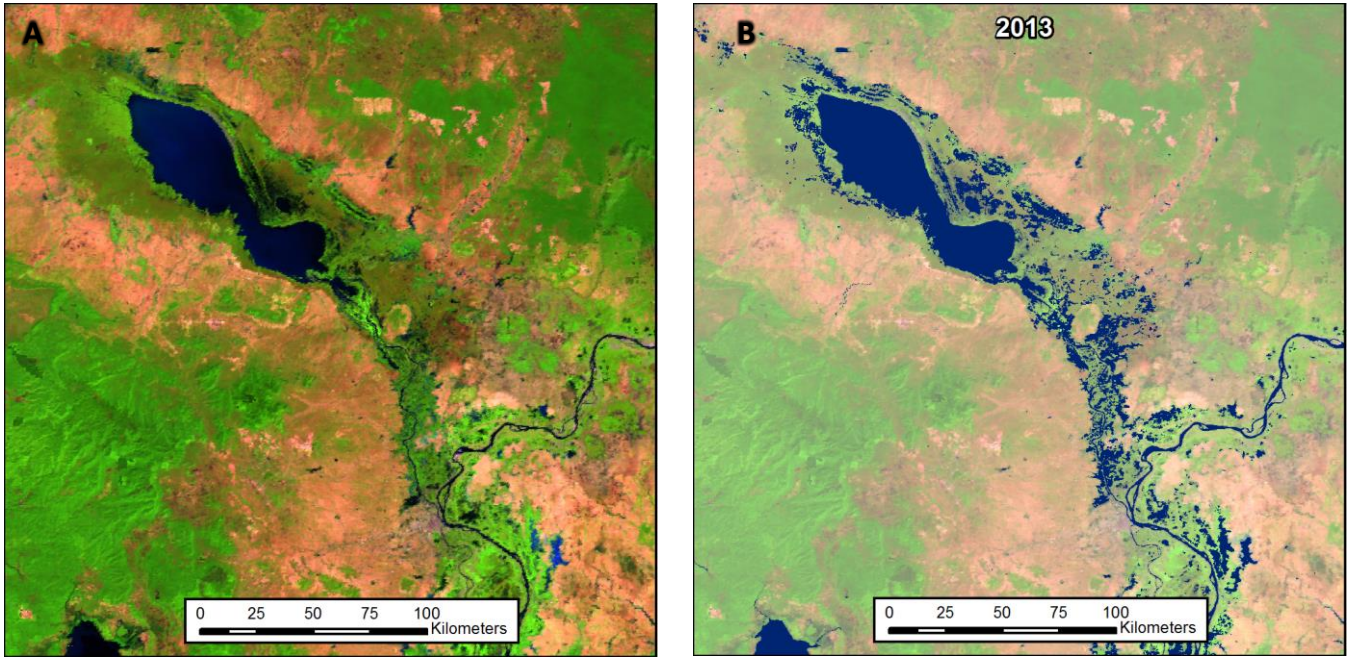
UNIVERSITY OF MARYLAND

- The GLAD team at the University of Maryland and its partners have created global maps of surface water change from 1999-2015 from every Landsat 5, 7, and 8 scene.
- They have created interannual change maps for the entire world that enable us to see shifting coastlines, wild rivers, drying lakes, new reservoirs and shifting aquaculture.
- They have also developed monthly maps composited to show seasonal variation.
- Together these maps help us understand the transitions and fluctuations of our environment.

Credit: *Amy Pickens, Matthew Hansen, Matthew Hancher, Peter Potapov*

TONLE SAP, CAMBODIA

ANNUAL VARIATION



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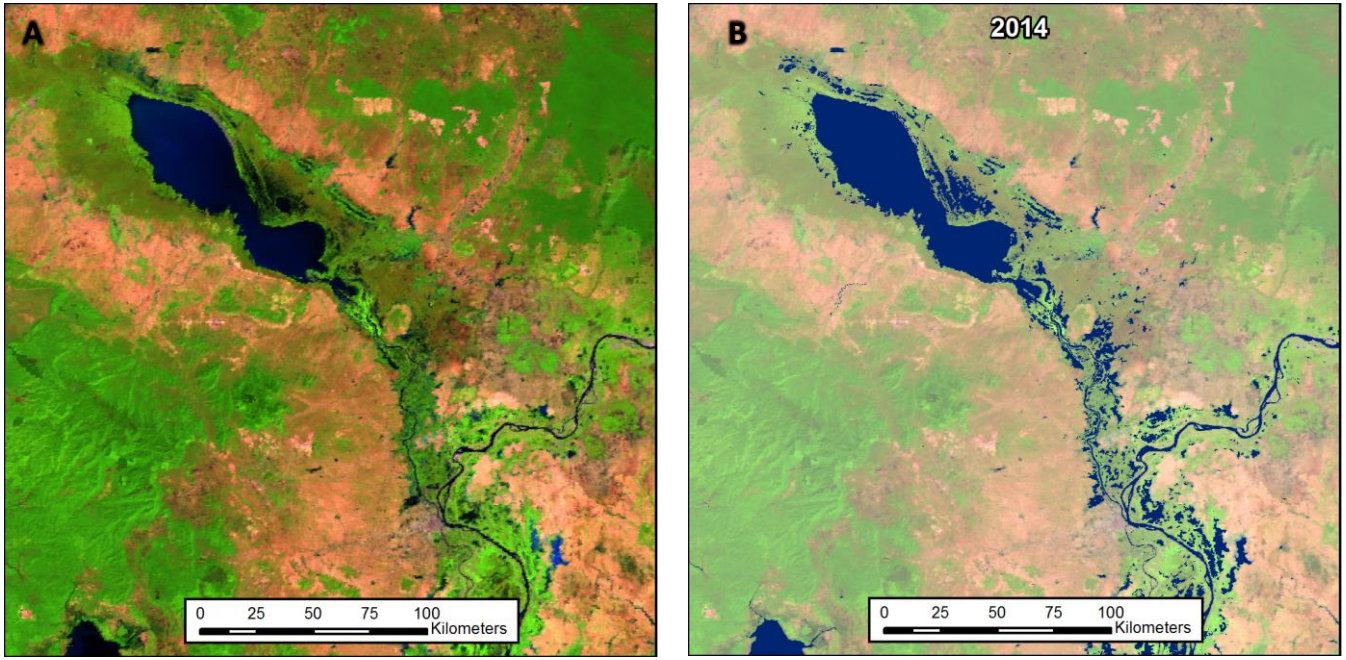

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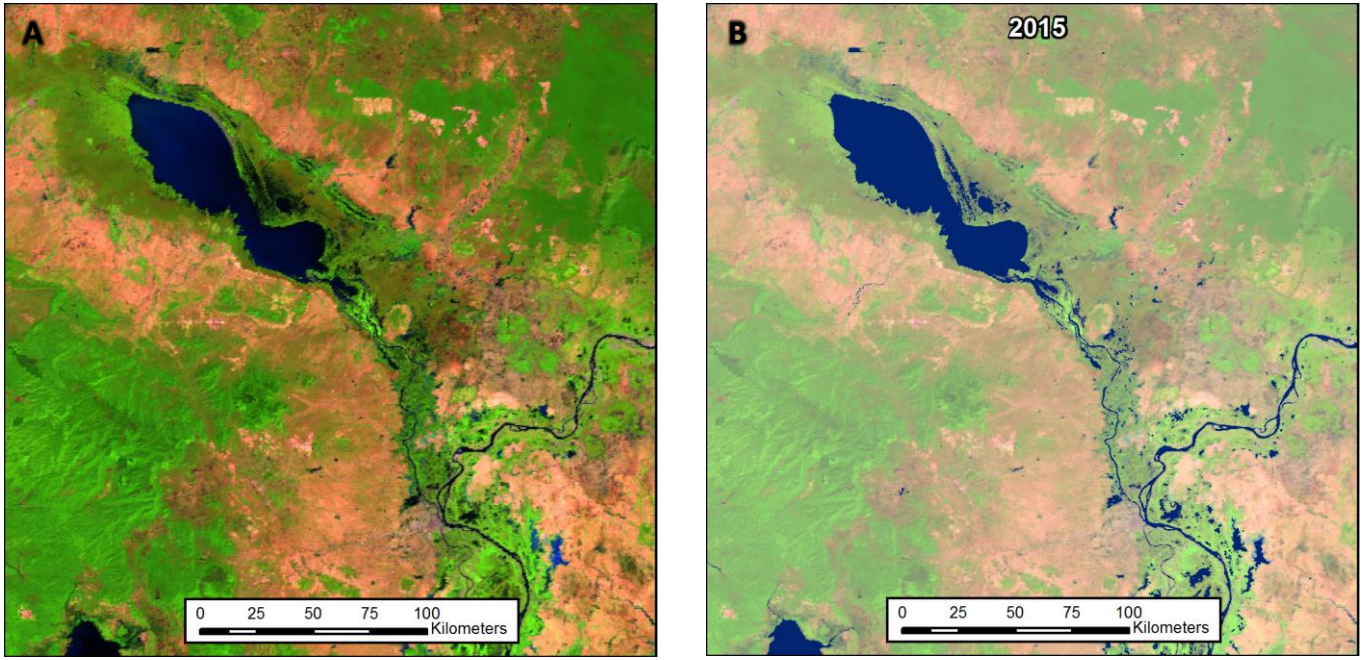
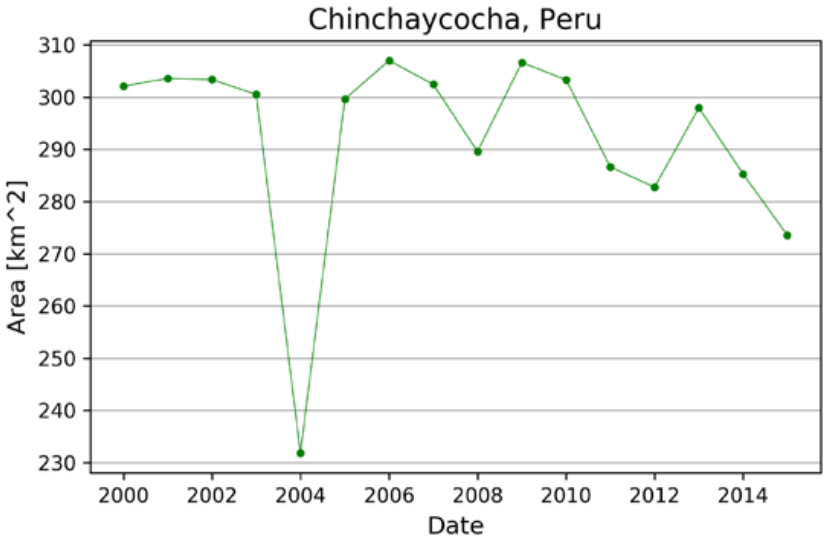
ANNUAL VARIATION

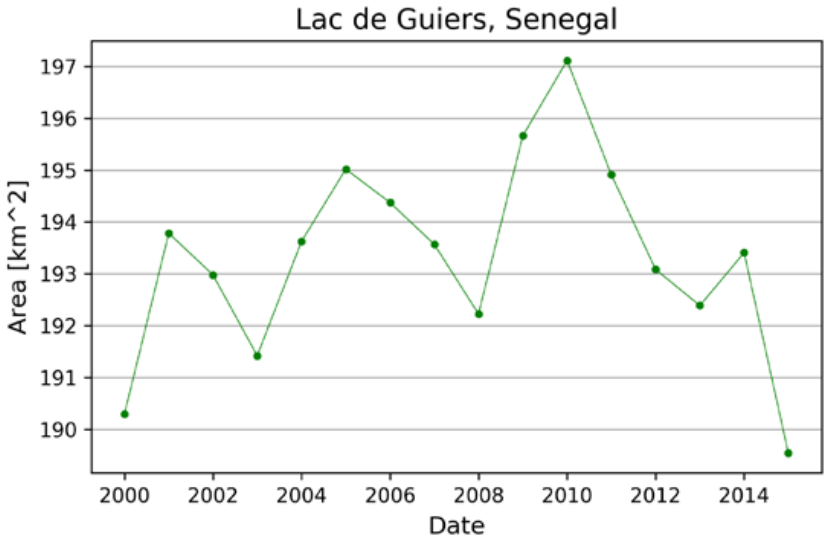


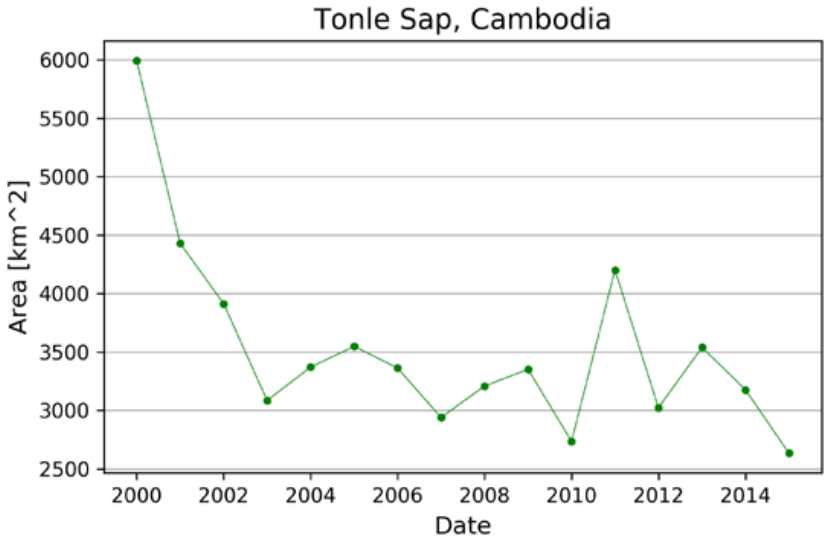
A) False color composite (6-2-1) MODIS surface reflectance image (MOD09A1) of the Tonle Sap and Lower Mekong River in Cambodia. Imagery is an 8-day composite collected from a period beginning on 1/17/13. B) Animation of annual water dataset, MOD44W C6.1 (Carroll et al., 2017), overlain in blue, showing measured spatial extent of open water for the 2015.

MOD09A1 citation: Vermote, E., et al., 2015, MOD09A1: MODIS/Terra Surface Reflectance 8-Day L3 Global 500m SIN. Version 6. NASA EOSDIS Land Processes DAAC, USGS Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota (https://lpdaac.usgs.gov), accessed 06 23, 2017, at http:// dx.doi.org/10.5067/MODIS/MOD09A1.006

Annual Change in Area of Selected Water Bodies







- Time series were created by plotting areas from the polygon-based methodology shown on previous slides.
- These plots show water bodies with fairly constant area (Lac de Guiers), fairly constant area with occasional large changes (Chinchaycocha), and large variations in area on an annual basis (Tonle Sap).

Tradeoff: Temporal vs Spatial Resolution

- Landsat **can resolve much smaller features** than MODIS, and therefore Landsat-based water products are able to map smaller water bodies than MODIS is able to capture

- On the other hand, annual maps created from MODIS data, with its **daily** repeat coverage, have a higher likelihood of accurately measuring surface water extent in **areas with limited imagery due to cloud cover** than those created from sensors with lower temporal resolution, such as **Landsat 8**, which images the globe **once every 16 days**

- Both Landsat and MODIS water products should only be used to study water bodies that are at minimum **the length of several pixels in each dimension**, which means Landsat is a more appropriate choice for smaller water bodies that don't change rapidly, including rivers, whereas MODIS is more appropriate for medium to large water bodies, and also in cloudy areas

Time-series Analyses of Water Quality (WQ) Indicators

- Used NASA Goddard's SeaDAS package for processing
  - Landsat (USGS – NASA)
  - Sentinel-2 (ESA)
- Processes:
  - Removed atmospheric effects
  - Applied empirical algorithms to derive products, including concentrations of Total suspended solids (TSS) – measure of inorganic particles in water column, and Chlorophyll-a (Chl) – measure of productivity

Credit: *Brandon Smith and Nima Pahlevan*

Pilot team: NASA & University of Maryland

Research Teams

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Additional information: http://eo4sdg.org/earthobservations-for-sdg6monitoring/

Water-related Ecosystems - Definitions

- Coastal Mangroves – woody vegetation that grows along low-lying coastal areas where surface water and groundwater are a mix between freshwater and seawater

- Mangrove Gain – the expansion of mangrove into previous uninhabited areas
  - Examples: open water to mangrove OR bare soil to mangrove

- Mangrove Loss – the reduction in mangrove extent erosion or cutting
  - Examples: mangrove to open water OR mangrove to soil, field, city, farm, pond or other non-vegetated cover

- Mangrove Regeneration – the increase in vegetation signal in areas that were previously identified as mangroves