# **Monitoring Reservoir Initial Impoundment (MRI<sub>2</sub>)**

# A Satellite-based tool to monitor the initial impoundment of new reservoirs in the Nile River basin Developed by Hisham Eldardiry (<u>dardiry@uw.edu</u>)



- MRI<sub>2</sub> is one of the NiBRAS tools that is currently implemented for the Grand Ethiopian Renaissance Dam (GERD)
- MRI<sub>2</sub> has two main products: 1) Hydrological Modeling Outputs and 2) Reservoir Modeling Outputs.
- The **hydrological modeling** over the Upper Blue Nile (UBN) is implemented using Variable Infiltration Capacity; VIC model). The VIC model was calibrated and validated at Eldiem station (GERD location and outlet of UBN).
- The **reservoir modeling** is based on deriving the reservoir storage area using a suite of satellite sensors including Landsat-8, Sentinel-1, and Sentinel-2.
- For more details on the reservoir and hydrological modeling framework, the user is referred to Eldardiry and Hossain (2019) [more references are provided at the end of this guide].

#### **Reservoir Modeling Outputs**

• MRI<sub>2</sub> uses three satellite missions (Landsat-8, Sentinel-1, and Sentinel-2) to monitor the initial impoundment of GERD (the only NiBRAS Watch or dam currently implemented in the tool).

Monitoring Reservoir Initial Impoundment   MRI <sub>2</sub>						RI <sub>2</sub> Products	About MRI <sub>2</sub>	User Guide	NiBRAS Home	
				Reser	voir Modeling	Outputs				
	Satellite Mission		Reservoir	(	GERD Elevation (A	AMSL)	Select Date	Gener	ate Maps	
L	Landsat-8	^	GERD	~	655	~	2021-07-04		Submit >>>	
	Landsat-8									
	Sentinel-2		Kar		Ammai	IRAQ	Cuwait City		Lahore	
	Sentinel-1 (SAR)	LG	RIA	IBYA	EGYPN	SAUDI ARABIA	Dubai	Karachi	<ul> <li>✓ Nile Streams</li> <li>✓ NiBRAS Wat</li> </ul>	tch
	MAURITANIA	~	1			oRiya Jeddah	OMAN	A	hmedabad INDIA Existing Dar Existing Dar Pune	ms N

• To check whether the GERD has been filled to one of its key elevations, the user can select a hypothetical GERD elevation and visualize how much of the GERD lake has been filled (as compared to the contour or boundary of the selected elevation). The default value is set to "655 m", which is the crest level of GERD.

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		Reser	voir Modeling Outputs	;	_		
Satellite Mission	Reservoir	(	GERD Elevation (AMSL)		Select Date	Gene	rate Maps
Landsat-8	∽ GERD	~	655 ^		2021-07-04		Submit >>>
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(a) (a)	ALGERIA		586	Riya	Dubai	PAKISTAN	vew Deini ✓ Nile Streams ✓ ヘ NiBRAS Watch
MAURITANIA			636		OMAN	Mum	Ahmedabad INDIA
DakarosENEGAD Bamako	MALI NIGER CHAD	1	<b>655</b> 686	E ME	Arabia	an Sea	Bengaluru Chennai

• The default date is set to yesterday date since the models run every day (at the end of the day) after having the forcing data, e.g., precipitation, available for running the hydrological model. The outputs are therefore made available in the next day.

Monitoring Reservoir Initial	Impoundment I MRI <sub>2</sub>	MRI <sub>2</sub> Products	About MRI <sub>2</sub> User C	Guide NiBRAS Hom	ne	
	Res	ervoir Modeling Outputs				
Satellite Mission	Reservoir	GERD Elevation (AMSL)	Select Date	Generate Maps		
Landsat-8 ~	GERD ~	655 ~	2021-07-04	Submit >>>		
		Amman IRAQ	July 2021	D		
MOROCCO	V 9 3	<b>K</b>	, Su Mo Tu We Th	Fr Sa	✓ Basin Boundary	
Set AL	GERIA		1	1 2 3	Vile Streams	
		SAUDI ARABIA	4 5 6 7 8	8 9 10	NiBRAS Watch	
		Jeddah	11 12 13 14 15	5 16 17 edabad INDIA	Existing Dams	
MAURITANIA		Red	18 19 20 21 22	2 23 24 Pune	Future Dams	
Dakaro	NIGER	SUDAN Chartouni YE ME	25 26 27 28 29	9 30 31 Hyder	abad Bay of Bengal Yan	

• Once the user submits the request to generate maps, the tool will zoom into the GERD dam showing a spatial map of the GERD lake as derived from the satellite mission and in comparison to the boundary of the selected elevation contour (default is 655 m AMSL).



• The user can zoom out to see the entire boundary of the hypothetical GERD lake (i.e., at elevation of 655 m). It is obvious that the GERD has not reached the elevation 655 m AMSL (on July 4<sup>th</sup>, 2021).

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	Res	ervoir Modeling Outputs			
Satellite Mission	Reservoir	GERD Elevation (AMSL)	Select Date	Generate Maps	
Landsat-8 ~	GERD ~	655 ~	2021-07-04	Submit >>>	
					<ul> <li>Basin Boundary</li> <li>Nile Streams</li> <li>NiBRAS Watch</li> <li>Existing Dams</li> <li>Future Dams</li> </ul>

• The user can also explore the GERD lake as derived from other missions such as Sentinel-1 and Sentinel-2.





• The images of GERD lake are saved for the last four years and therefore the user can visualize the GERD lake for the same date last year (to compare the filling progress).



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	Reservoir M	odeling Outputs		
Satellite Mission	Reservoir GERD El	evation (AMSL) Select Da	te Generate	e Maps
Sentinel-1 (SAR) 🛛 🗸	GERD ~ 586	5 ~ 🖄 2020	9-07-04	Submit >>>
				<ul> <li>Basin Boundary</li> <li>Nile Streams</li> <li>NiBRAS Watch</li> <li>Existing Dams</li> <li>Future Dams</li> </ul>

• The NiBRAS Watch icon indicates the dams or stations that are currently monitored by the MRI<sub>2</sub> tool. In case of MRI<sub>2</sub> tool, only GERD and Eldiem station (same location as GERD) are monitored.



• When clicking on GERD, the user can visualize the daily inflow into the dam based on the hydrological modeling over the UBN (using the VIC model). The VIC model runs every day to simulate the hydrology of UBN and produces the streamflow at Eldiem station (or GERD inflow).

	Satellite Mission		Reservoir		GERD Elevation	n (AMSL)	Select Da	ite	Generate Maps	
	Landsat-8	~	GERD	~	655	~	📛 2021	-07-04	Submit >>>	
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Paris	Vienna		Inflow	Impour	nding Elevation	Im	pounding Sto	rage		Nile Streams
FRANCE	AUS TRIA HUNG			Bos	anyoir Inflow			_	MONGOLIA	NiBRAS Watch
2	TTALY		Dam: Grand	Ethiopian Rer	aissance Dam	River: Blue N	ile	=		Future Dams
Barcelona	Rome	30000.0							The	Beijing
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	X			_	Reservoir Inflow				(a) (BURMA)	HongKong
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CINA SO	Kano					Ber	ngaiuru ynennai		Bangkok VIETNAM	Manila
500 km NLG	BERIA	han	Addis Ababa		Leaflet   Tiles © Esri	Source: Esri Del orme 1	NAVTEO LISGS Int	erman iPC NBCA	Phnom Penho Ho Chi Minh City	FHILIPPN
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• In the popup window, the user can also explore the impoundment rate (elevation and volume) of GERD as monitored by different satellite missions.

Satellite Mission	Reservoir	GERD Elevation (A	MSL) Select	t Date	Generate Maps	
Landsat-8	∽ GERD	~ 655	~	2021-07-04	Submit >>>	
ondon Brugzele GERMANY Parts CZECHIA Parts Viena G AUSTRIA B	Inflow	Impounding Elevation	Astana Impounding	Storage		Basin Boundary Nile Streams
Barcelona OROme E	560.0 <b>Dam:</b> Grand	Reservoir Impounding Leve d Ethiopian Renaissance Dam R	l iver: Blue Nile	=	MÖNGOLIA	<ul> <li>Existing Dams</li> <li>Future Dams</li> </ul>
Mediterranear See Junis Algiers Tunis TUNIS (A Tripoli	540.0	$\bigwedge$			CHINA	Tianjin NOR
AL GERIA LIB YA	500.0 Jul '20 Sep	'20 Nov '20 Jan '21	Mar '21	May '21	Chengdu <sub>o</sub> Chongqing	Wuhan Shangh
J.	[	— Landsat-8 — Sentinel-1 — Sentine-	2	Elevation Quarte	MYANMAR a (BURMA)	Hong Kong
NIGER CHAE			Benganyu Sine	Elevation Curve	Yangon THAILAND Bangkok OAMBODIA Phnom Penho Ho Chi	

• The elevation and volume of GERD impoundment are calculated based on the Area-Elevation Curve (AEC) relationship for GERD. The AEC for GERD is derived based on SRTM satellite observations and can be displayed in the popup window.

Satellite Mission	Reservoir		GERD Elevation (A	MSL)	Select Date	Generate Maps	
Landsat-8	∽ GERD	~	655	~	2021-07-04	Submit >>>	
ondon Brussels GERMANY OCologne		×m	24	Astana			Denia Dena den
Paris CZECHIA Vienna	Inflow	Impo	unding Elevation	Impo	ounding Storage		Nile Streams
FRANCE Milan	Dam	Reservoir A	Area Elevation Cur enaissance Dam R	ve iver: Blue Nile	e	Mongolia	<ul> <li>NiBRAS Watch</li> <li>Existing Dams</li> <li>Future Dams</li> </ul>
id Barcelona oRome	4000.0					the second	Beijing
Mediterranean	3000.0				/		Tianjin
oAlgiers Tunis TUNISIA Tripoli	2000.0					CHINA <sup>X1'an</sup> Chengdu	Wuhan Shangh
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KINA Kano 500 km NIGERIA	man wind	lis Ababa	Leaflet   Tiles © Esri – Sour	Beng ce: Esri, DeLorme, NA	AVTEQ, USGS, I	Bangkok VIETNAM Phnom Penho Ho Chi Minh City CAN, Esri Japan, METI, Esri China (Hong Kong).	Esri (Thailand), TomTorn, 2012

• The MRI<sub>2</sub> provides a variety of overlay maps including Google Satellite, Terrain Map, and Street Map.





• The user can display the existing and future dams in the Nile basin based on the databases produced by Lehner et al. (2011) [existing dams or GRaND Database] and Zarfl et al. (2015) [future hydropower dams]. These layers are turned off by default.



# **Hydrological Modeling Outputs**

• The second product from the MRI<sub>2</sub> tool is the outputs from the hydrological model.



• The user can explore different hydrological variables upstream the reservoir of interest (e.g., GERD) including precipitation, evaporation, runoff, baseflow, and soil moisture.



• The hydrological variables are made available at daily and monthly scale.

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				Hydro	logical Modeling	Outputs				
Res	ervoir	Нус	drological Variable		Temporal Scale		Select Date	Gener	ate Maps	
	GERD	~	Precipitation	~	Daily	^	2021-07-04		Submit >>>	
					Daily					
Dakeros	MOROCCO MAURITANIA AMA ENEGAD Bamako By Comany Comany Comany Comany Comany Comany Comany	AL GERIA LLI RKINA HANA III AACTA SAGA	LIBYA NIGER Kano NIGERIA DAMEROON SABON CONCO Kinshaa D	RAL	Honthy	AUDI ARABIA oRiyac Iddah Ujibouti dia Ababa DPIA S OMALIA Mogadisi	Arab	PAKISTAN Garachi A Mumbu ran Sea	Lahore New Dathi ymedabad INDIA Bengalymu Chennal Colombo	Basin Boundary Nile Streams NIBRAS Watch Existing Dams Future Dams Bay of Bengal Yan

• Producing a spatial map of the total daily precipitation on July 4<sup>th</sup>, 2021 over the UBN (almost zero precipitation).





• Producing a spatial map of the total daily evaporation on July 3<sup>rd</sup>, 2021 over the UBN.

• Producing a spatial map of the total monthly precipitation on June, 2021 over the UBN.



• Producing a spatial map of the total monthly runoff on June, 2021 over the UBN.



### References

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