NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program
NASA Water Resources PI Meeting, 27-28th June 2018, Boulder CO

G-REALM: Sustained Water Level Monitoring for Agriculture, Regional Security, and Inland Fisheries

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Student Intern: Scott Kinsey (UMD)

G-REALM: Sustained Water Level Monitoring of Lake and Reservoirs

THE IMPORTANCE of information on GLOBAL CROP STATISTICS

USDA/FAS output global monthly crop conditions and crop production estimates.
Statistics are produced via a monthly operational USDA/OGA DSS process.
Estimates drive price discovery, trade and foreign policy, farm programs.

THE PROBLEM

Availability of stored water for irrigation is required, but an unknown, in many regional locations.
Such information maybe deemed “sensitive”, with denied or delayed access.

THE SOLUTION

Use of satellite radar altimetry to provide long-term and operational surface water levels for the world’s largest lakes and reservoirs. “Levels” act as a proxy for storage volume. Satellite continuity is assured and data is available in near real time.

IMPACTS

(USDA) Enhances the USDA/FAS DSS via improved knowledge of irrigation potential i.e., short term agricultural drought (seasonal), and longer-term hydrological drought (multi year).

(USACE) Improves regional/global assessments regional security – in terms of water resources, hydro-electric power production, and flood potential.

(Science) Contributes to climate change and basin-hydrology research investigations.

Funding partners

• USDA/FAS for near real time operations

USDA United States Department of Agriculture Foreign Agricultural Service

IPAD International Production Assessment Division

• NASA MEaSUREs program (Manager: Martha Maiden).
Making Earth System Data Records for Use in Research Environments
"Development of pre-SWOT ESDRs for Global Surface Water Storage Dynamics and River Discharge Predictors", PI: Prof. Dennis Lettenmaier, UCLA.

Running to FY19, this is non-operational, and looks to G-REALM for a one-off delivery of archival water level products (1992-2017) relevant to high latitude lakes and reservoirs that are outside the current region of USDA agricultural interest (<40deg South, > 25deg North).

• USACE no direct funding offered, but system software transition requested with "standby technical support". However, data complexity (new missions, long time lines), the tools always being somewhat in the research domain, lack of USACE technical expertise, G-REALM not being 100% automated, and the lack of 100% public access, placed this idea on a backburner.

G-REALM: Sustained Water Level Monitoring of Lake and Reservoirs

Current access to the Global Reservoir and Lake Monitor (G-REALM) is via the USDA/FAS Crop Explorer portal
https://ipad.fas.usda.gov/cropexplorer/

Application example

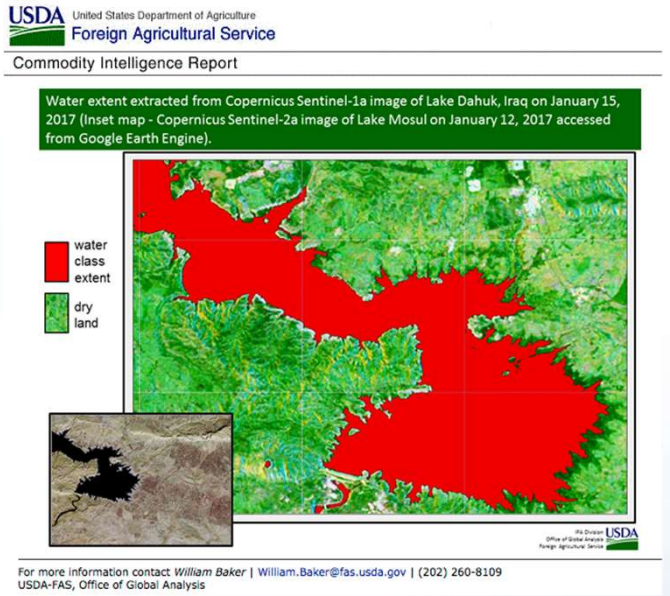
G-REALM provides water level data in **remote arid and semi-arid regions** where water resources vulnerability or poor infrastructure affects regional security. Temporal resolutions 10-35days across the 1992-2018 time span.

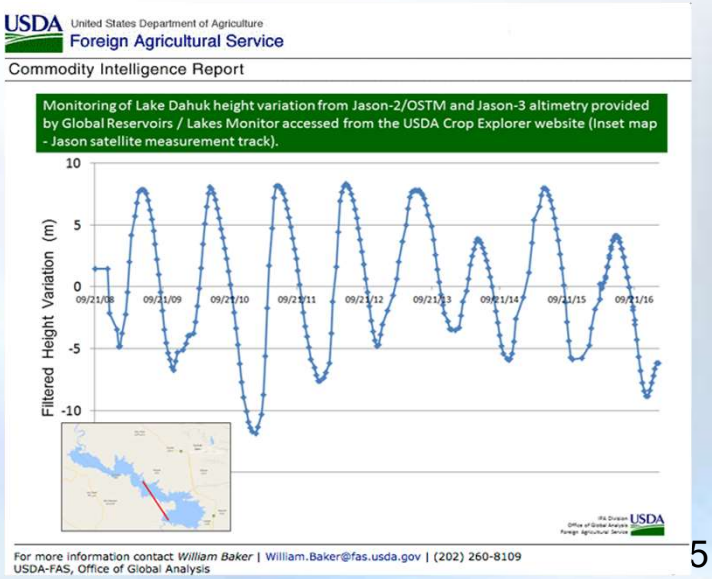
Example: Lake Dahuk (Mosul Dam, Iraq).
The largest dam in Iraq, the waters are a source for hydroelectric power and spring and summer crop irrigation. Recharge depends on snow melt in North-East Turkey.

The most dangerous reservoir in the world due to poor construction and downstream flood potential. The water level has been recently lowered to reduce pressure on the dam.

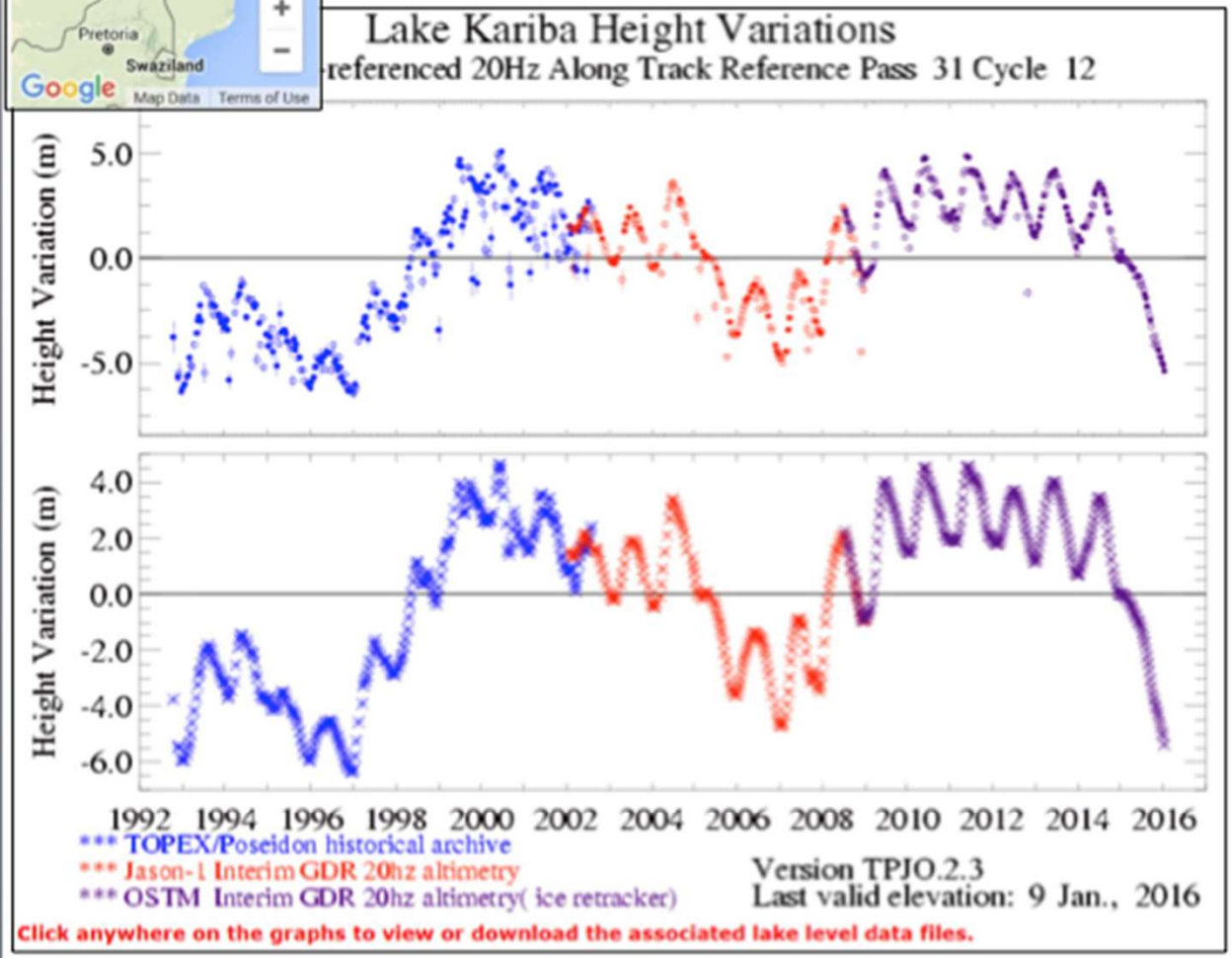
USDA/FAS regional analysts look to G-REALM products to help assess summer crop statistics.

https://pecad.fas.usda.gov/highlights/2017/02/iraq/index.htm





2015/16 Super El Nino Lowers Lake Kariba Water Levels (Zambia/Zimbabwe) to 12% Capacity (Jan. 9, 2016) and Power Generation Reduced to Conserve Water



Click anywhere on the graphs to view or download the associated lake level data files.

Zambia and Zimbabwe's Kariba dam levels sink to 12 percent as drought scorches

Tue Jan 19, 2016 2:34pm GMT

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LUSAKA Jan 19 (Reuters) - Water levels in southern Africa's Lake Kariba have dropped to 12 percent of capacity, the authority in charge said on Tuesday, raising concerns about severe power rationing in Zimbabwe and Zambia.

Both countries rely heavily on the Kariba dam for electricity.

The levels were 477.25 metres (1,500 feet) above sea level on Monday, just two metres above the point their working capacity, the Zambezi River Authority, which manages the lake for Zambia and Zimbabwe, said on its web site.

"The Kariba Lake was created and designed to operate between levels 475.50 metres and 488.50 metres," it said.

The dam was 12 percent full on Monday compared with 53 percent on the same date last year, underscoring the severity of a prolonged drought that threatens crops across the Southern African region where the United Nations has warned that 14 million people face hunger.

Zambia asked South Africa last week for up to 300 megawatts (MW) of emergency power to ease an electricity crunch that has hit mining companies already grappling with a slide in global copper prices.

Meanwhile, on Monday, water flow measurements from the famed Victoria Falls, a major tourist site, were recorded at 492 cubic metres per second, close to the historic low of 390 cubic metres per second posted in the 1995/96 season, its authority said.

Zambian power companies and mining firms in August 2015 agreed to cut power supply to the mines by 30 percent due to a power deficit which rose to 985 MW in September from 560 MW in March. (Reporting by Chris Mfula Editing by Jeremy Gaunt; Editing by Ed Stoddard/Jeremy Gaunt)

USDA Foreign Agricultural Service (FAS)
Office of Global Analysis (OGA
International Production
Assessment Division (IPAD)

Sources: USDA/NASA's G-REALM (Global Reservoir and Lake Monitor)
http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/
Reuters: https://www.reuters.com/article/africa-drought-kariba-idUSL8N1532RG

Gibe III Dam, Ethiopia, Begins Filling in 2016

Hydroelectricity

Ethiopia opens Africa's tallest and most controversial dam

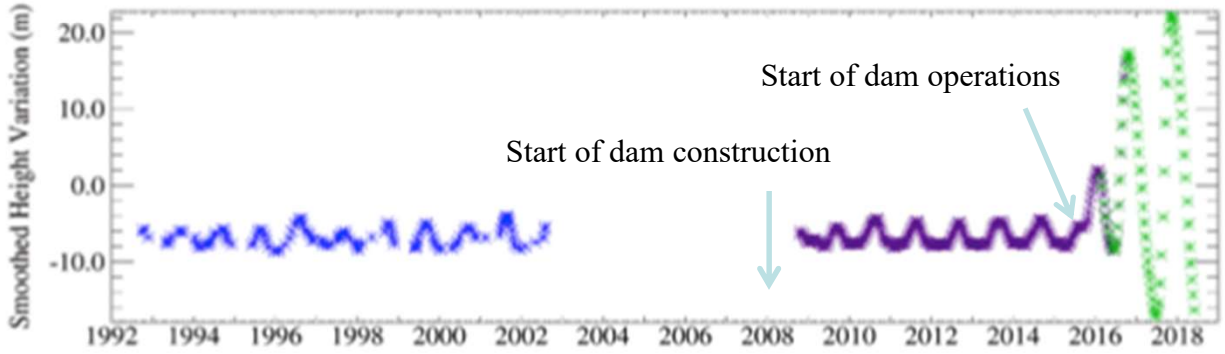
The Gibe III dam has the capacity to double the country's electricity output at the flick of a switch

SUB-Saharan Africa's largest mass-housing programme; its first metro; its biggest army. Ethiopia's government likes to deal in superlatives. Last week the ruling Ethiopian People's Revolutionary Democratic Front (EPRDF) added another to the list: the tallest dam.

After years of delay, due primarily to funding shortages, the prime minister, Hailemariam Desalegne, at last inaugurated the 243-metre (800ft) Gibe III dam on the Omo River on December 17th. Its hydroelectric plant has the potential to double the country's measly energy output at the flick of a switch.

Dubbed "the water tower of Africa", Ethiopia has long sought to harness the power of the rivers that tumble from its highlands. Flagship dam projects were central to the modernisation plans drawn up by the Italian administration of 1936-1941 and by the former emperor, Haile Selassie, in the 1960s. Gibe III is the latest in a series being built along the Omo River by the government, which is also constructing what will be the largest-ever dam in Africa when it opens, in theory, next year: the Grand Ethiopian Renaissance Dam on the Blue Nile. Together these projects are intended to turn Ethiopia, which has scarce minerals but enormous hydropower potential, into a renewable-energy exporter. Gibe III alone is expected to generate as much electricity as currently produced by the whole of neighbouring Kenya, which has enthusiastically signed up to buy some of its power. The export earnings will help to plug Ethiopia's gaping current-account deficit, while the cheap power will provide a timely fillip to its nascent manufacturing sector.

Lake Gilgel_Gibe_3



*** TOPEX/Poseidon historical archive
*** Jason-1 Interim GDR 20hz altimetry
*** OSTM Interim GDR 20hz altimetry (ice retracker)
*** Jason-3 Interim GDR 20hz altimetry (ice retracker)

Version TPJOJ.2.3
J-2 Ref Pass 31 Cycle 282
Last valid elevation:31 May, 2018

Sources: USDA/NASA's G-REALM (Global Reservoir and Lake Monitor)
http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/
Economist: https://www.economist.com/middle-east-and-africa/2016/12/21/ethiopia-opens-africas-tallest-and-most-controversial-dam

USDA Foreign Agricultural Service (FAS)
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International Production
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G-REALM: 2018-2020 Stakeholder Expectations

"Faster, better, smaller, more, AND maintain product continuity"

Improved system, accuracy, time coverage, and delivery

Greater number of lakes/reservoirs (~1,000)

Additional emphasis on capturing reservoirs in the 10-99km^2 size range

Additional emphasis on capturing in-fills of newly completed dams

Provision of additional reservoir information – dead/flood levels, bathymetry

Introduction of test-case lake extent products for storage analysis

Introduction of test-case level products for wetlands and fish catch analysis

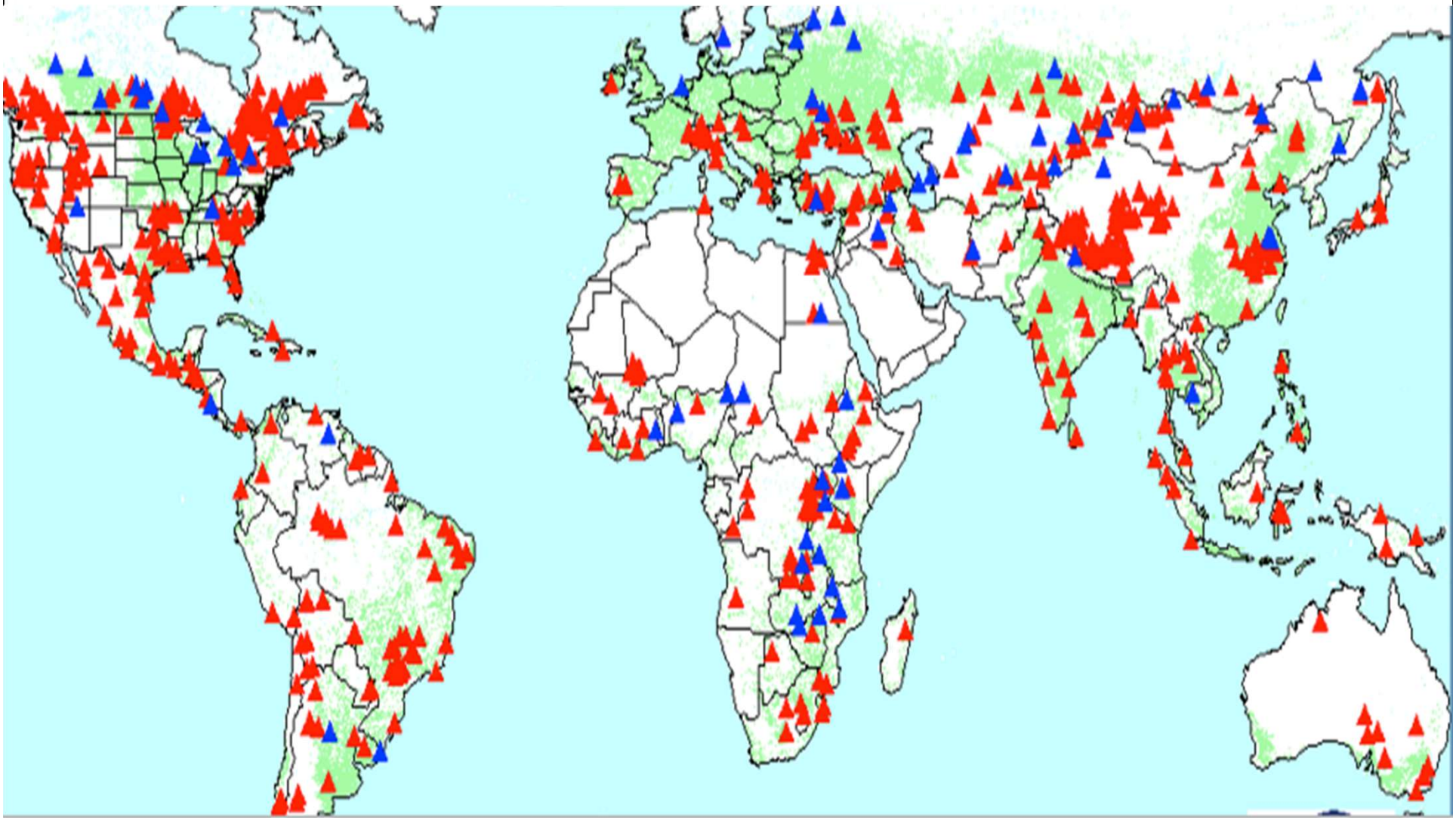
(New web site for test product access)

Continuity via Jason-CS and Sentinel series,
(additional storage products from Imagery/SWOT/ICESat-2/STRM)

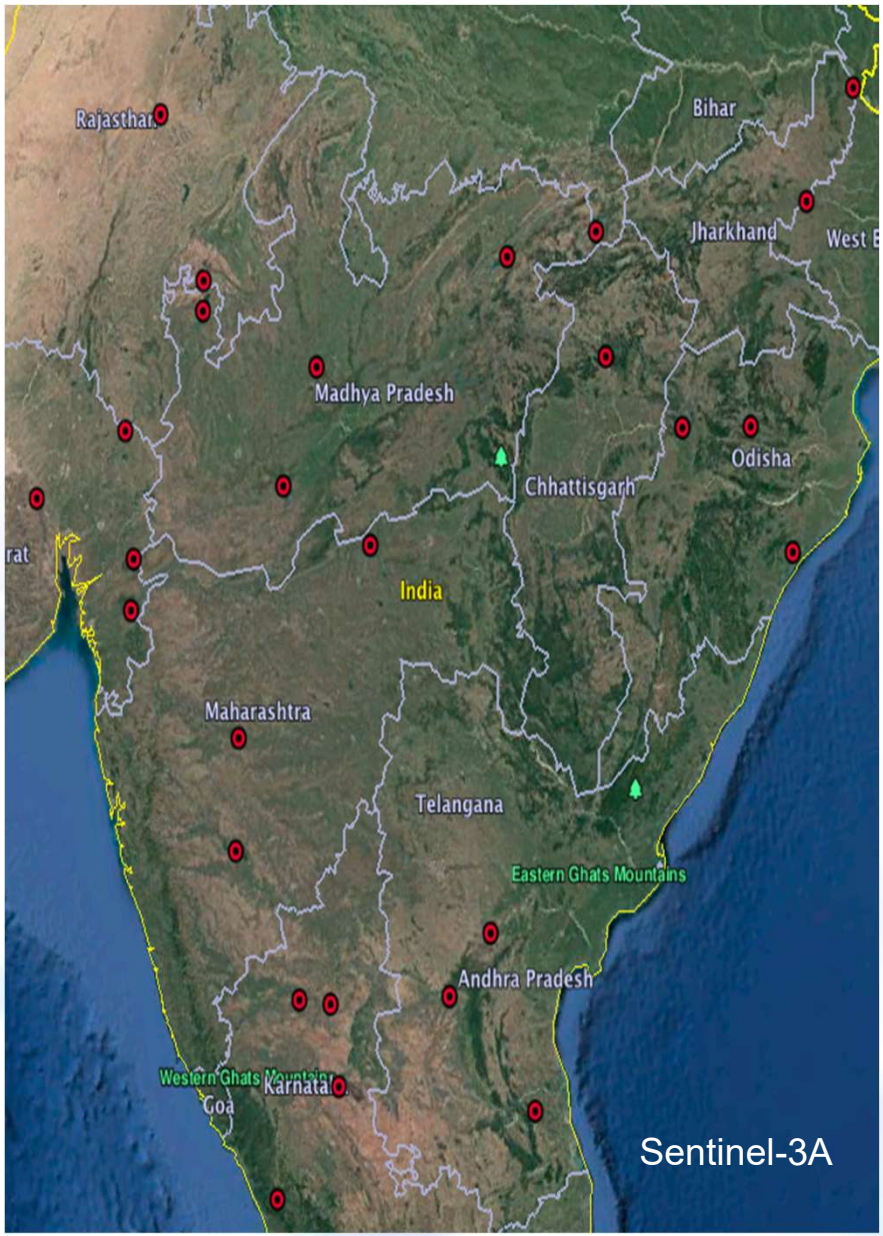
Sustained Operations - USDA (in part) but seeking other sources
Sustained Technical Core Input – Gov (NASA?) directed funding?

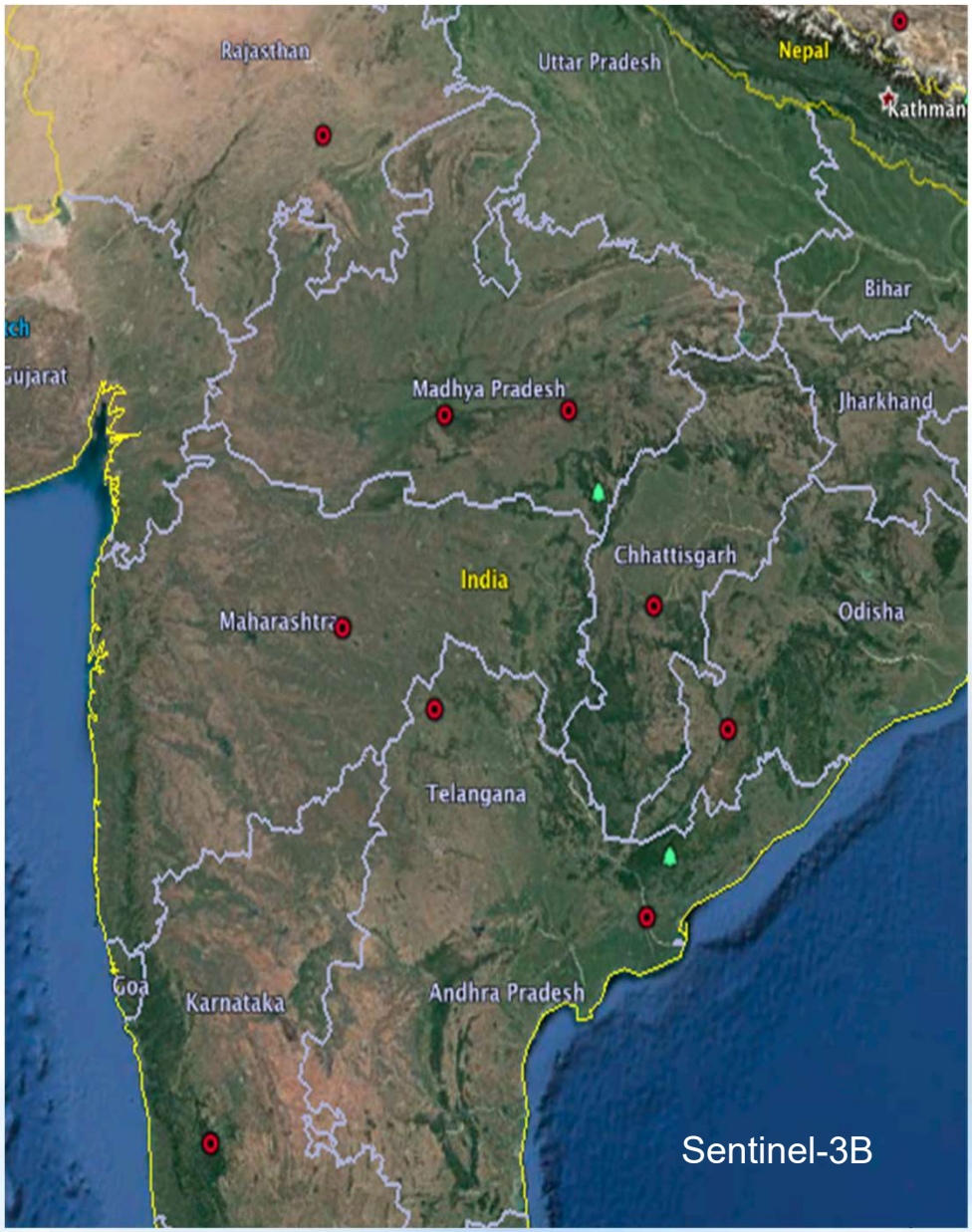
G-REALM:
Increased Number of Water Bodies via multiple altimeter platforms

Water body location and satellite overpass availability checks still ongoing – estimates place final numbers around 500 (≥100km^2) and an additional 500 (10-99km^2) in the mid-latitude range.

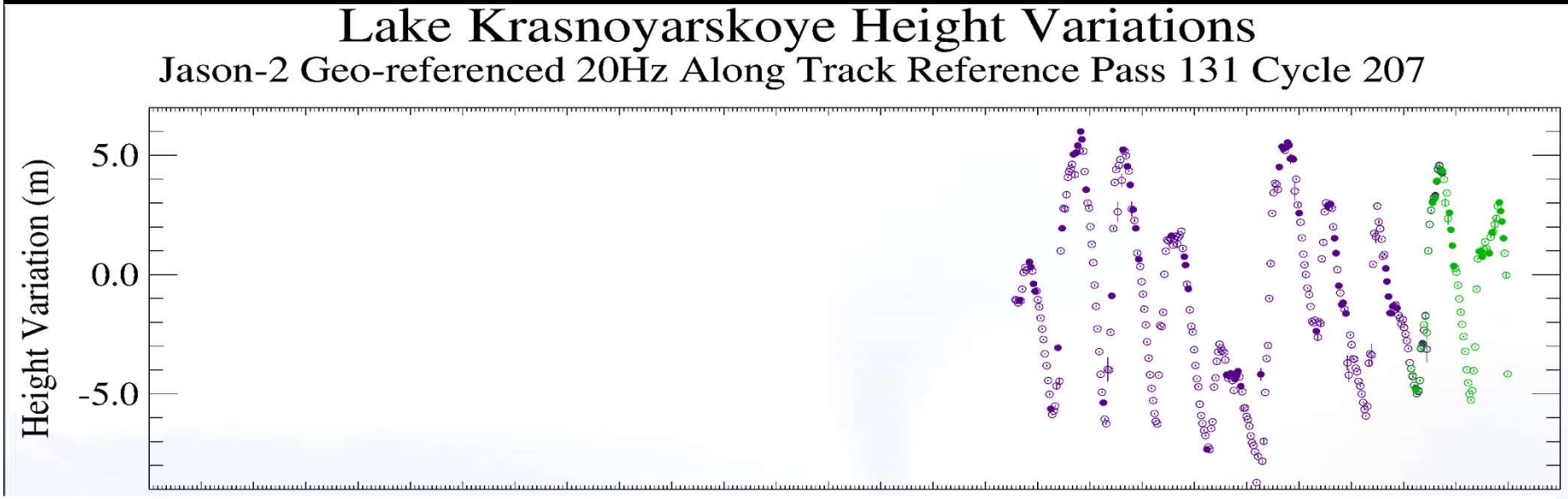


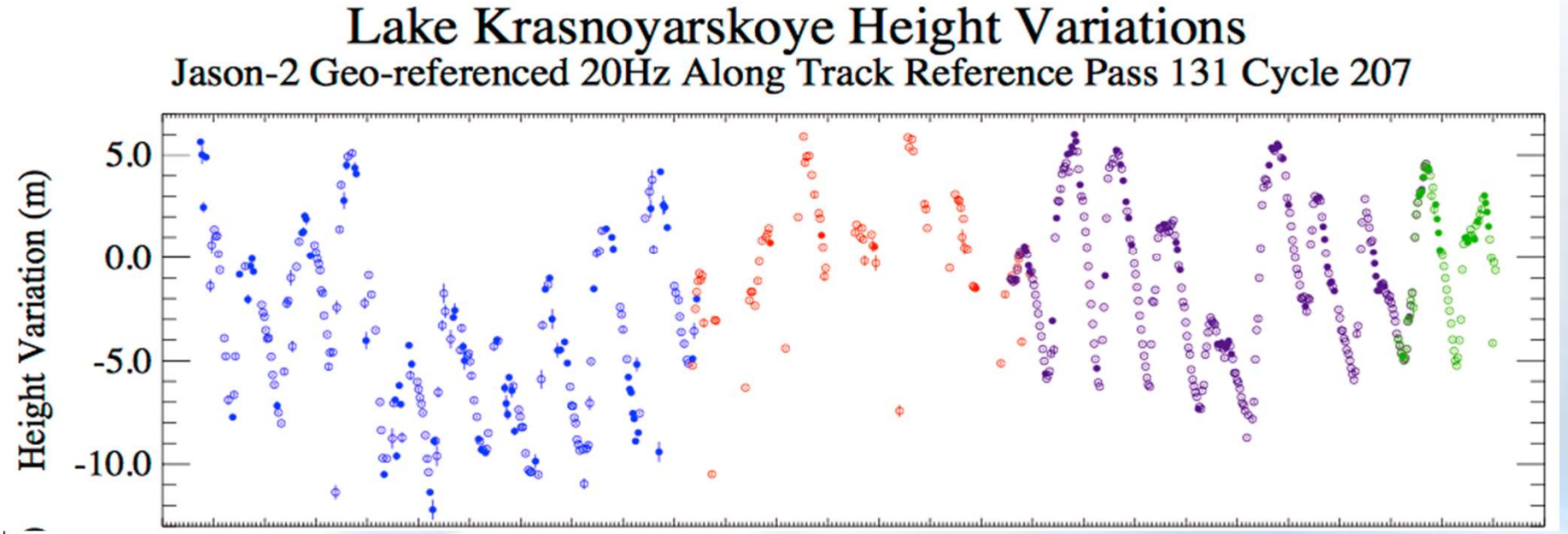
G-REALM: Additional lakes from the ESA Sentinel satellite series (e.g. India)



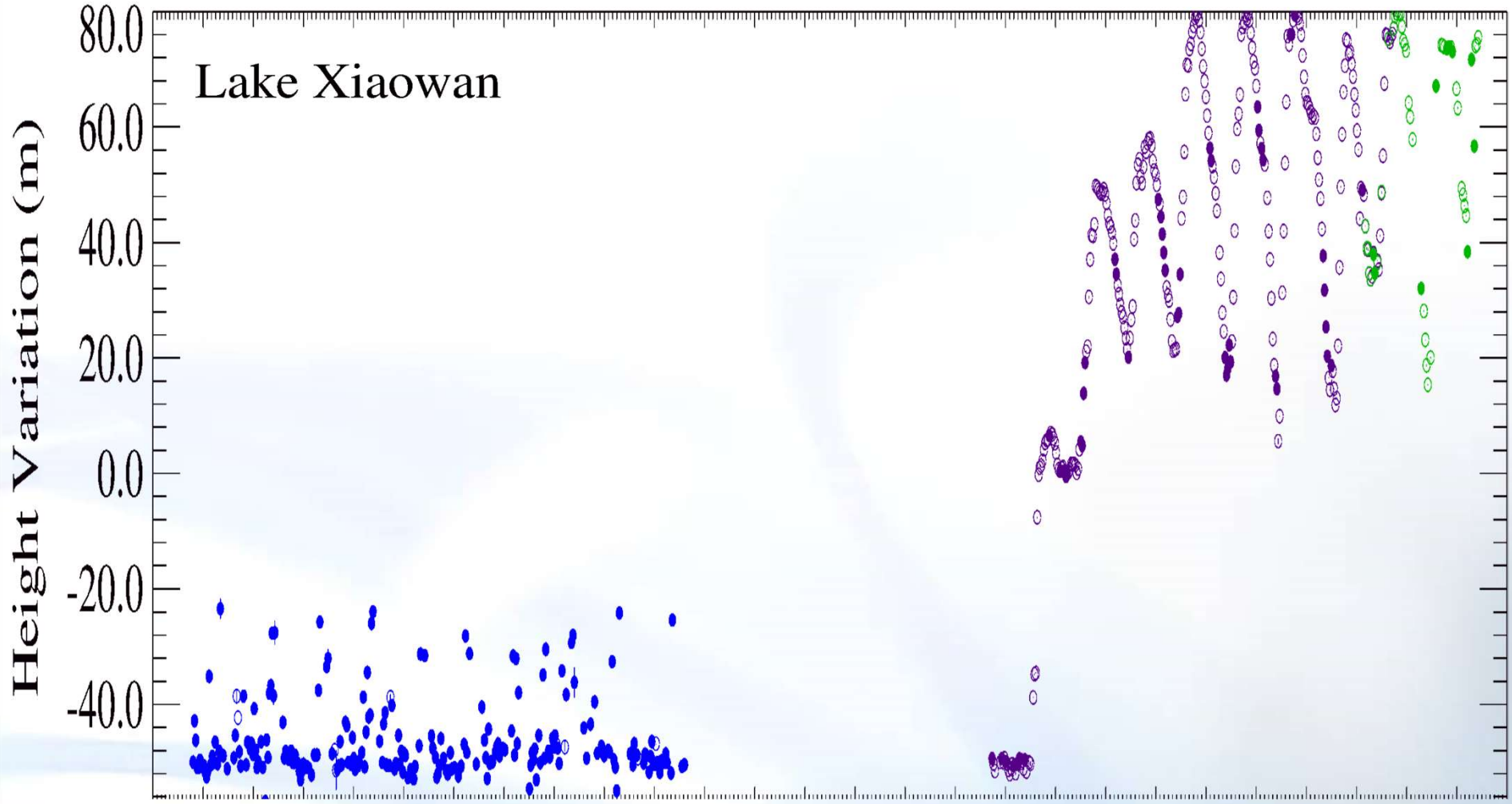


G-REALM: Extending product time series to gain longer-term perspective

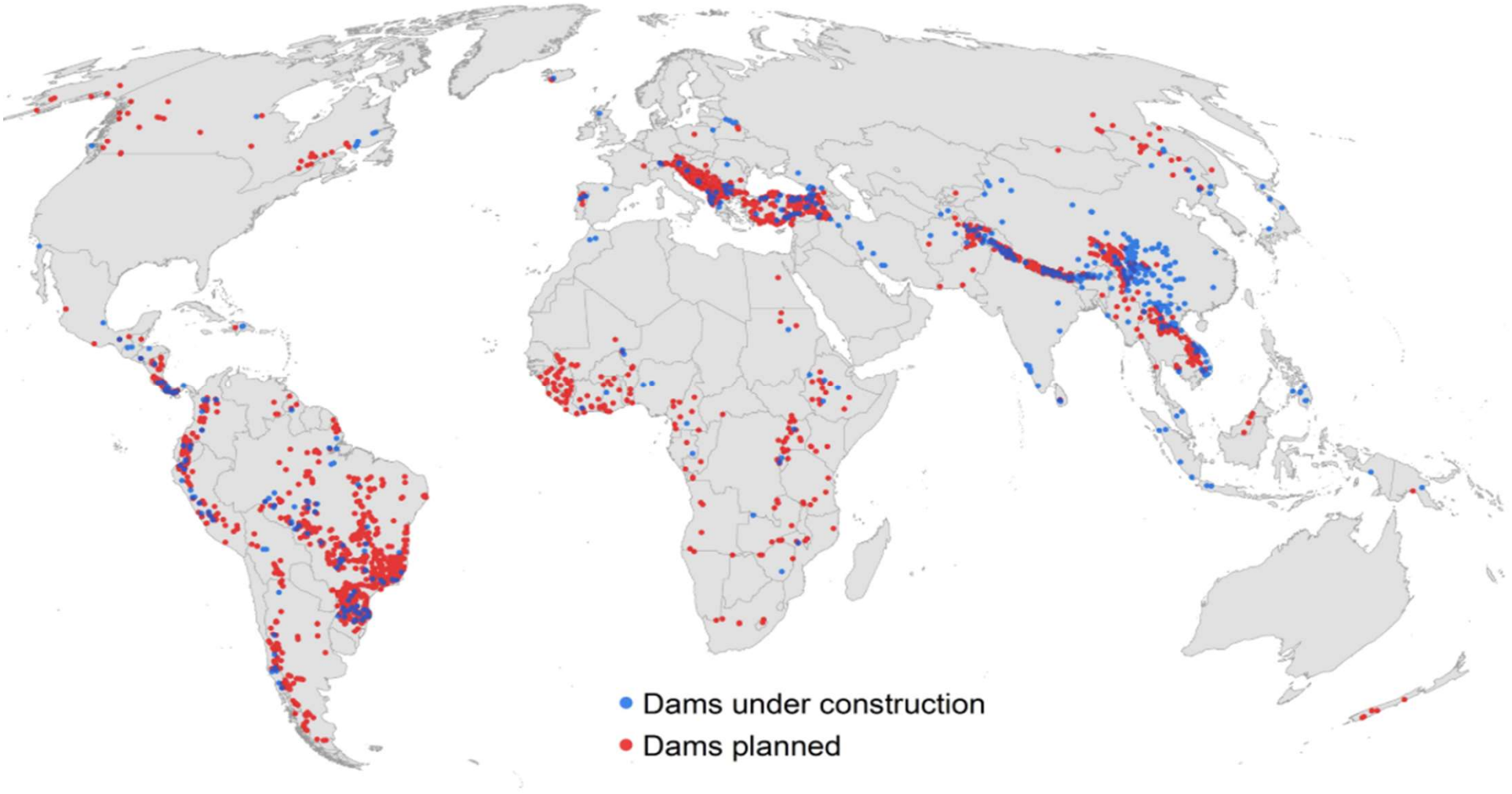




G-REALM: Capturing the in-fills of new reservoirs

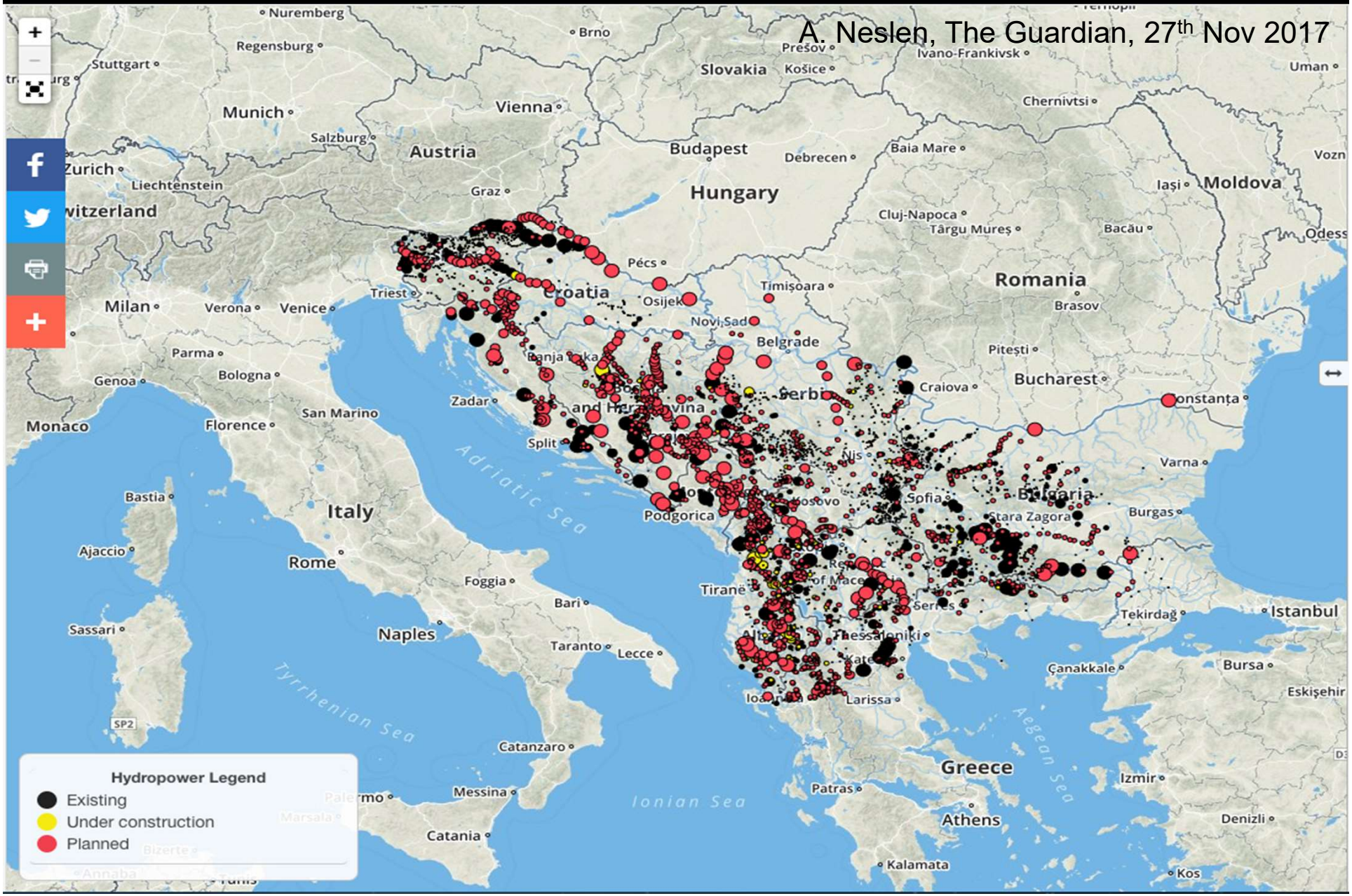


G-REALM: Using all-sources data for current and future reservoir location



Zarfl et al., (2015) “A global boom in hydropower dam construction”, Aquat. Sci. 77:161-170

G-REALM: (Balkan region in detail)



G-REALM: New Wetland Case Studies - Monitoring for Fish Catch Potential

Water Dynamics and Fisheries

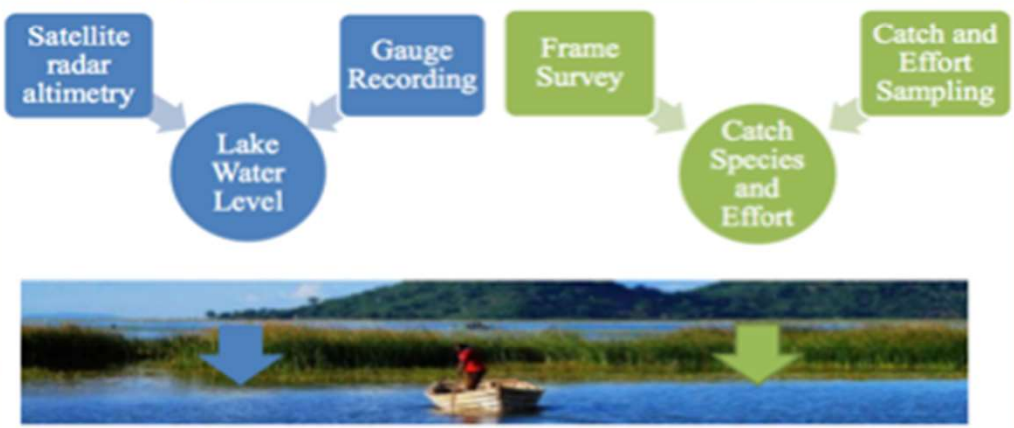
"Fish come with the rains"

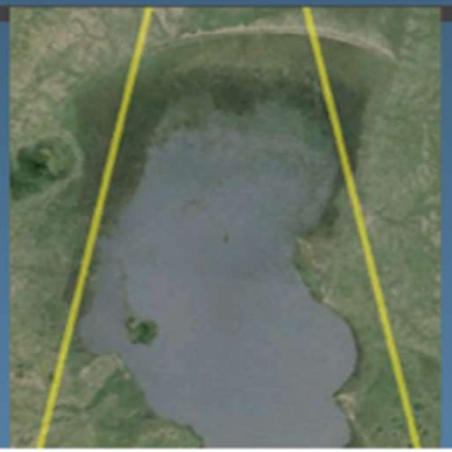
F. Simmance; A. Simmance; J. Kolding; G.M. Poppy; K. Schreckenberg; C. Birkett

Case Study: Endorheic Lake Chilwa, Malawi

Unstable, highly fluctuating, shallow, complex socio-ecological system. Van Zwieten (2003) determined lake level fluctuation significant factor governing catch.

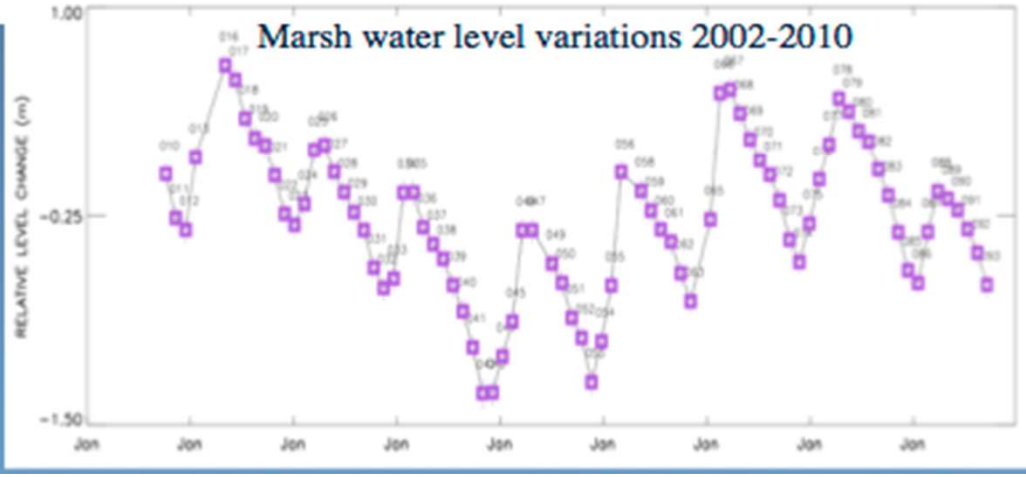
Presented at the Global Conference on Inland Fisheries, FAO HQ, Rome, January 2015





Time Series Multiple Regresssion: between RLLF, fishing effort and catch by species

0079.Chilwa Pass092 ENVISAT – Try1 Sealcetracker USO-corrected



Non G-REALM wetland product showing 1m seasonality, general decline 2002-2007 followed by recovery. Consistent with historical gauge data. "Cost-effective, timely and reliable monitoring, combined with RLLF may provide a deeper understanding of **drivers and trends**". Smaller lakes included in G-REALM program in Years 3+4. Inclusion of marsh/wetlands – a future direction?