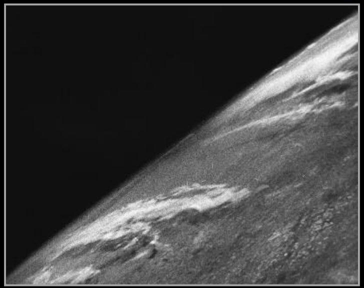
Water Management Challenges and Operational Remote Sensing Applications

COPERNICUS FOR WATER MANAGEMENT Workshop

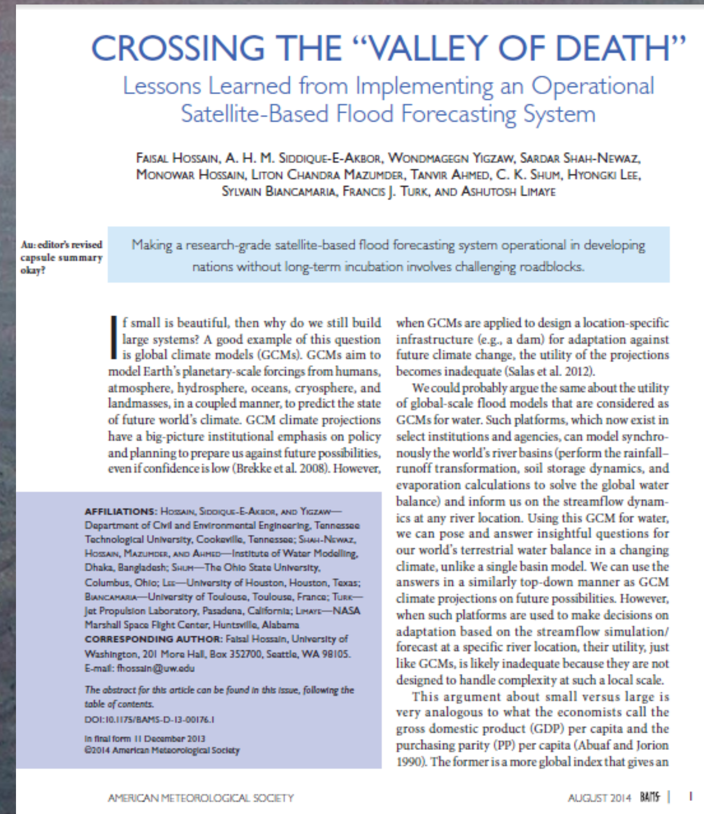
Aleix Serrat-Capdevila, Water Global Practice, The World Bank



1946 – First Pictures of Earth

1972 – The Blue Marble

Research & Experimental



CROSSING THE "VALLEY OF DEATH"

Lessons Learned from Implementing an Operational Satellite-Based Flood Forecasting System

Faisal Hossain, A. H. M. Siddique-E-Akbor, Wondmagegn Yigzaw, Sardar Shah-Newaz, Monowar Hossain, Liton Chandra Mazumder, Tanvir Ahmed, C. K. Shum, Hyongki Lee, Sylvain Biancamaria, Francis J. Turk, and Ashutosh Limaye

Au: editor's revised capsule summary okay?

Making a research-grade satellite-based flood forecasting system operational in developing nations without long-term incubation involves challenging roadblocks.

If small is beautiful, then why do we still build large systems? A good example of this question is global climate models (GCMs). GCMs aim to model Earth's planetary-scale forcings from humans, atmosphere, hydrosphere, oceans, cryosphere, and landmasses, in a coupled manner, to predict the state of future world's climate. GCM climate projections have a big-picture institutional emphasis on policy and planning to prepare us against future possibilities, even if confidence is low (Brekke et al. 2008). However, when GCMs are applied to design a location-specific infrastructure (e.g., a dam) for adaptation against future climate change, the utility of the projections becomes inadequate (Salas et al. 2012).

We could probably argue the same about the utility of global-scale flood models that are considered as GCMs for water. Such platforms, which now exist in select institutions and agencies, can model synchronously the world's river basins (perform the rainfall–runoff transformation, soil storage dynamics, and evaporation calculations to solve the global water balance) and inform us on the streamflow dynamics at any river location. Using this GCM for water, we can pose and answer insightful questions for our world's terrestrial water balance in a changing climate, unlike a single basin model. We can use the answers in a similarly top-down manner as GCM climate projections on future possibilities. However, when such platforms are used to make decisions on adaptation based on the streamflow simulation/forecast at a specific river location, their utility, just like GCMs, is likely inadequate because they are not designed to handle complexity at such a local scale.

This argument about small versus large is very analogous to what the economists call the gross domestic product (GDP) per capita and the purchasing parity (PP) per capita (Abuaf and Jorion 1990). The former is a more global index that gives an

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The abstract for this article can be found in this issue, following the table of contents.

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Operational Water Management Applications

Obstacles to the Use of RS Applications

- Lack of technical capacity

  data handling - assimilation - bias correction - calibration - validation

- Lack of human & financial capacity
- Complex data processing, raw data access, internet connectivity
- Varying accuracy of RS data and applications:

  By data product & application

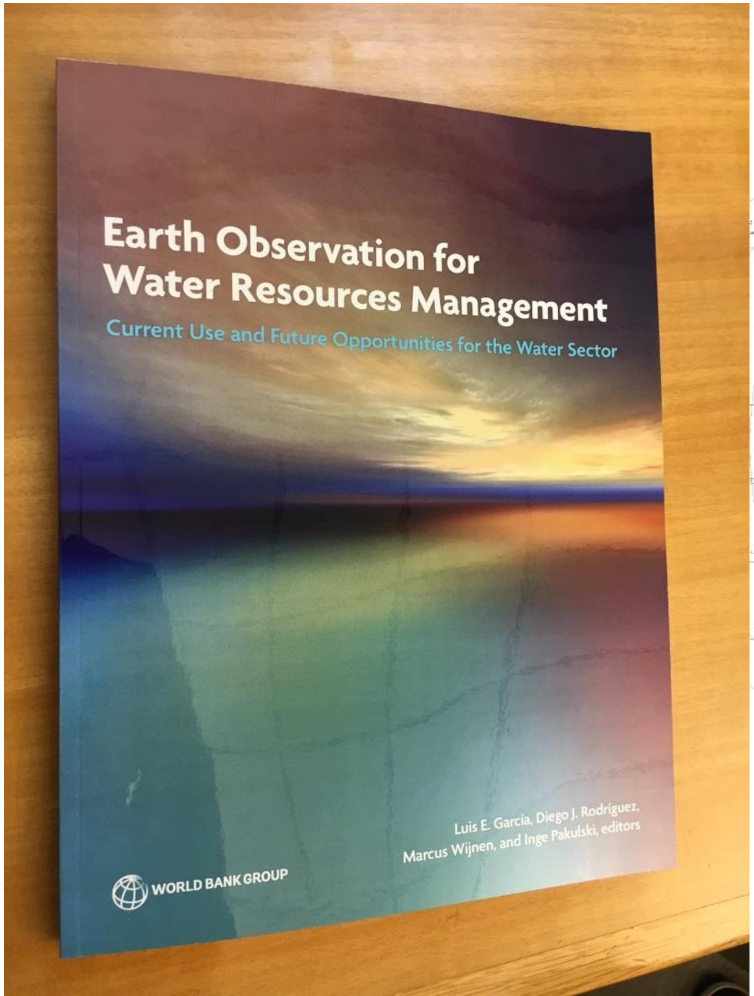
  By region, climate, topography, land cover

- (and some others)
- Different decision contexts, and needs for decision support. → **Need for customized applications addressing needs of management**

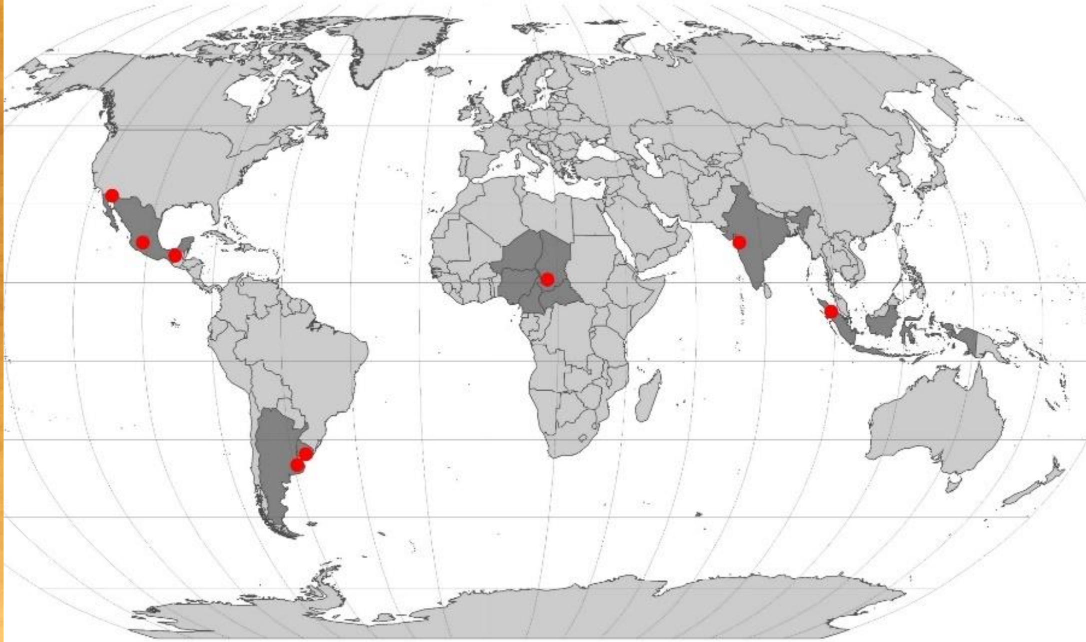
Global vs Local !

The Global Remote Sensing Initiative

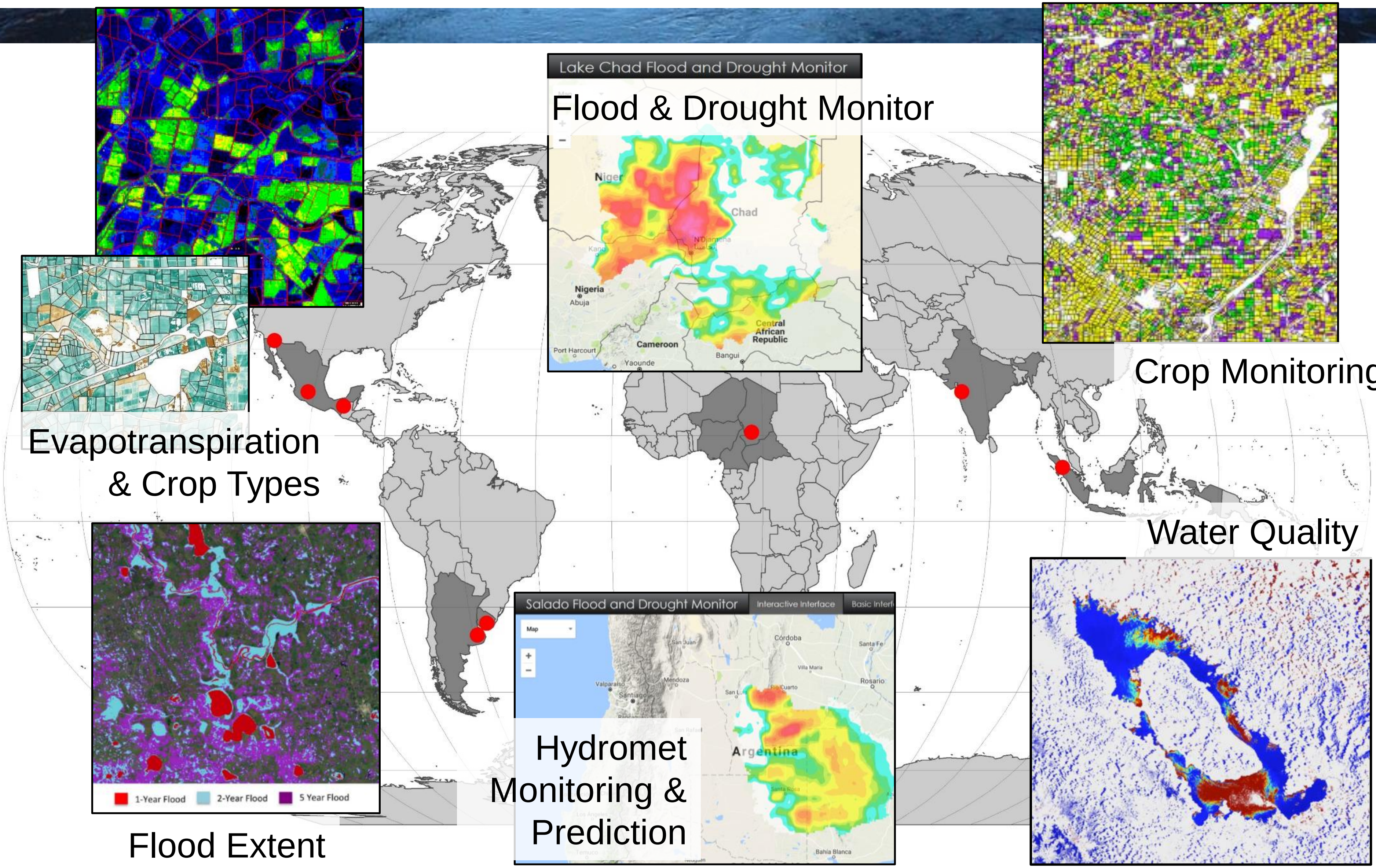
Phase I



Phase II



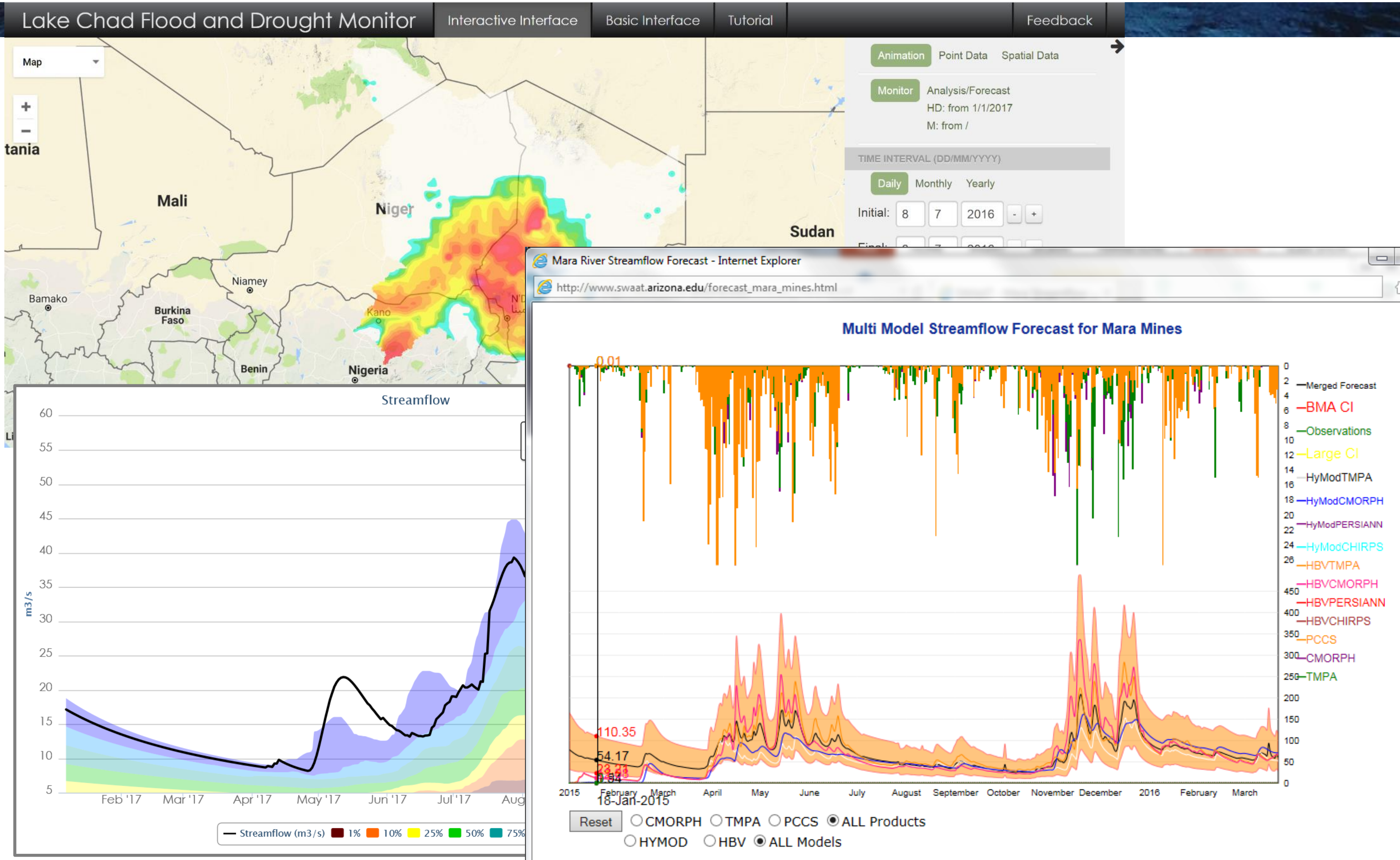
The Global Remote Sensing Initiative - II



WRM Challenges and Opportunities

#1 - Hydromet Monitoring and Forecasting

Packaging & delivering information



Global Challenge

Real-Time Hydromet Monitoring and Forecasting:

Compound Eye for basin-wide view:

Precipitation (multiple sat products)

ET (basin-wide, low resolution), **Soil-Moist.**

Altimetry in Rivers (for stages/flows)

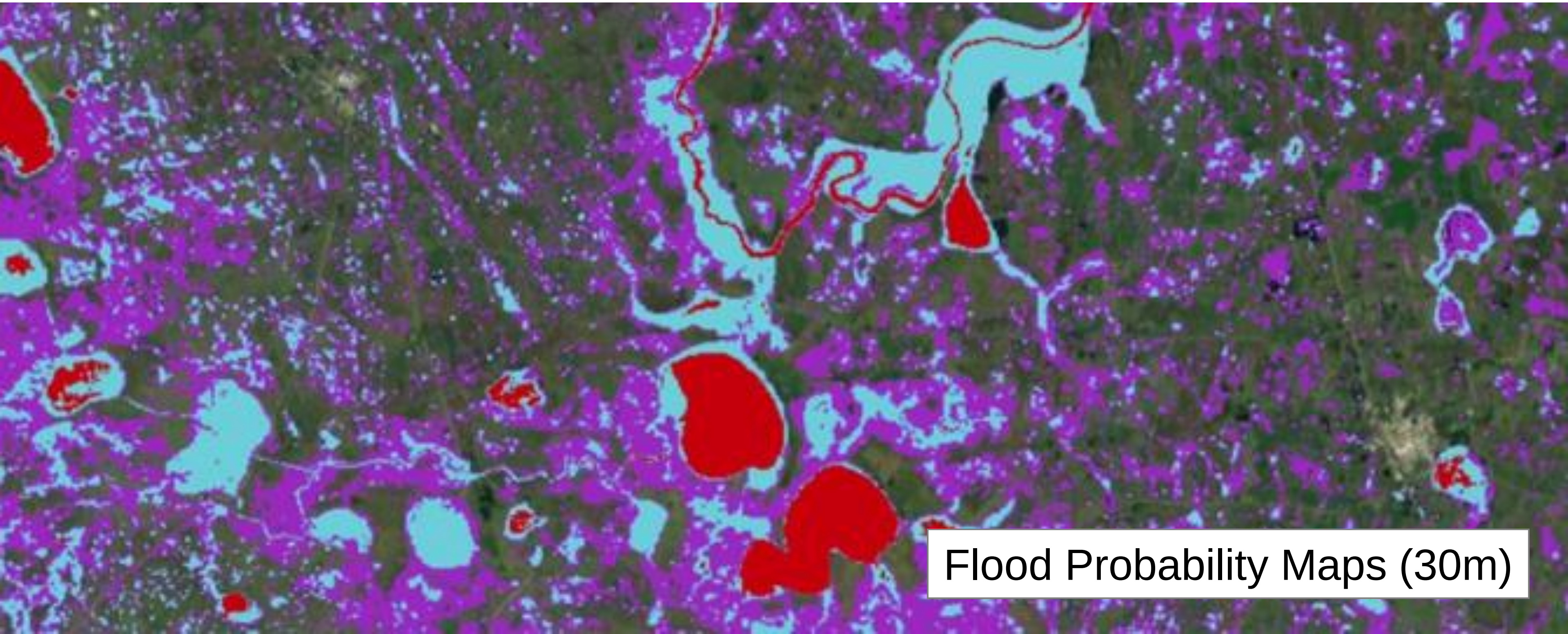
Meteorological Forecasts; Drought Indexes

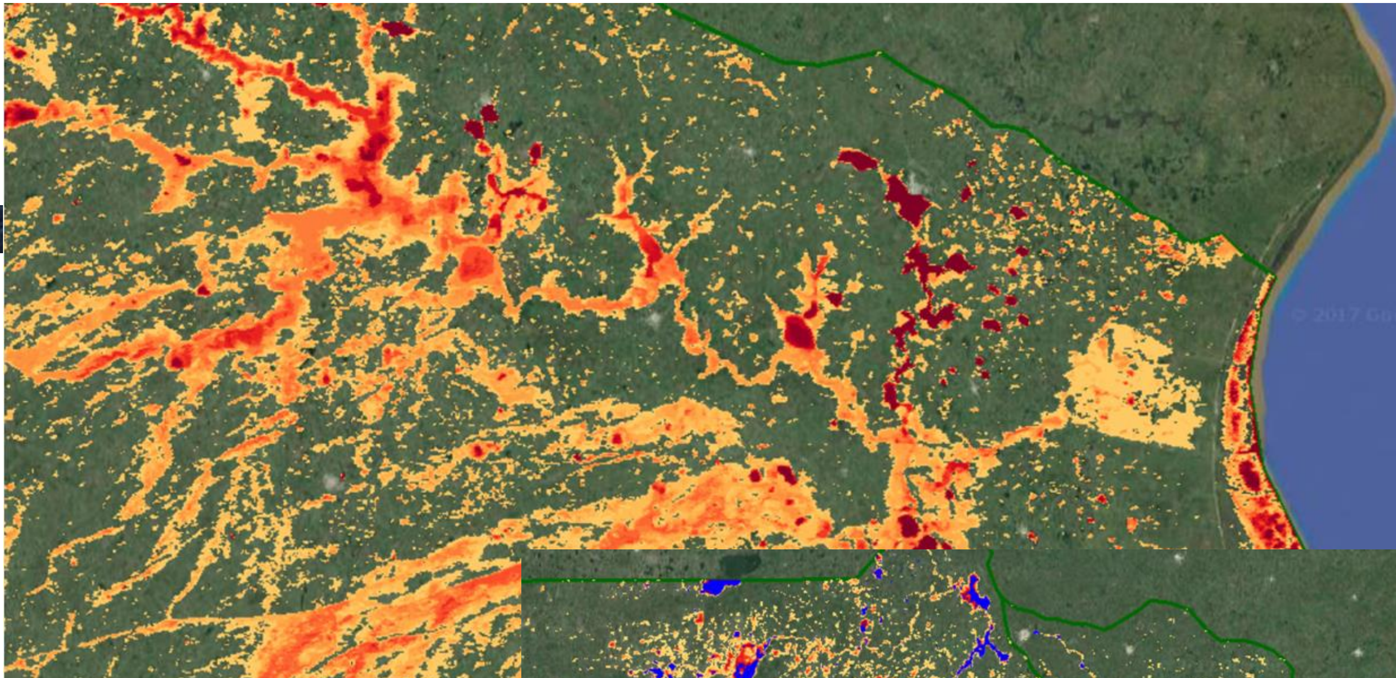
Hydrologic + Hydrodynamic Models in RT

Limited by cloud cover !

(except for radar)

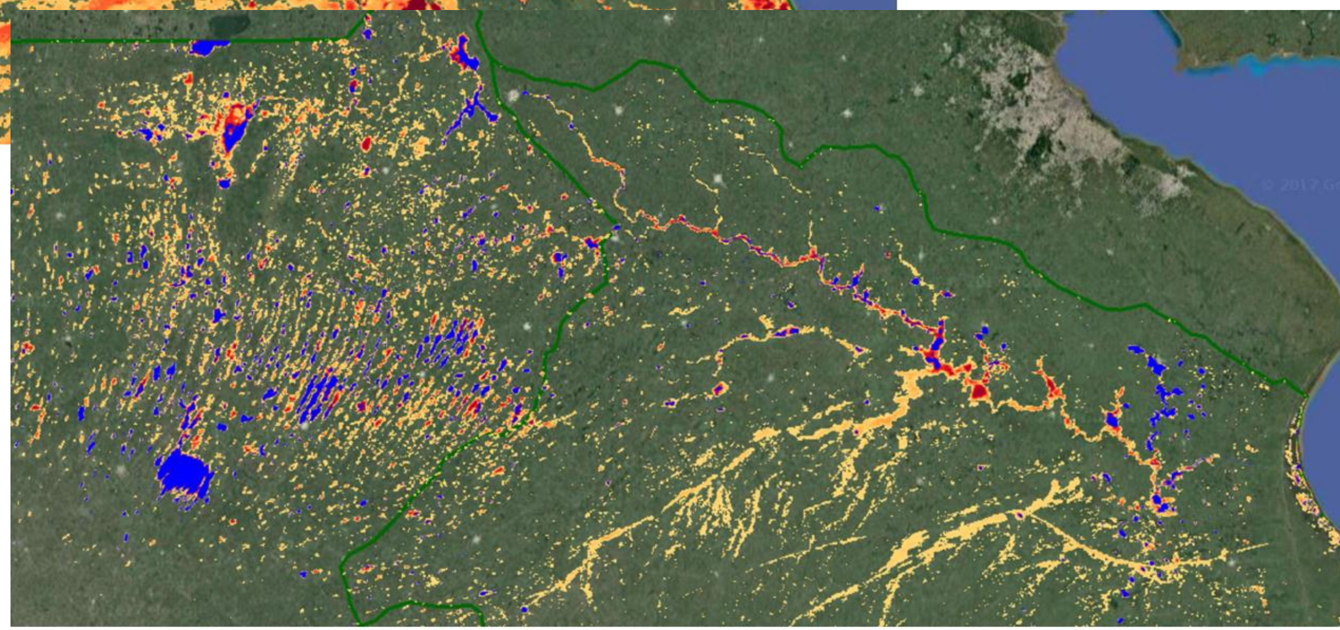
#2 Flood Monitoring & Analysis





Flooded Years

1 16



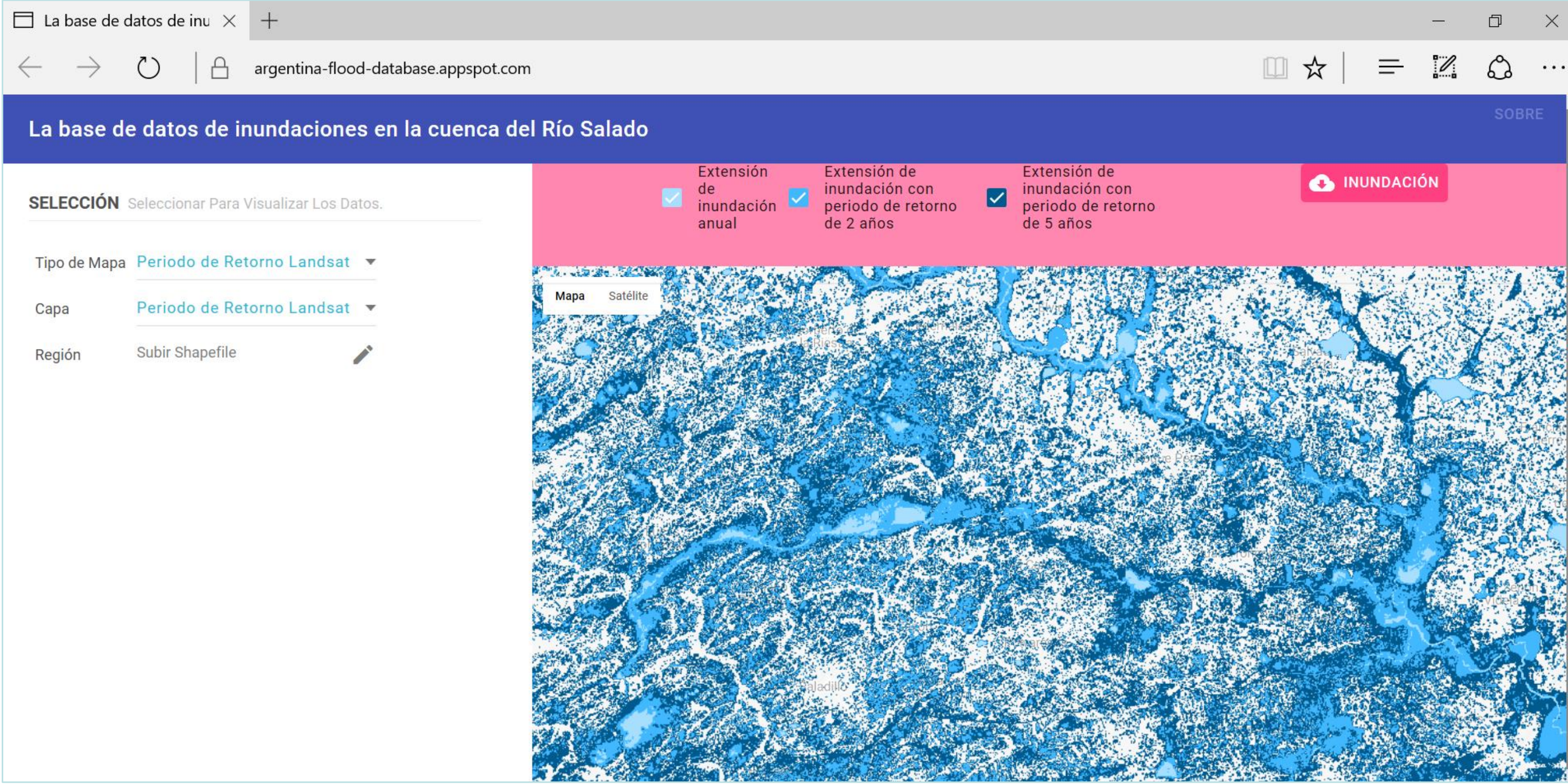
Dias inundados en 2003

1 270+

Permanent Water

Number of flooded days in a given year (i.e. 2003).

Easy delivery of information



Global Challenge

Global Flood Monitoring and Analysis

Quick and easy analysis of flood risk (frequency, extent, duration) over previously un-gauged areas using many satellites.

Compound Eye for Integral view:

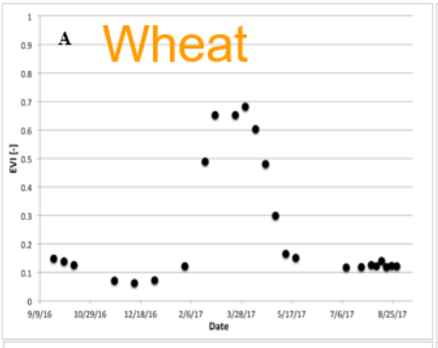
Flood Extent (Sentinel, Landsat, Modis)

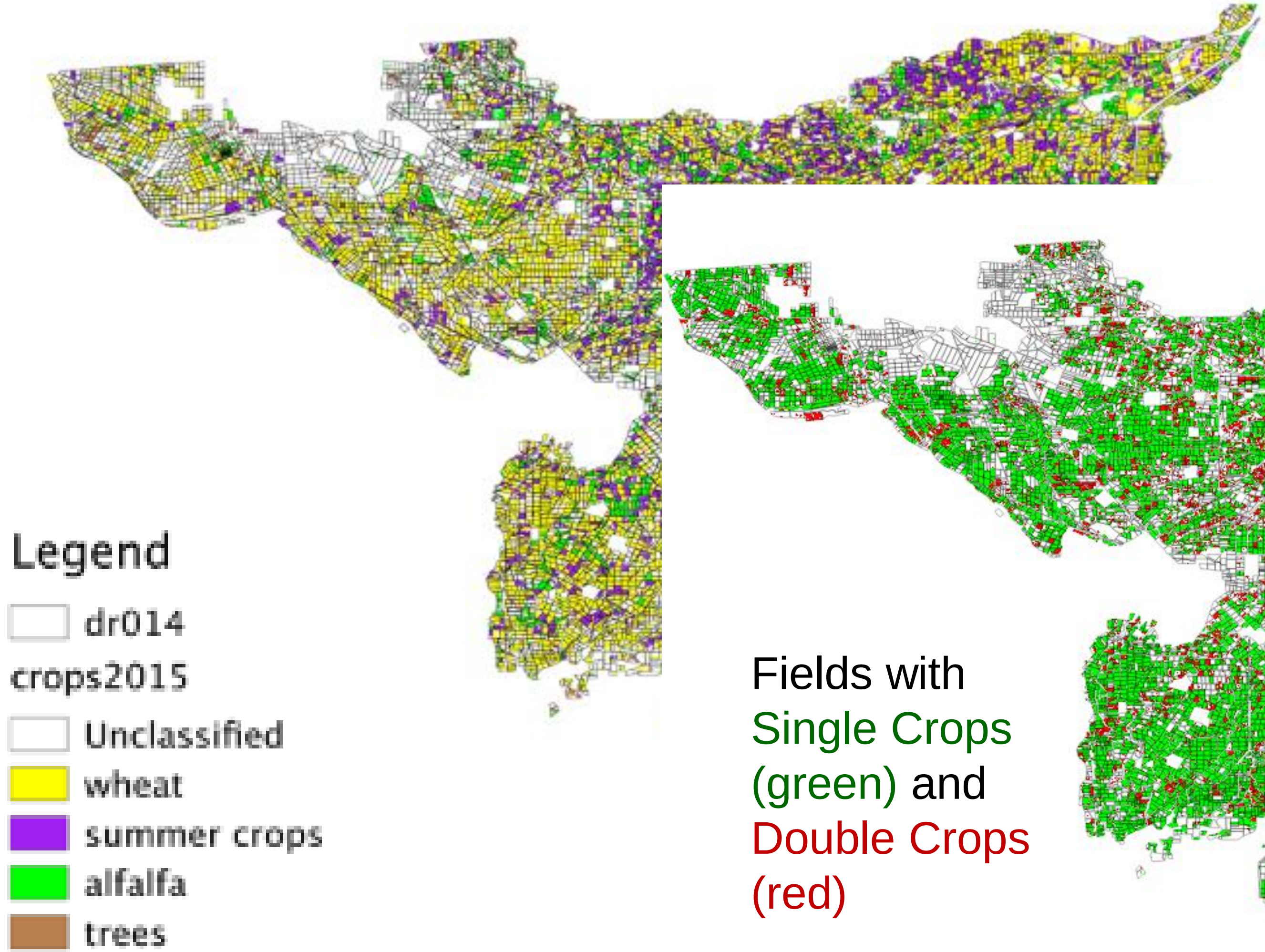
DEM (High resolution, Lidar)

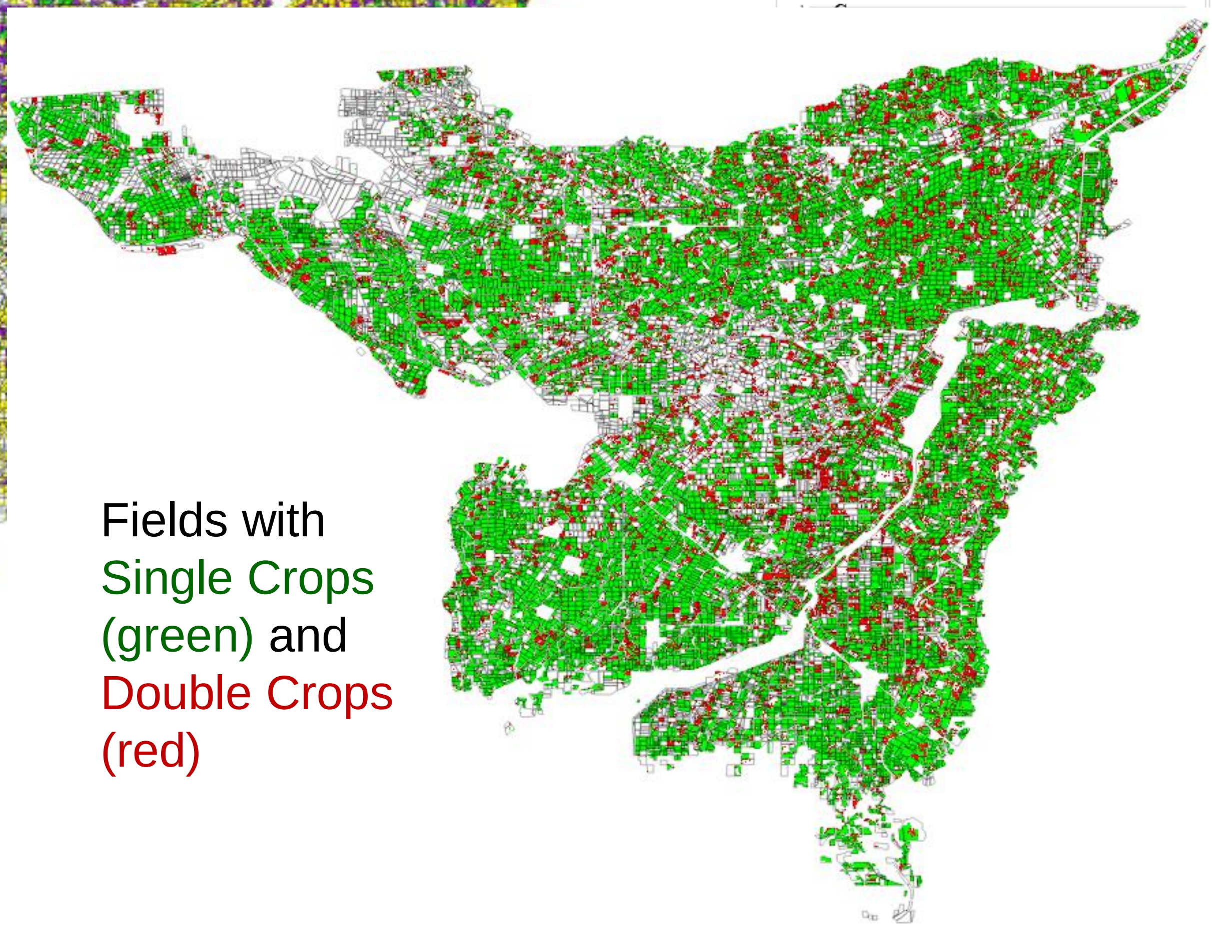
Link with Hydromet Monitoring & Forecasting: from streamflows to stages and flood extents.

#3 - ET and Crop Monitoring

Crop Types for 2015

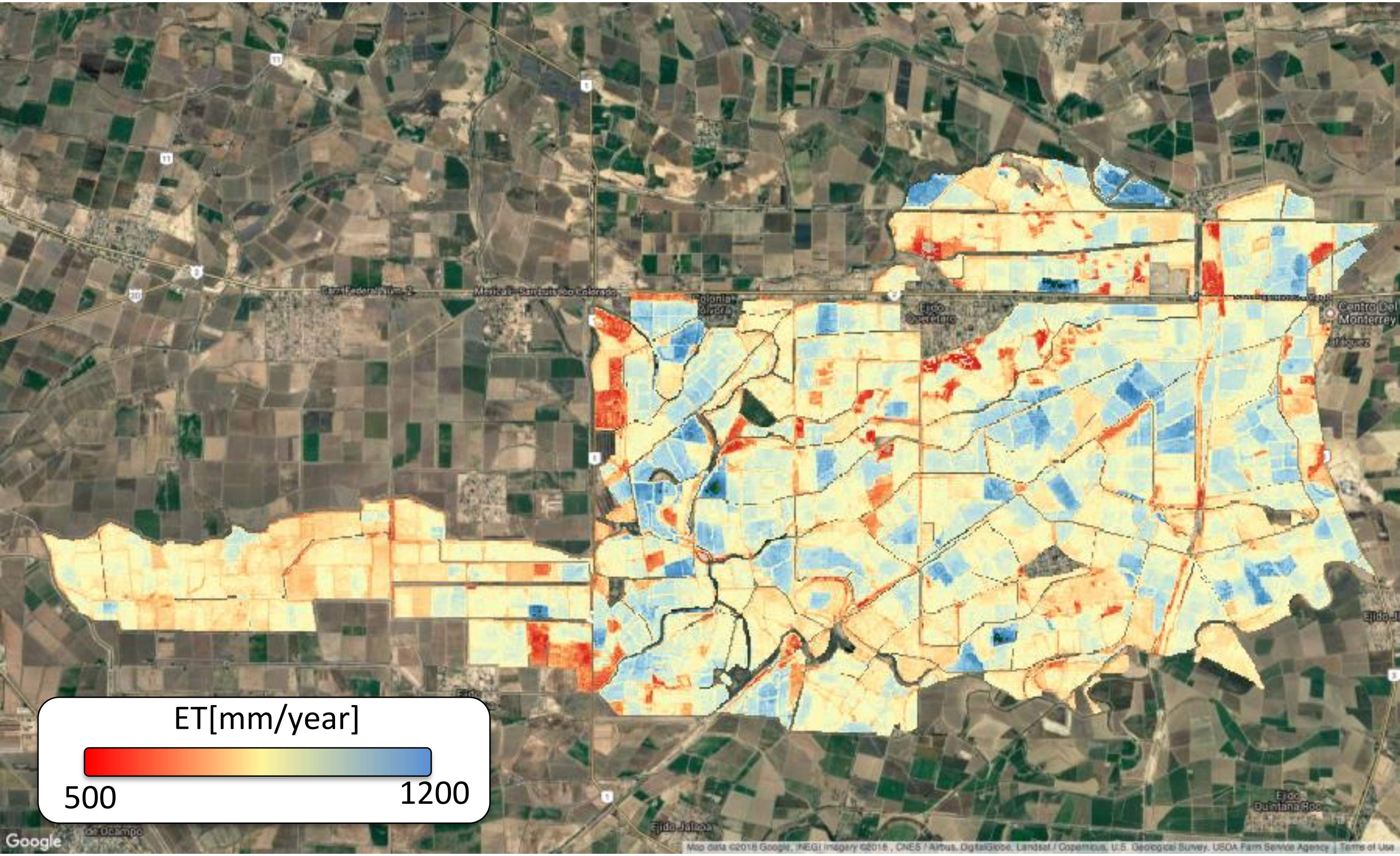




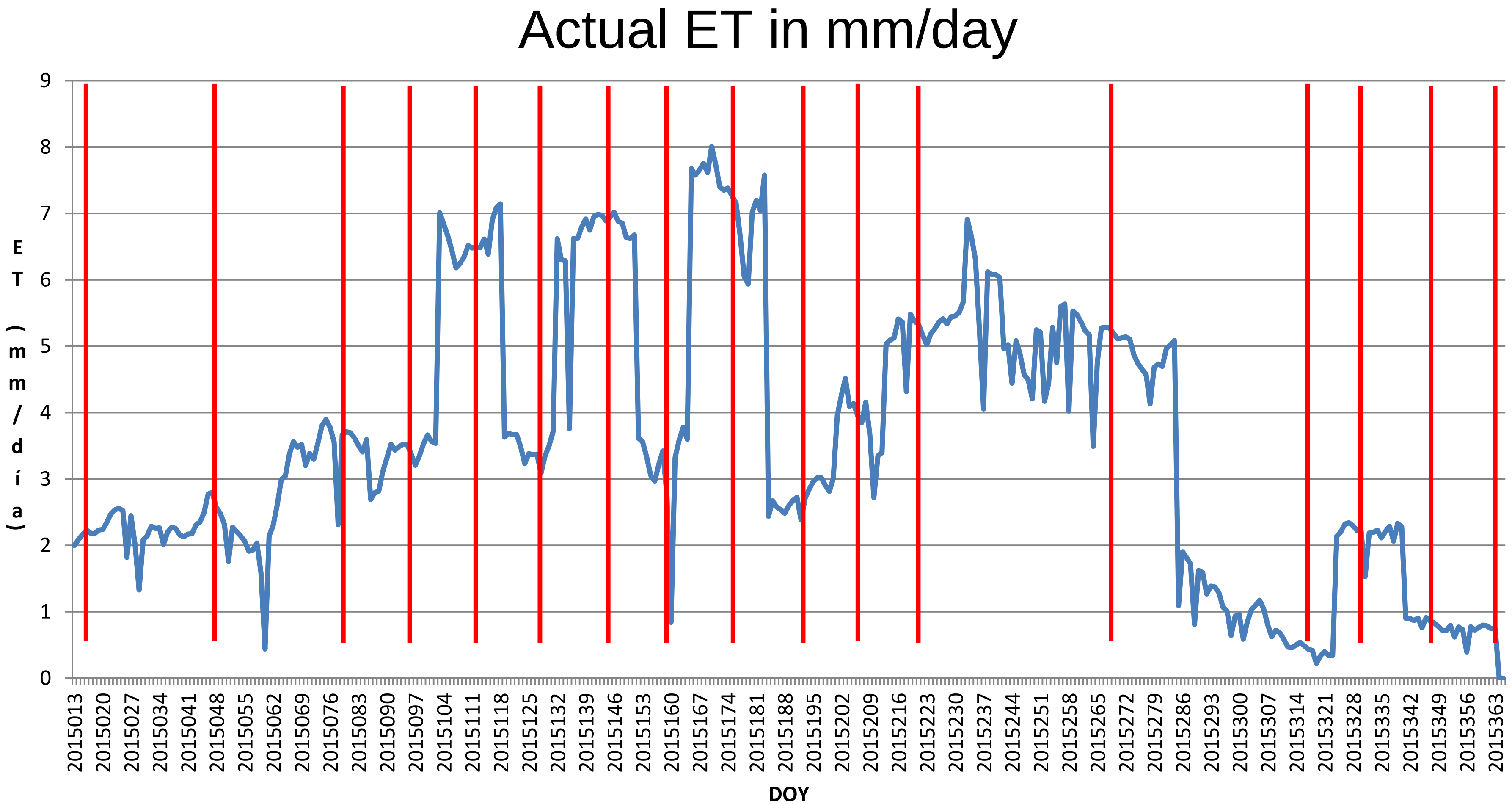


Fields with Single Crops (green) and Double Crops (red)

Evapotranspiration (ET) Monitoring



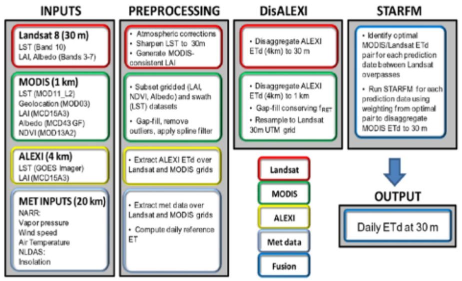
ET: guessing between overpasses



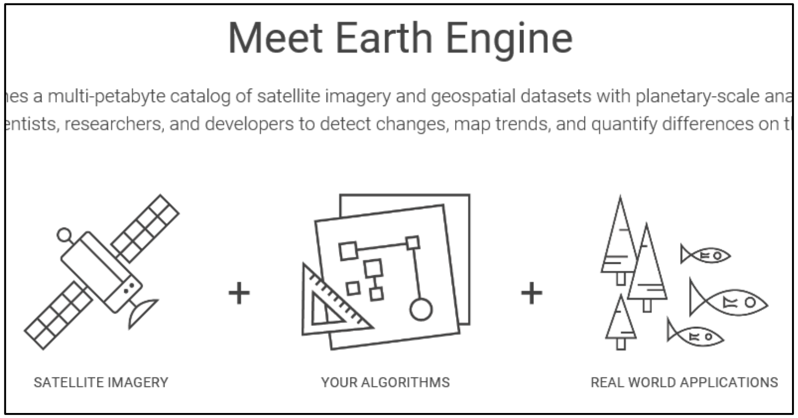
Red lines: Cloud-free Landsat Images (in arid area)

Operationalizing ET - **Periodic & Regular**

Coding ET algorithms into cloud language



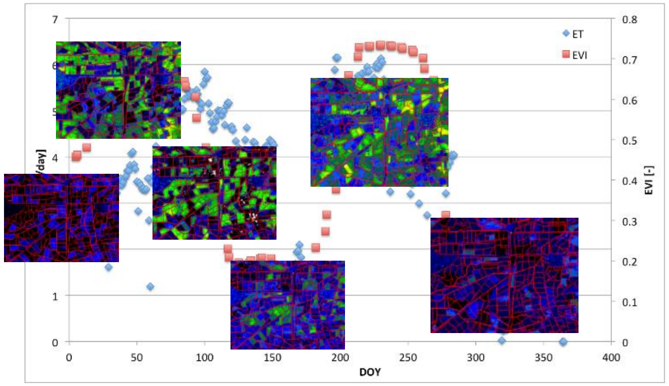
Implementing the algorithm in Earth Engine so that **it can run periodically over areas of interest**



Validation

Validation

REGULAR & PERIODIC Estimation of ET Over Large Areas



Global Challenge

Field-Scale periodic ET estimation over large areas of interest.

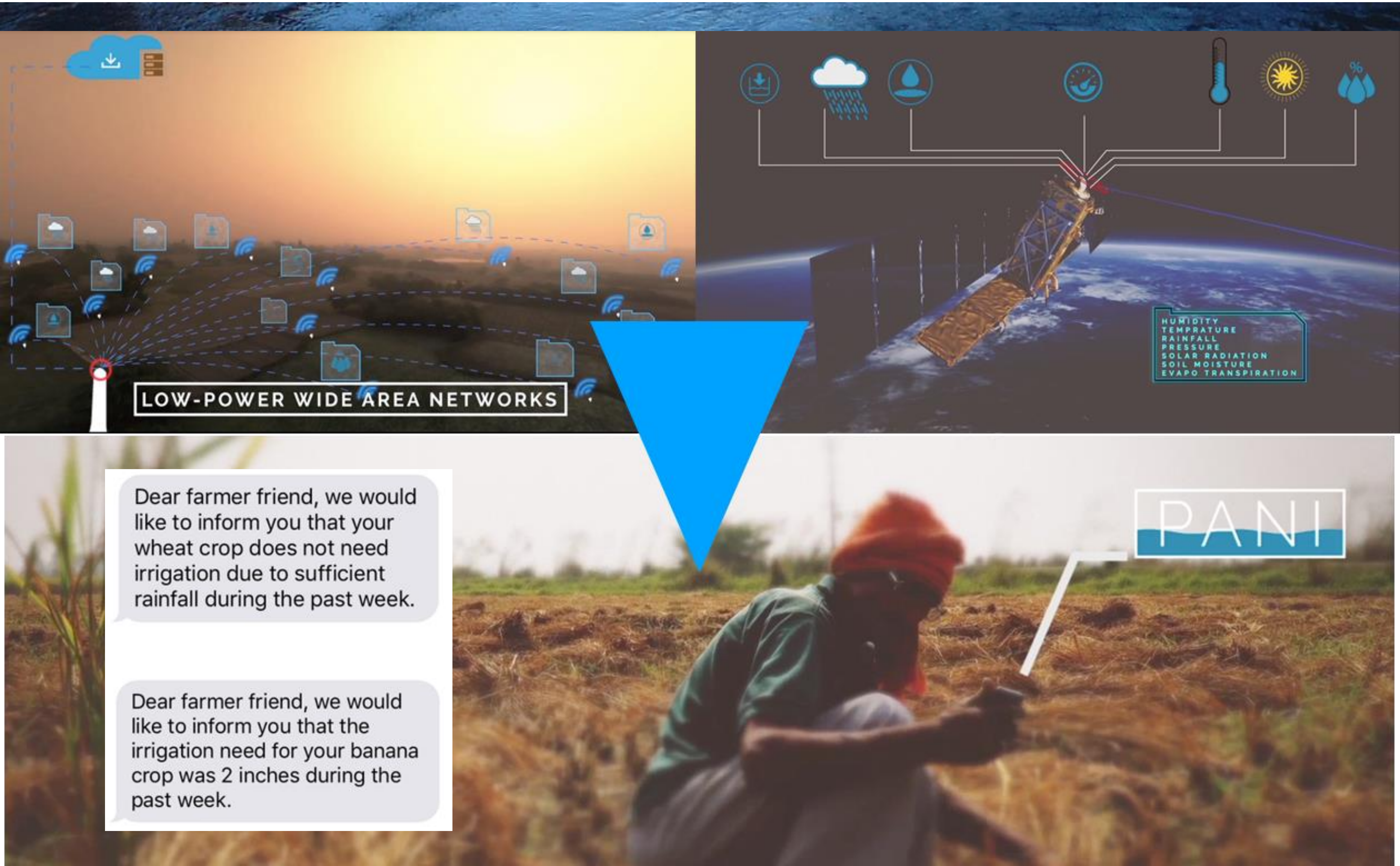
Compound Eye for Integral view:

ET (multiple products, OpenET framework)

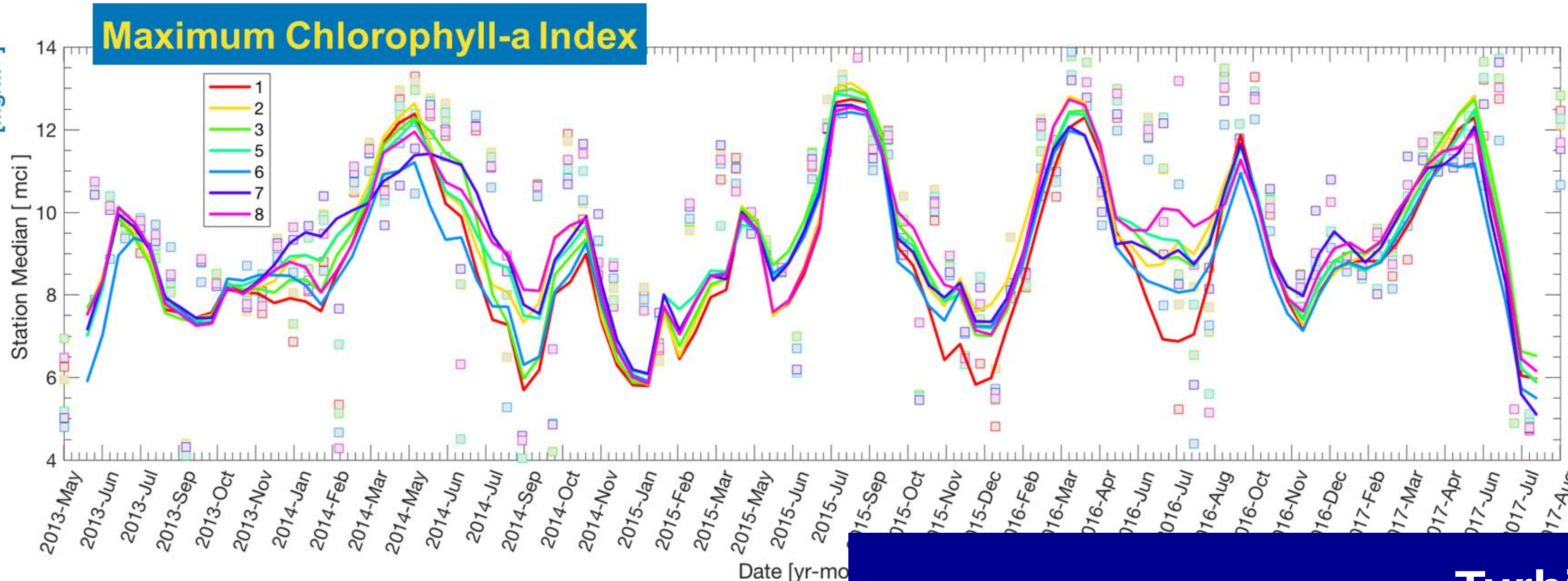
Crop Monitoring (EVI, NDVI)

Precipitation (for irrigation advisory, work in India, Pakistan, Bangladesh)

Irrigation Advisories



#4 Water Quality


Maximum Chlorophyll-a Index
CHL (mci) [mg/m³]
Station Median [mci]
1
2
3
5
6
7
8
2013-May
2013-Jun
2013-Jul
2013-Sep
2013-Oct
2013-Nov
2014-Jan
2014-Feb
2014-Mar
2014-May
2014-Jun
2014-Jul
2014-Sep
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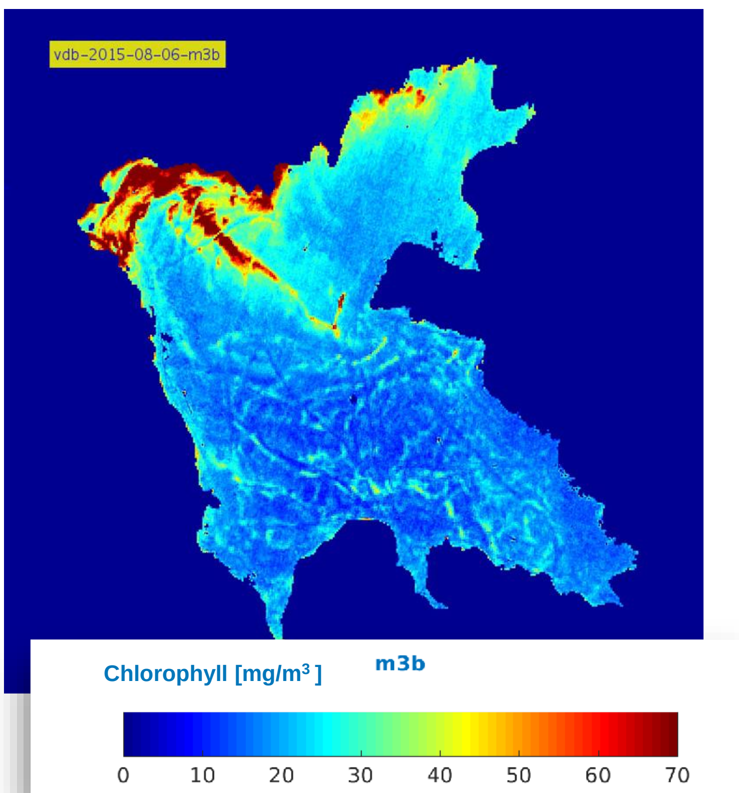
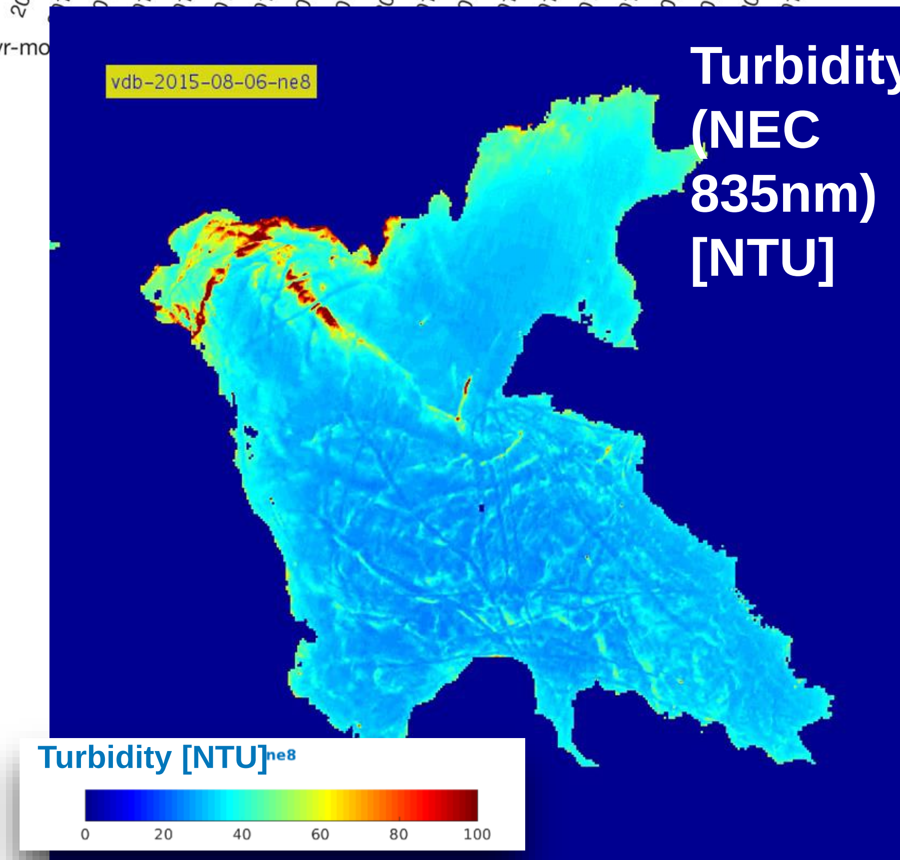
2014-Nov
2015-Jan
2015-Feb
2015-Mar
2015-May
2015-Jun
2015-Jul
Date [yr-mo

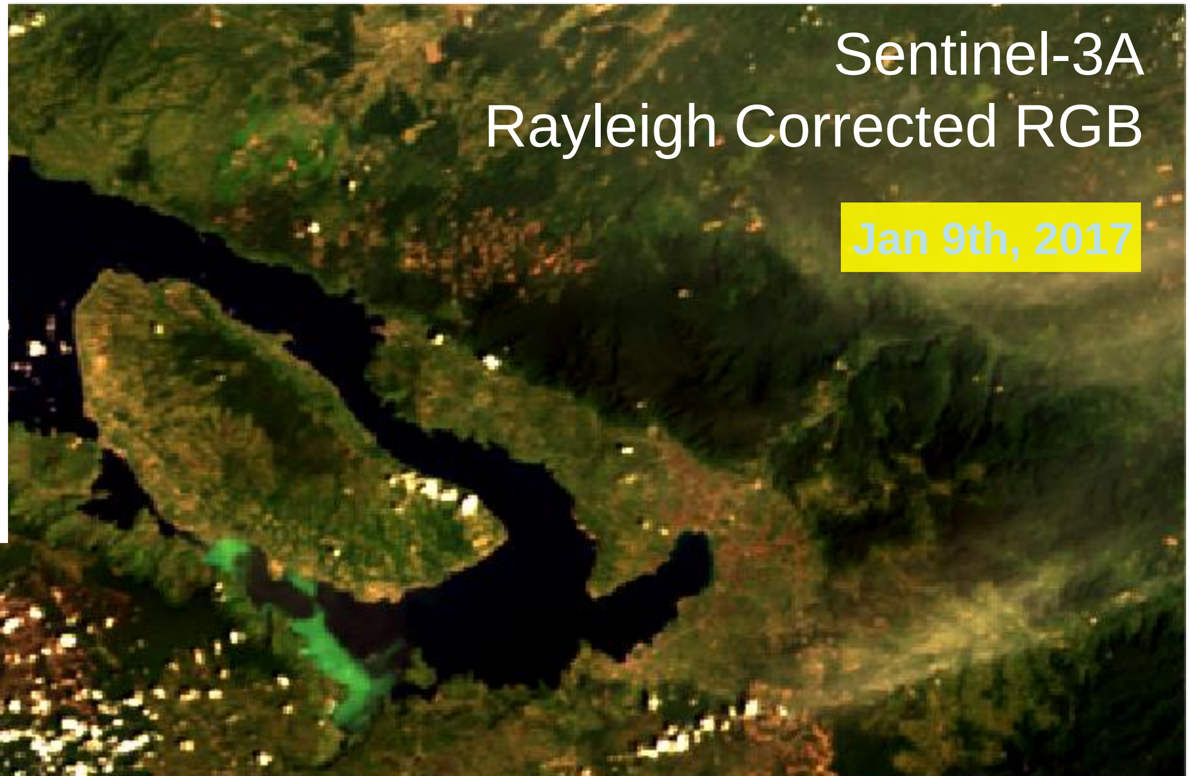

vdb-2015-08-06-m3b
Chlorophyll [mg/m³]
m3b
0 10 20 30 40 50 60 70

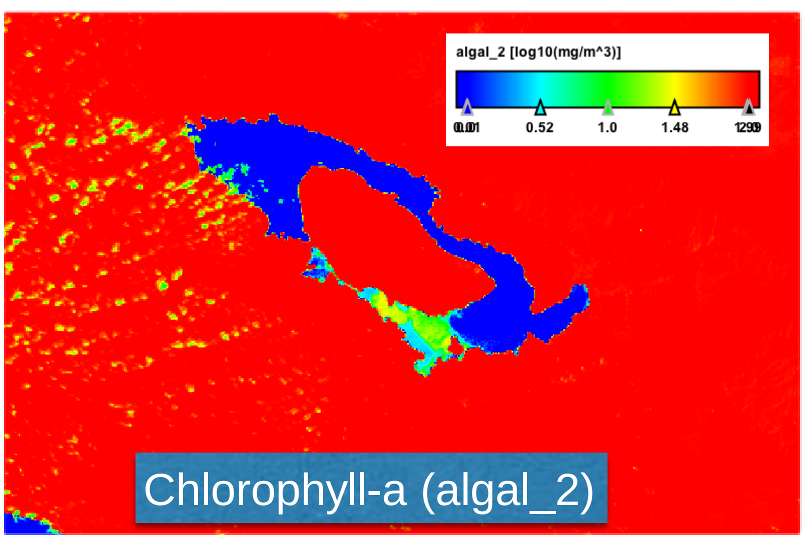

vdb-2015-08-06-ne8
Turbidity (NEC 835nm) [NTU]
Turbidity [NTU]ne8
0 20 40 60 80 100

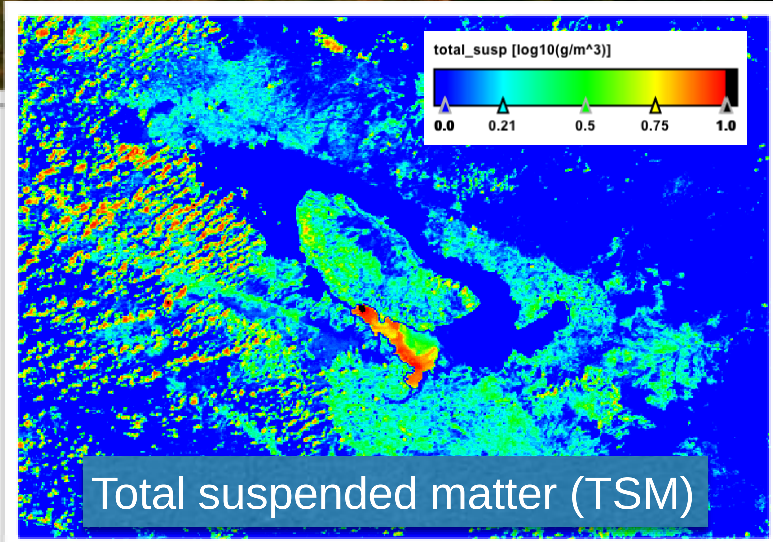
Sentinel-3A L1B processed to L2 using ESA SNAP


Hundreds of Tons of Dead Fish in Lake Toba

In the last three days, hundreds of tons of floating net cage fish (KJA) in Lake Toba, Baktiraja, Humbang Hasundutan (Humbahas) die. SINDO / Baringin Lumban Gaol







Global Challenge

Water Quality Monitoring and Analysis

Spatial view to understand water quality dynamics in space and time and complement point measurements.

Compound Eye for Integral view:

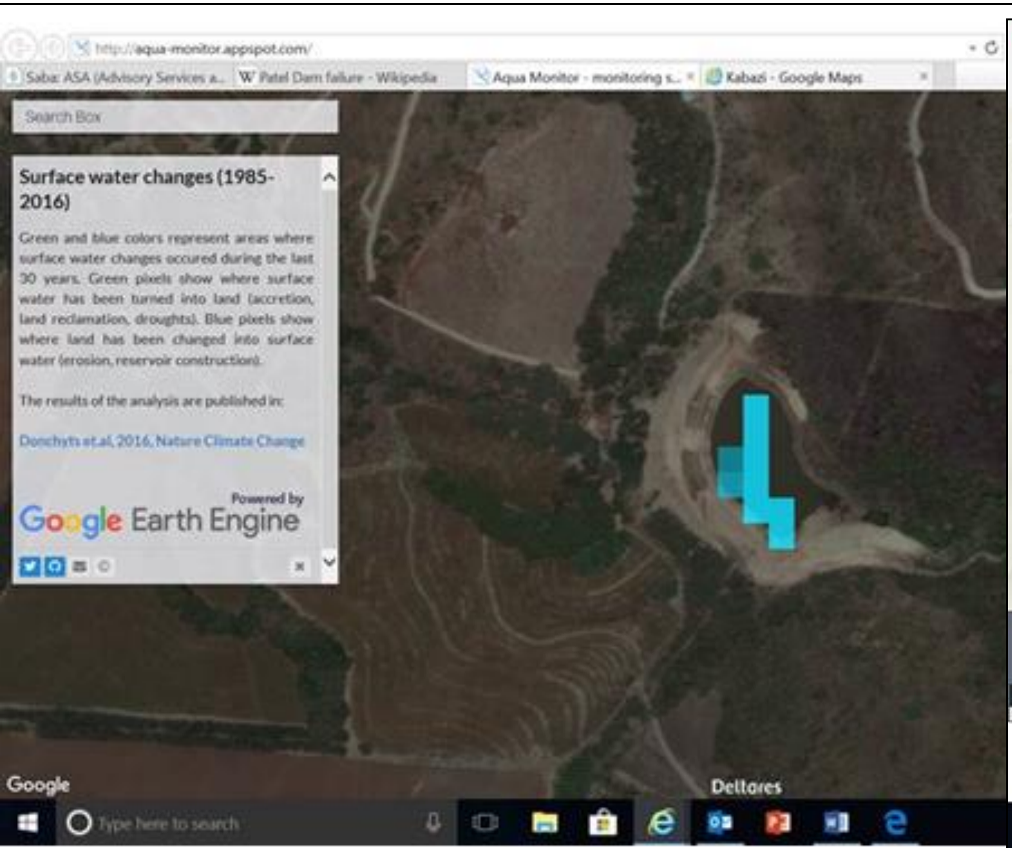
Hyperspectral would be great!

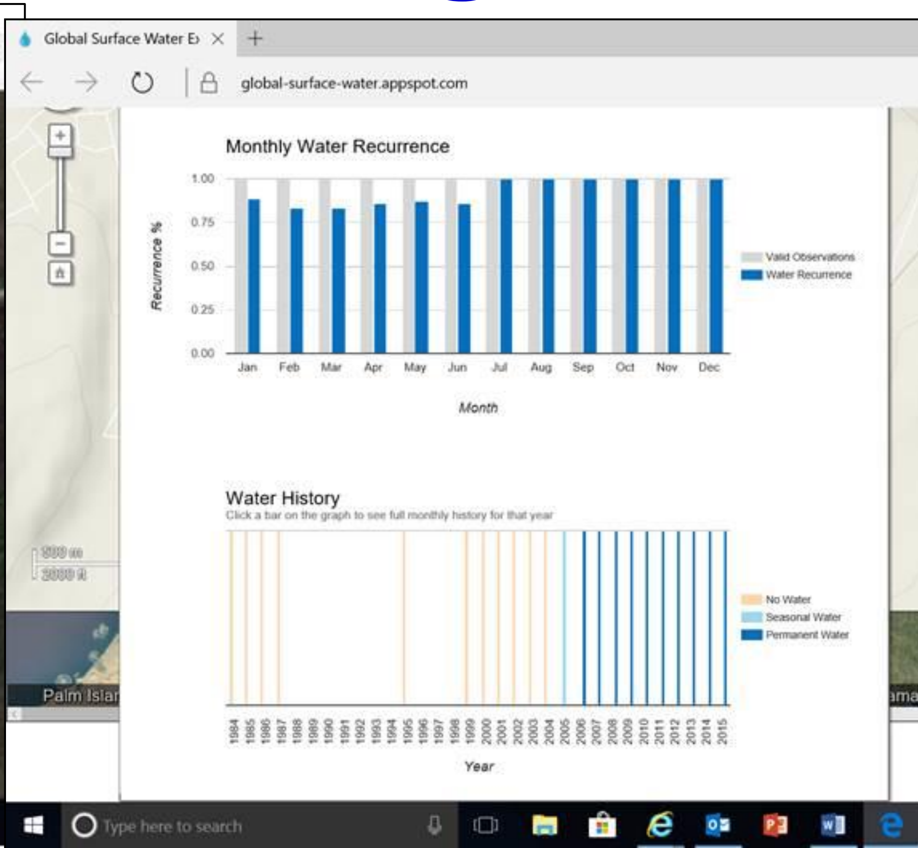
Water Quality Parameters (turbidity, chlorophyll, phosphorous, nitrogen, oxygen content, etc., with range of satellites)

Land Use Change / Land Cover /Other

Link with Hydromet Monitoring & Forecasting: from streamflows to stages and flood extents.

#5 Reservoir Monitoring

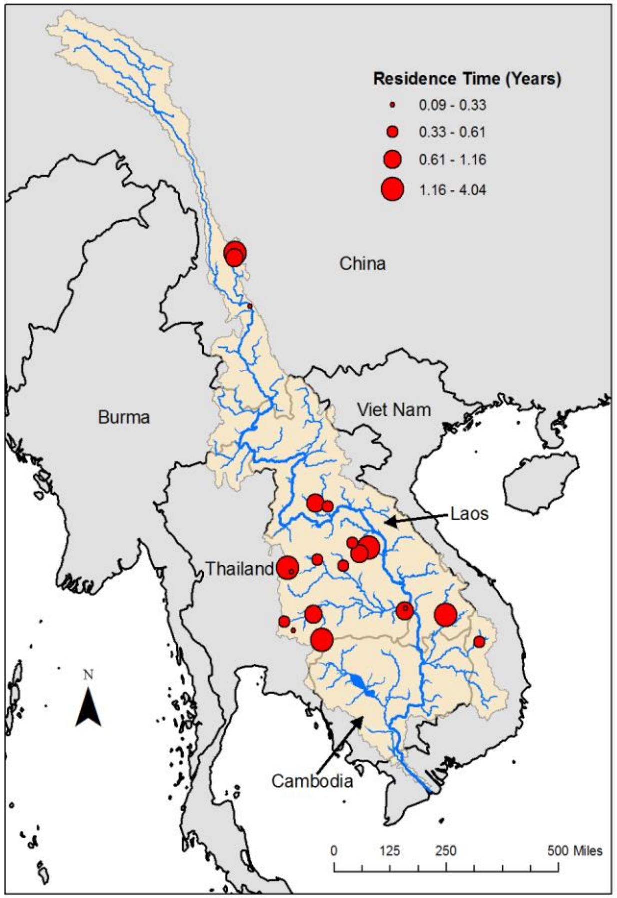


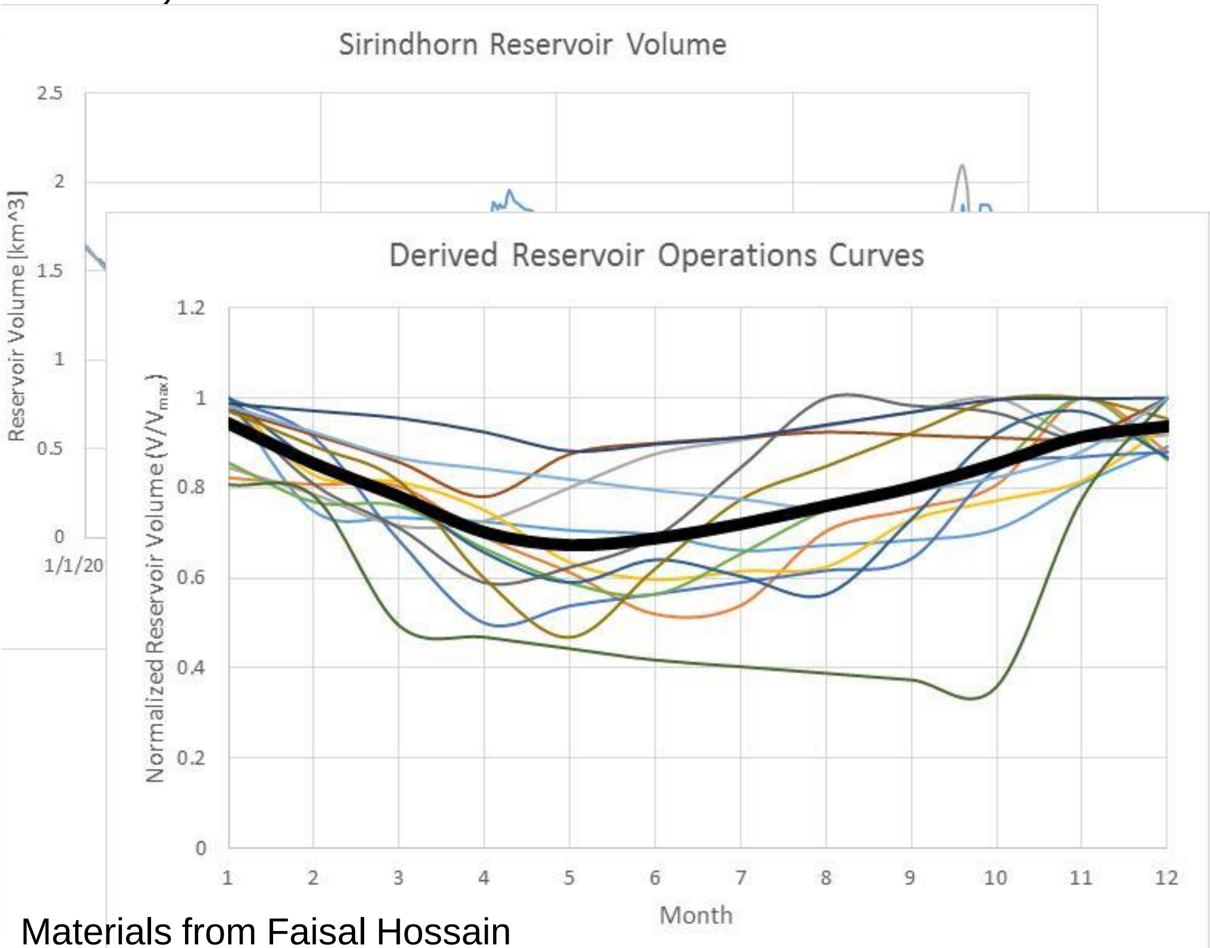


Reservoirs & Transboundary Systems

"Seeing" Upstream operating policies and bringing transparency to transboundary management.

Compound Eye of **SRTM, Landsat, MODIS, GPM**, VIC, **Altimetry**.
Automated Tool being developed by UW *locally*





Materials from Faisal Hossain

#6 Natural Riparian Ecosystems

#7 Water Point Functionality

7 Global Challenges

1 – Real-Time Hydromet Monitoring and Forecasting: satellite data + met forecasts + models

2 – Global Flood Monitoring and Analysis

Quick and easy analysis of flood risk (frequency, extent, duration), historical archive and in real-time.

3 - Field-Scale periodic ET estimation over large areas of interest, globally.

4 – Water Quality Monitoring and Analysis

5 – Reservoirs & Transboundary Systems

6 – Riparian Ecosystems Monitoring

7 – Water Point Functionality