
GEO GLOWS
GLOBAL WATER SUSTAINABILITY
Providing a service to deliver global water information for local decision-making
On behalf of the GEOGloWS Team
NASA
USAID
SERVIR
AQUAVEO
THE WORLD BANK
BYU
aws
esri
ECMWF
copernicus

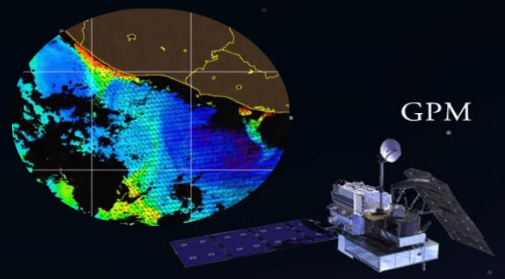
GEO Global Water Sustainability Initiative

GEO GLOWS
GLOBAL WATER SUSTAINABILITY

Connect People with Global Water Information

SERVIR GLOBAL

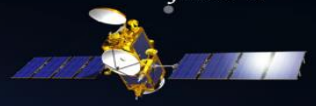
Weather and Climate



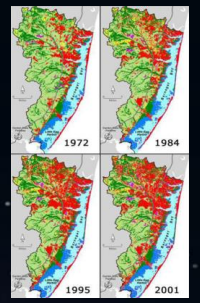
Food Security

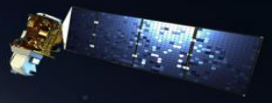
Resilience In…

Water and Disasters



Land Use Change





ICIMOD

CILSS

RCMRD

adpc

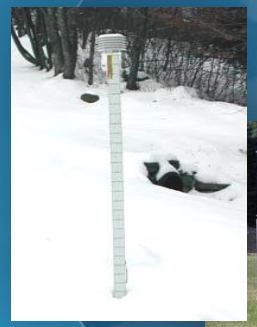
CIAT

Connecting Space To Village

In Situ Streamflow Monitoring Systems

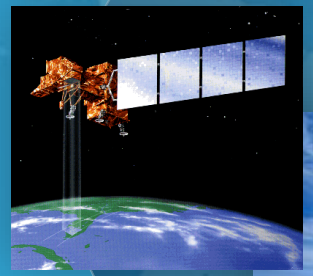
Water Quantity and Quality

Rainfall & Snow



Meteorology

Remote Sensing

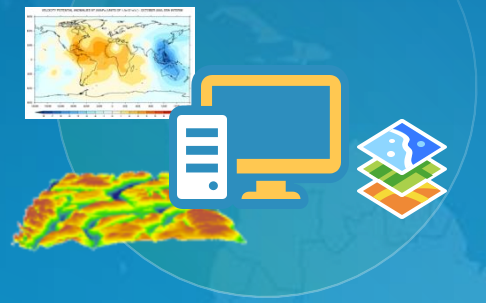


Soil Water

GEOGloWS Global Streamflow Services – A Paradigm Shift

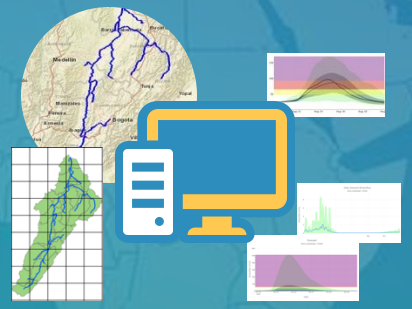
Individual Hydrologic Forecasting

DEM, Land Use, Meteorology



Global Data

Hydrologic Modeling



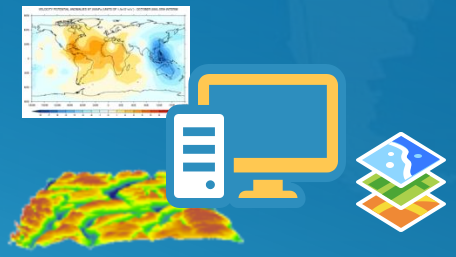
HydroMet Services

Local Governments

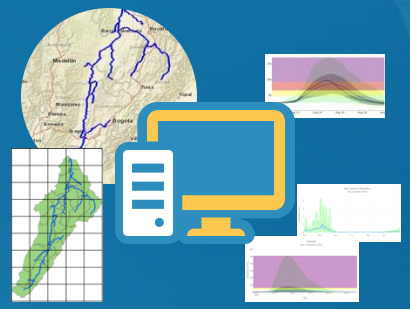
NGO's and GEO Partners

Global Hydrologic Forecasting

DEM, Land Use, Meteorology



Hydrologic Modeling



Global Services

HydroMet Services

Local Governments

NGO's and GEO Partners

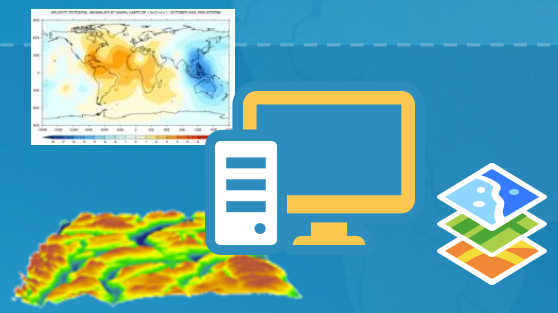
Primary Challenges of Making a Global Model Useful Locally

Global Hydrologic Forecasting

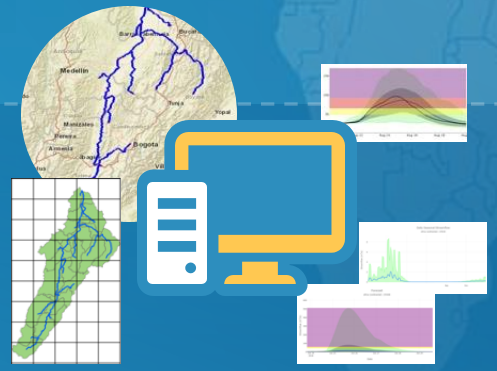
Challenge 1: Build a Model

Challenge 2: Make it Usable

DEM, Land Use, Meteorology



Hydrologic Modeling



Global Services

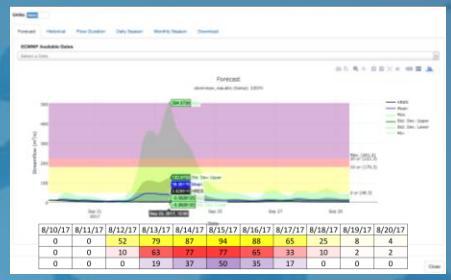
HydroMet Services

Local Governments

NGO's and GEO Partners

GEOGloWS ECMWF Streamflow Services

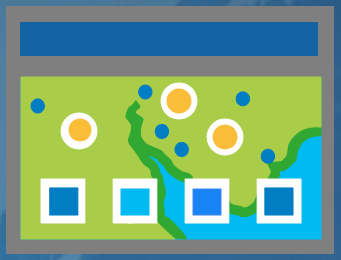
Web Services



Streamflow API at ECMWF

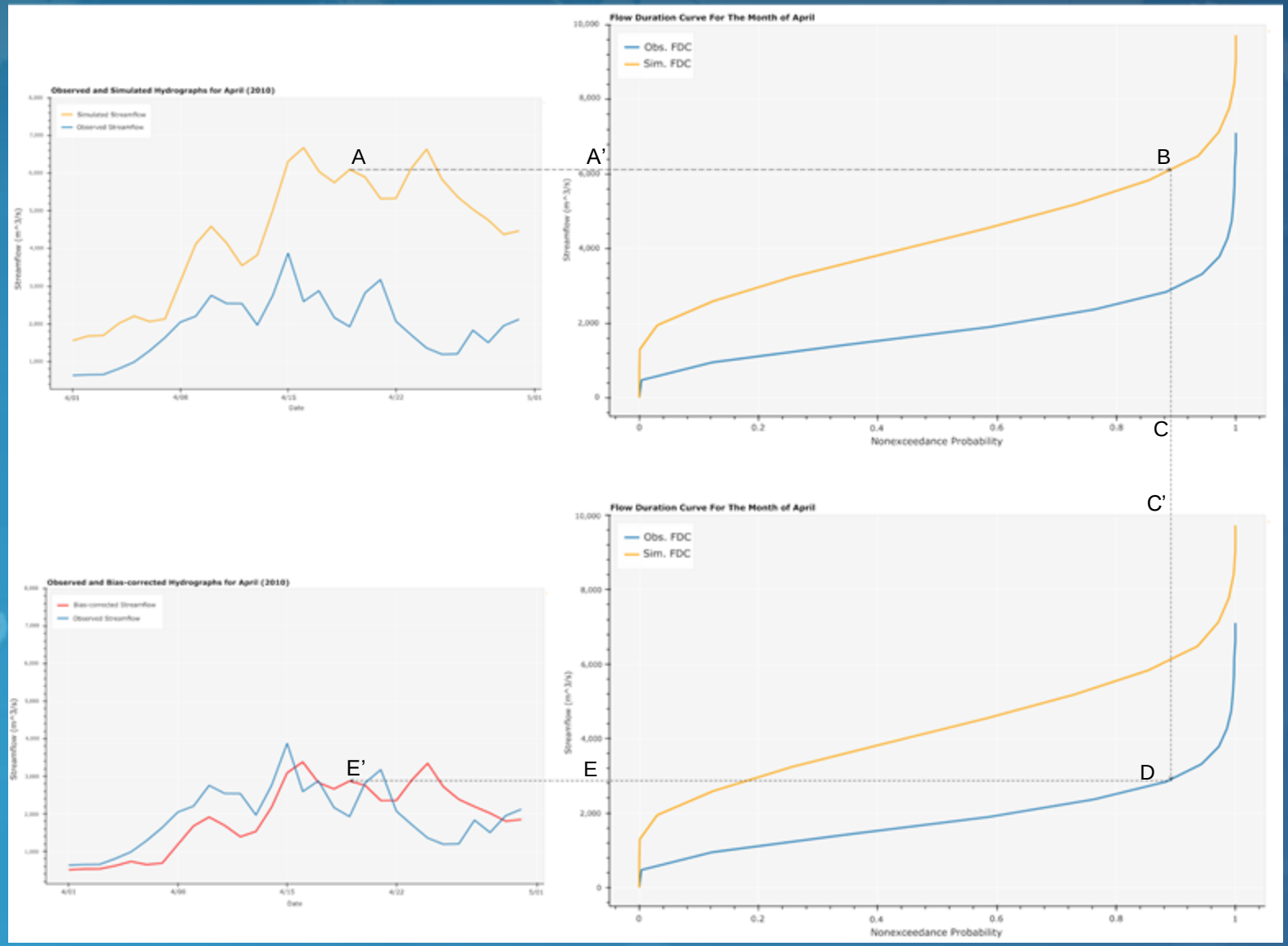
Global WMS at Living Atlas

Custom Web Apps

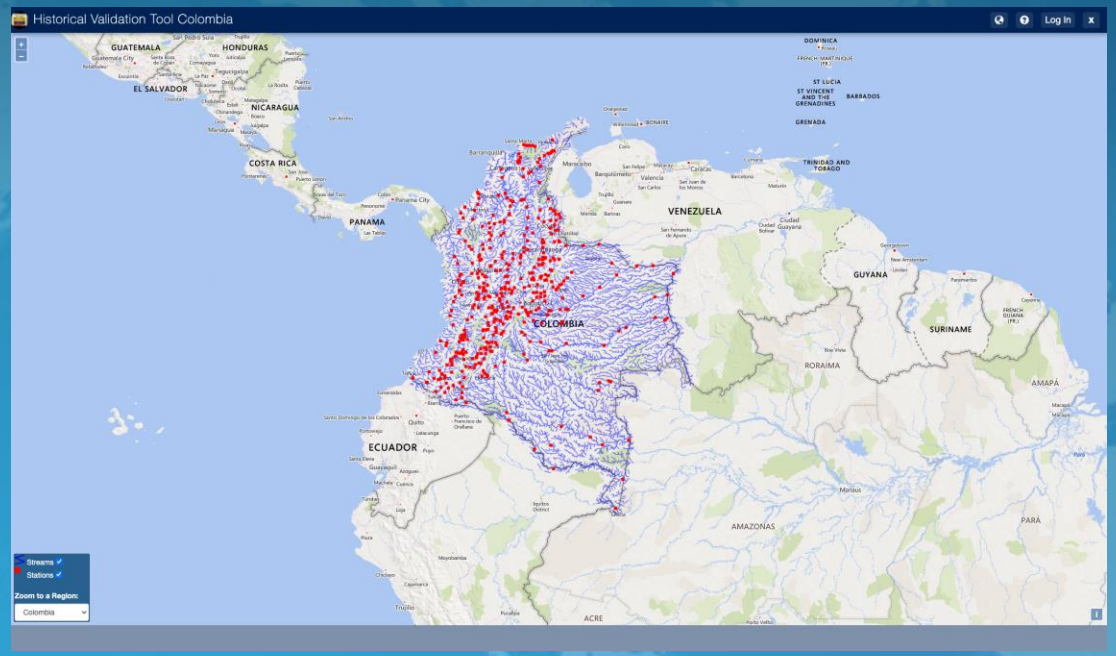


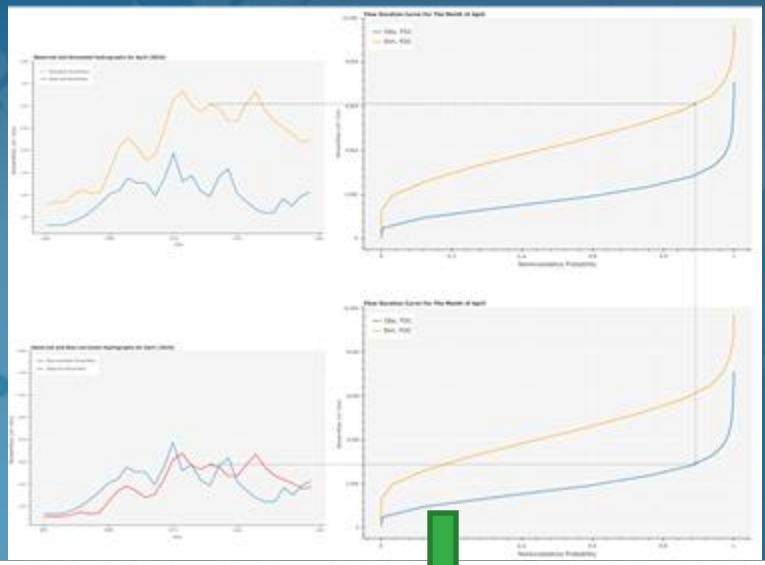
Farmer's Method of Bias Correction

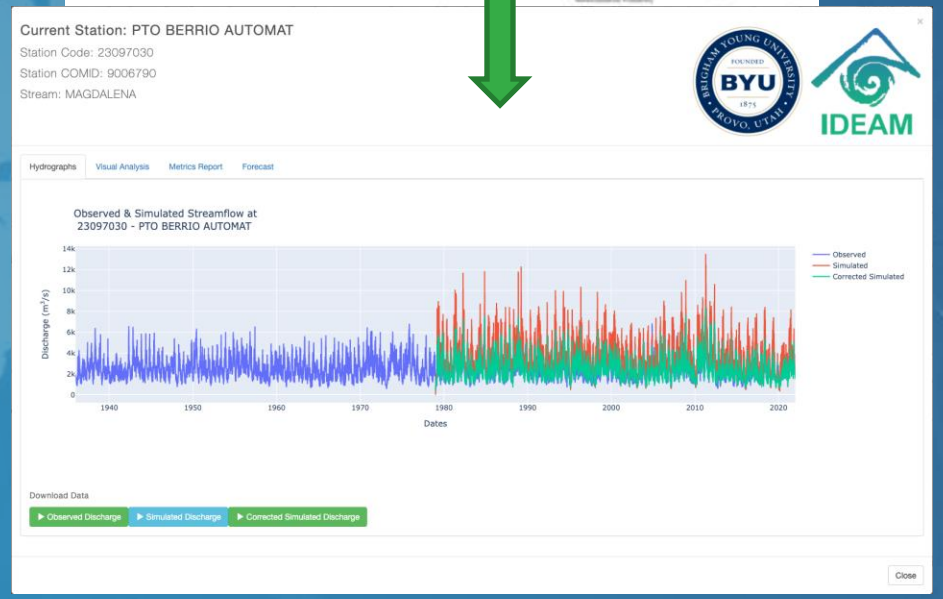
- **Match exceedance probability of simulated to observed**
- **Remap simulated discharge based on the corresponding discharge from observed**



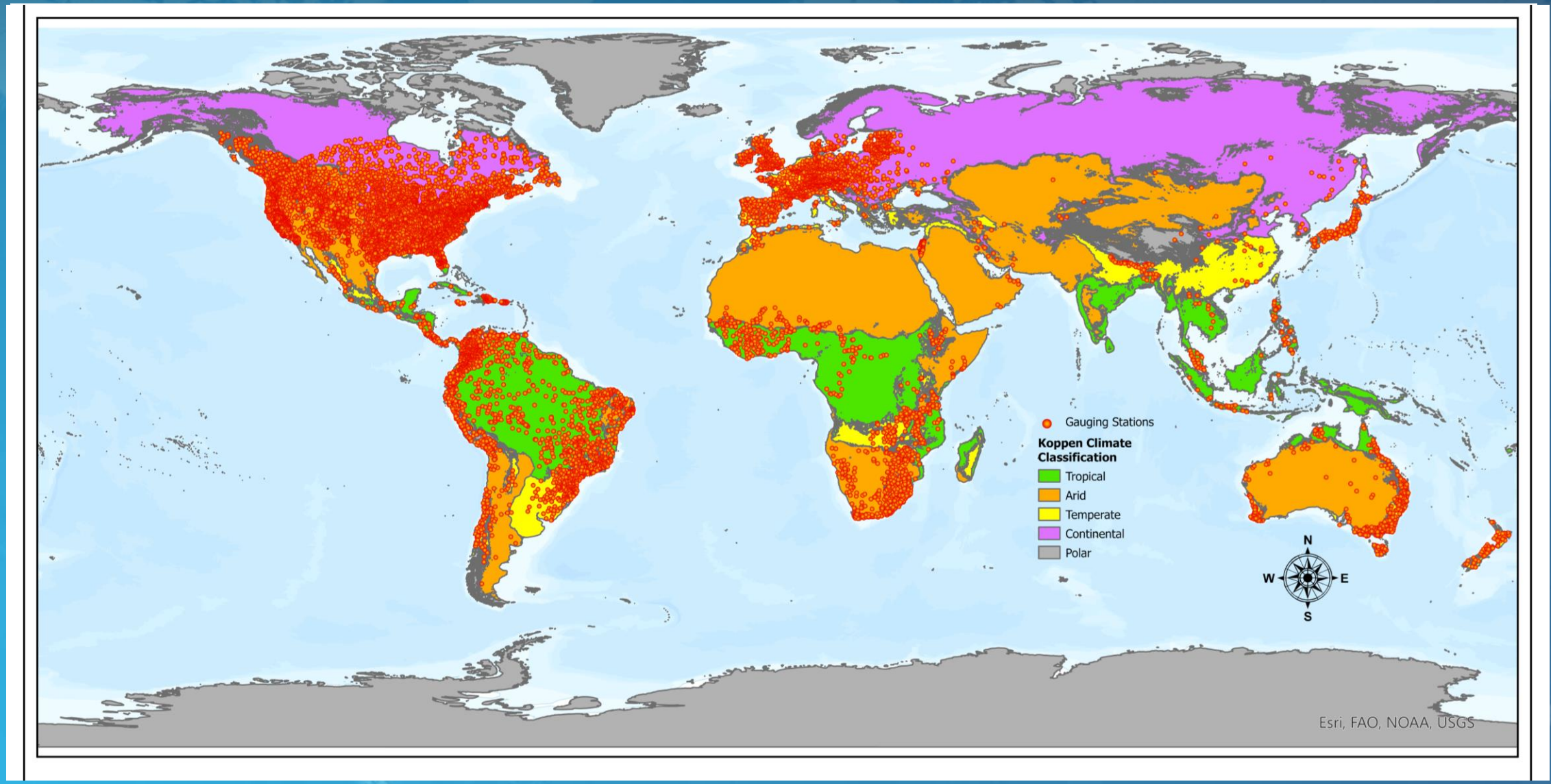
Bias Correction with Local Data







Validation and Local Adaptation



Validation and Local Adaptation

Observed Data

Gauging Stations per GEOGloWS Region.

Region	Number of Stations
Africa	1198
Australia	486
Central America	1953
Central Asia	2
East Asia	45
Europe	1931
Islands	137
Japan	152
Middle East	80
North America	7336
South America	2155
South Asia	95
West Asia	16

Gauging Stations per Köppen climate classification group.

Köppen climate classification group	Number of Stations
Arid	2471
Continental	5555
Polar	67
Temperate	5487
Tropical	2006

Gauging Stations per Simulated Watershed Area.

Watershed Area	Number of Stations
≤ 500km²	3802
500km² - 2500km²	5850
2500km² - 5000km²	1820
5000km² - 10000km²	1421
10000km² - 50000km²	1882
50000km² - 100000km²	386
100000km² - 500000km²	321
> 500000km²	104

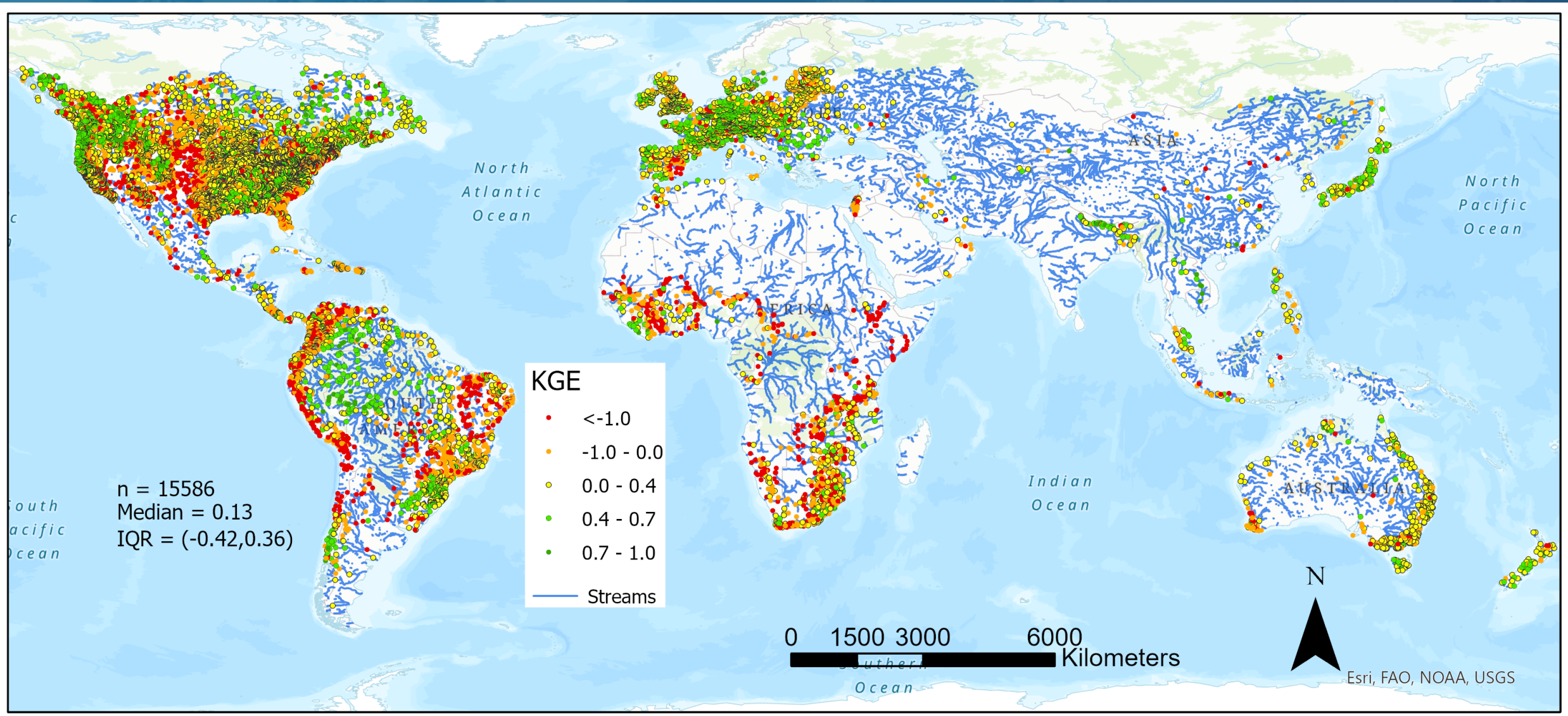
Gauging Stations per Observed Time Series Length.

Watershed Area	Number of Stations
≤ 5 years	3802
5 years - 10 years	5850
10 years - 20 years	1820
20 years - 30 years	1421
30 years - 50 years	1882
50 years - 100 years	386
> 100 years	104

Gauging Stations per Observed Time Series Length after 1979-01-01.

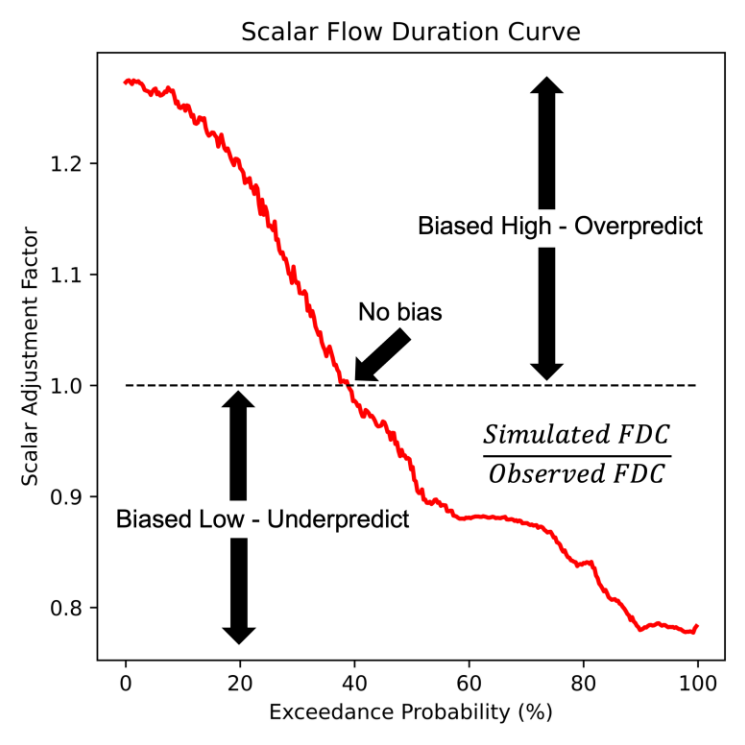
Watershed Area	Number of Stations
≤ 5 years	1677
5 years - 10 years	1150
10 years - 20 years	2673
20 years - 30 years	2261
30 years - 40 years	3000
> 40 years	4825

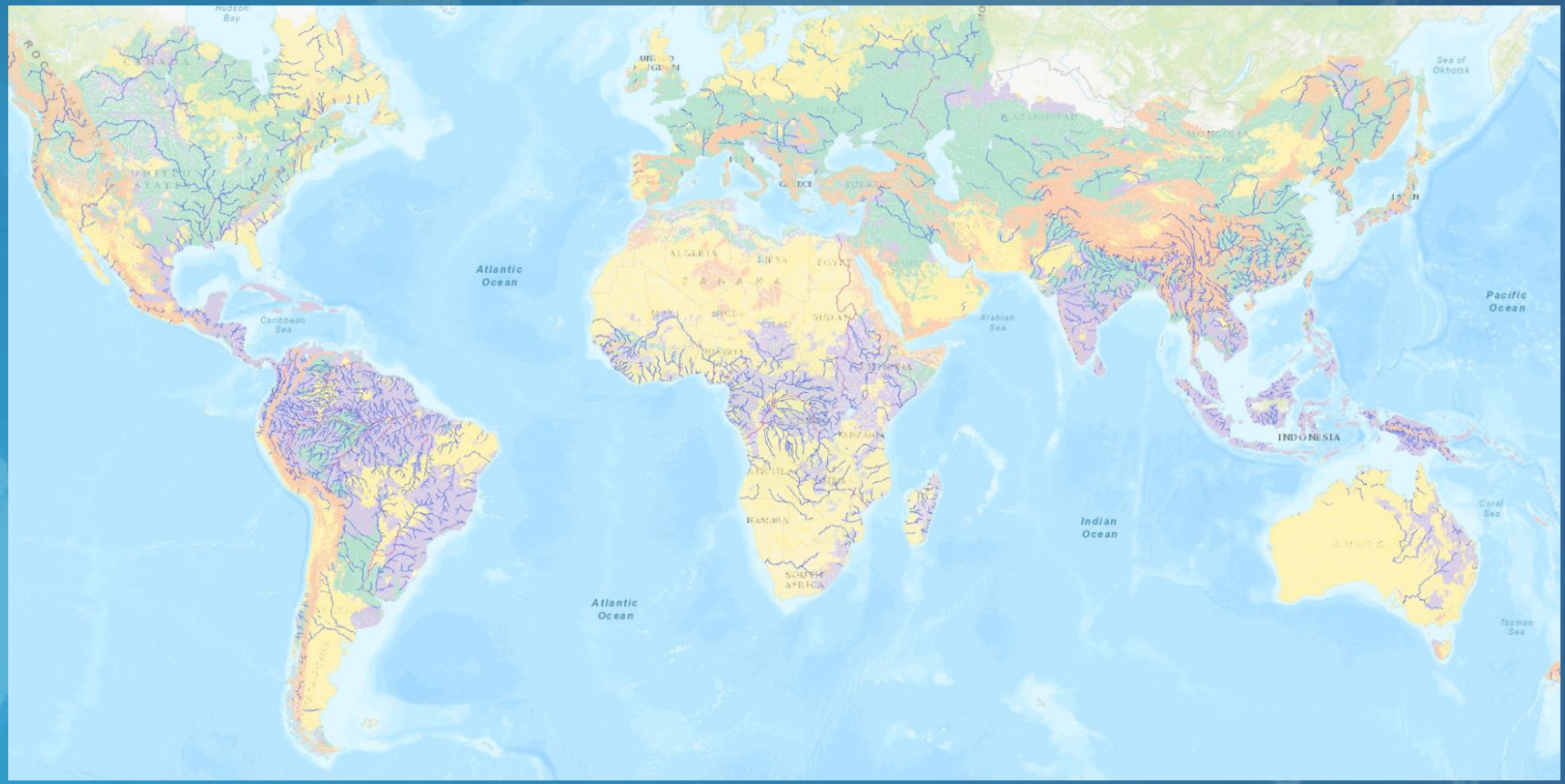
Global Validation



Validation and Local Adaptation

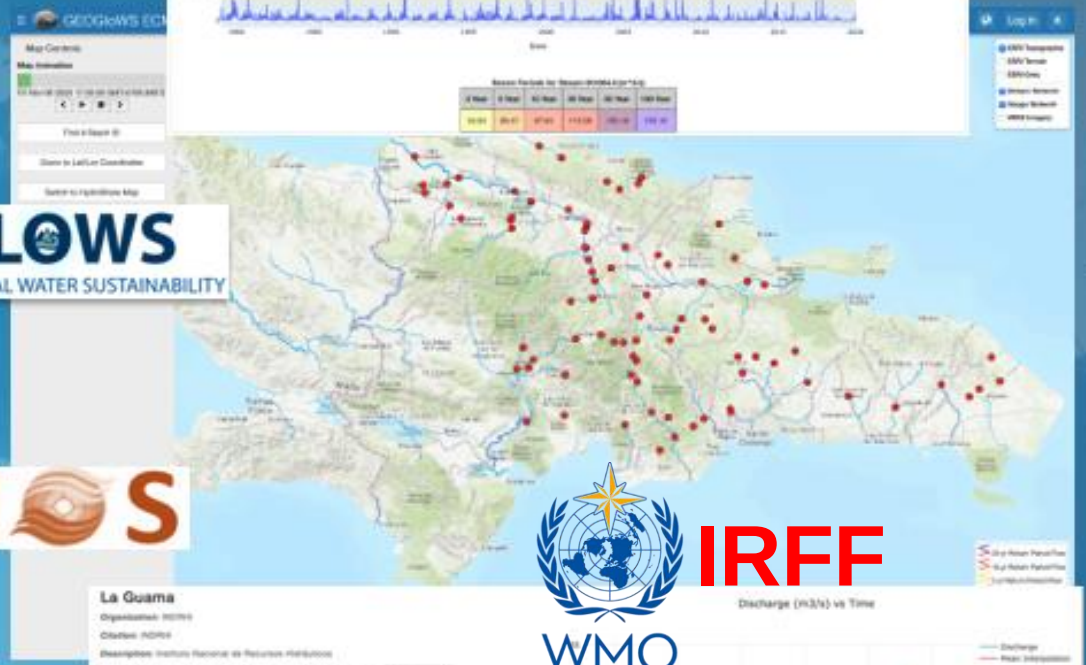
Extended to ungaged rivers through machine learning

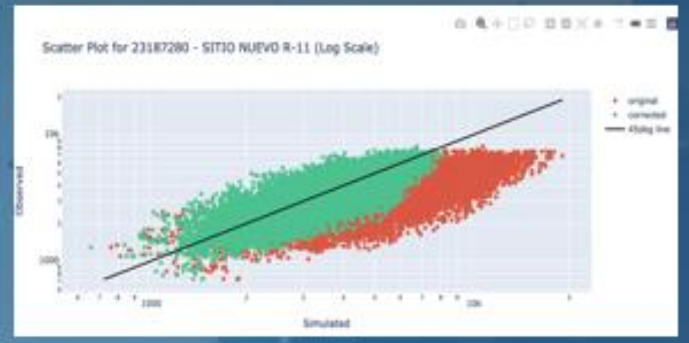


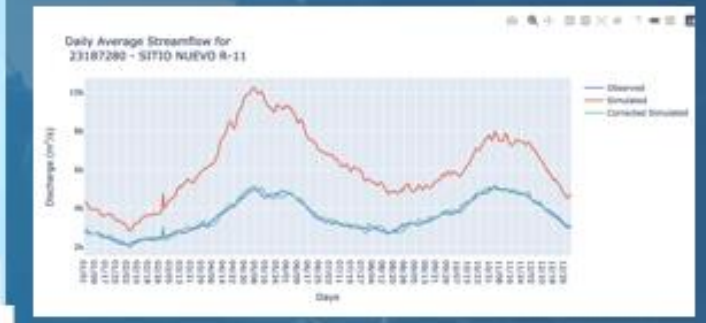


WHOS and GEOGloWS Global Streamflow Data Services

GEOGLOWS
GLOBAL WATER SUSTAINABILITY



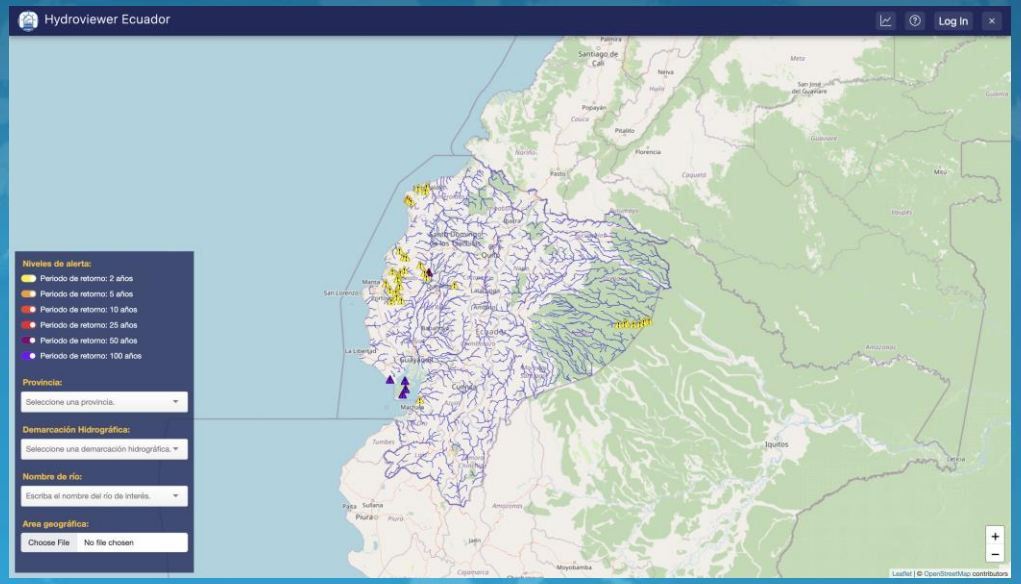


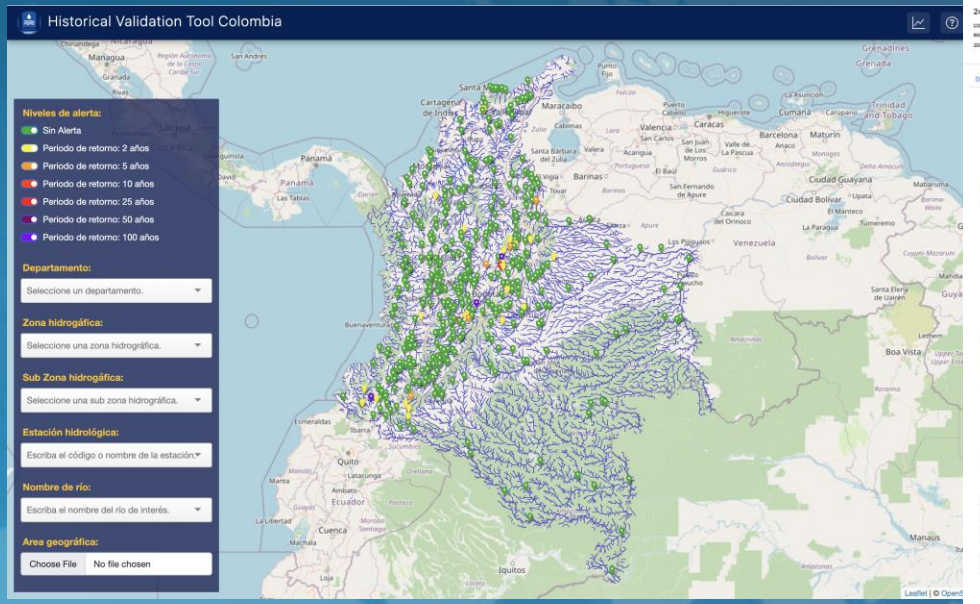


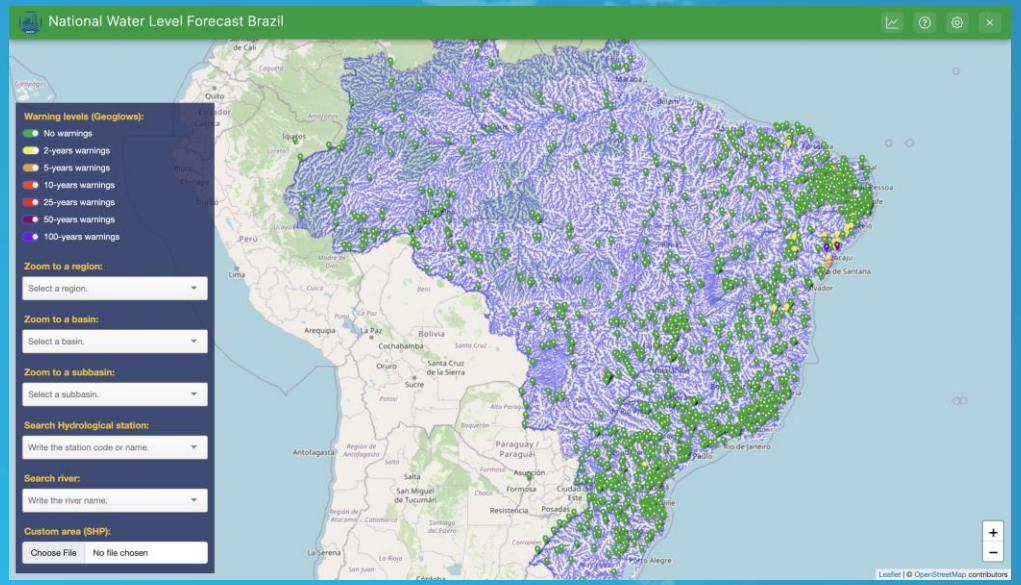
WHOS

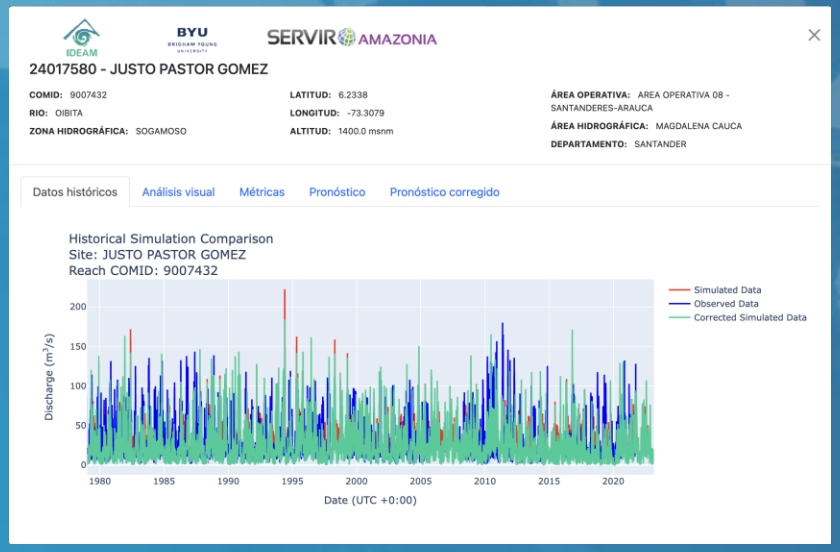
IRFF
WMO

Other Customizations with the Historical Validation Tool

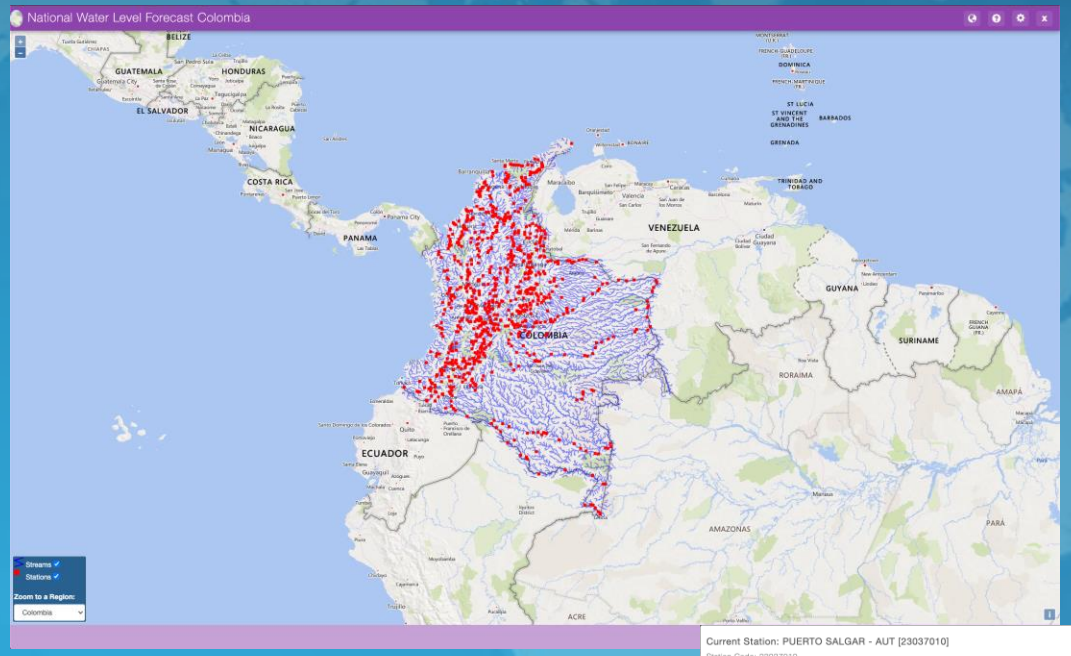


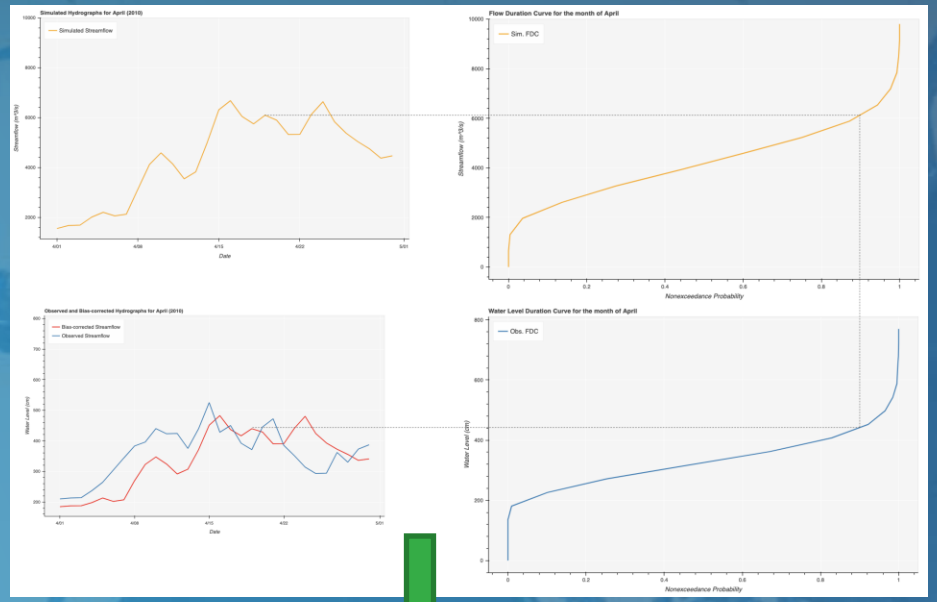


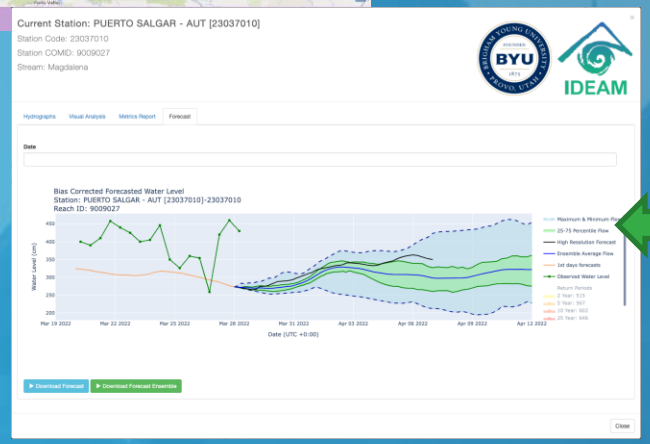




Using Water Level Information

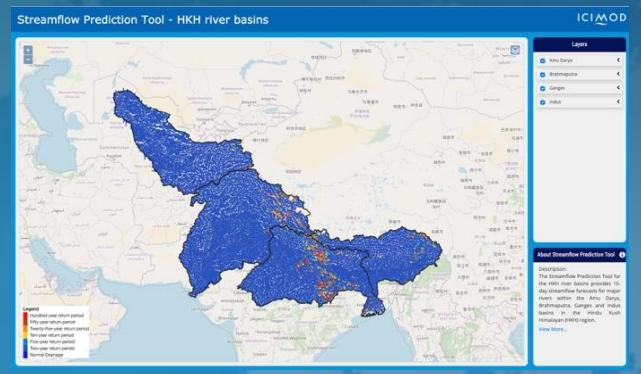


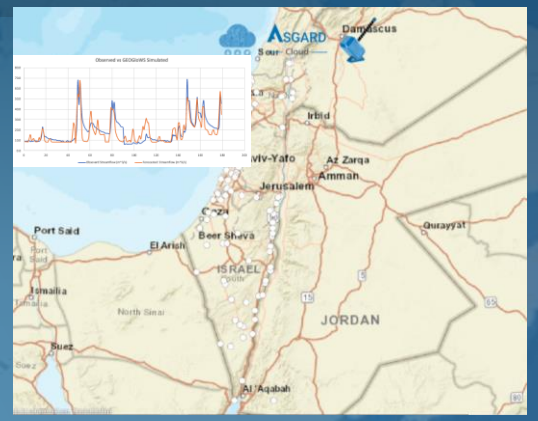


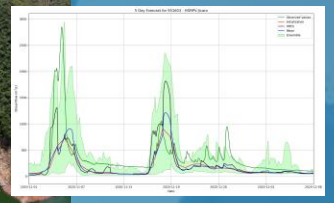


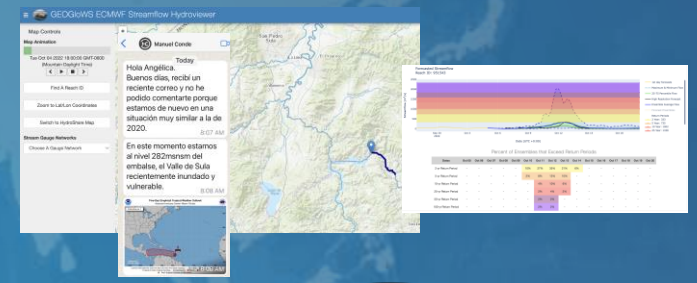
Successful Adapations

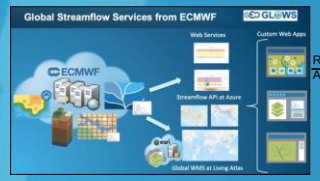
- Nepal
- Bangladesh
- Israel
- Dominican Republic
- Honduras
- Guatemala
- Ecuador
- Peru
- Colombia
- Brazil
- Malawi





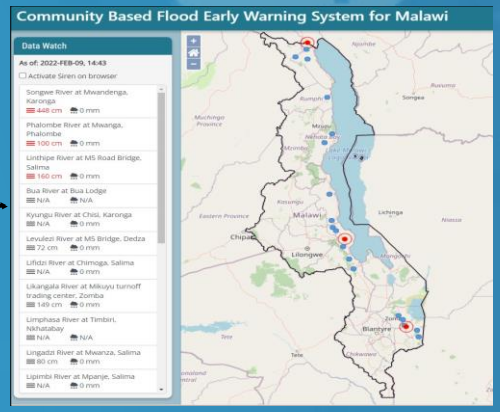






GSM Telemtry

REST API



https://stories.geoglows.org/

Malawi CBFEWS and GEOGloWS

- **Not one life lost compared to 10's of lives lost in a normal flooding season**
- **Government estimated a $40,000,000 reduction in damage costs (just one season)**
- **Scaling and expanding as part of EW4All with support of US Govt through NOAA**

THE NATION

Floods warning gadgets save lives in Karonga

ANDREW MKONDA
Malawi News Agency

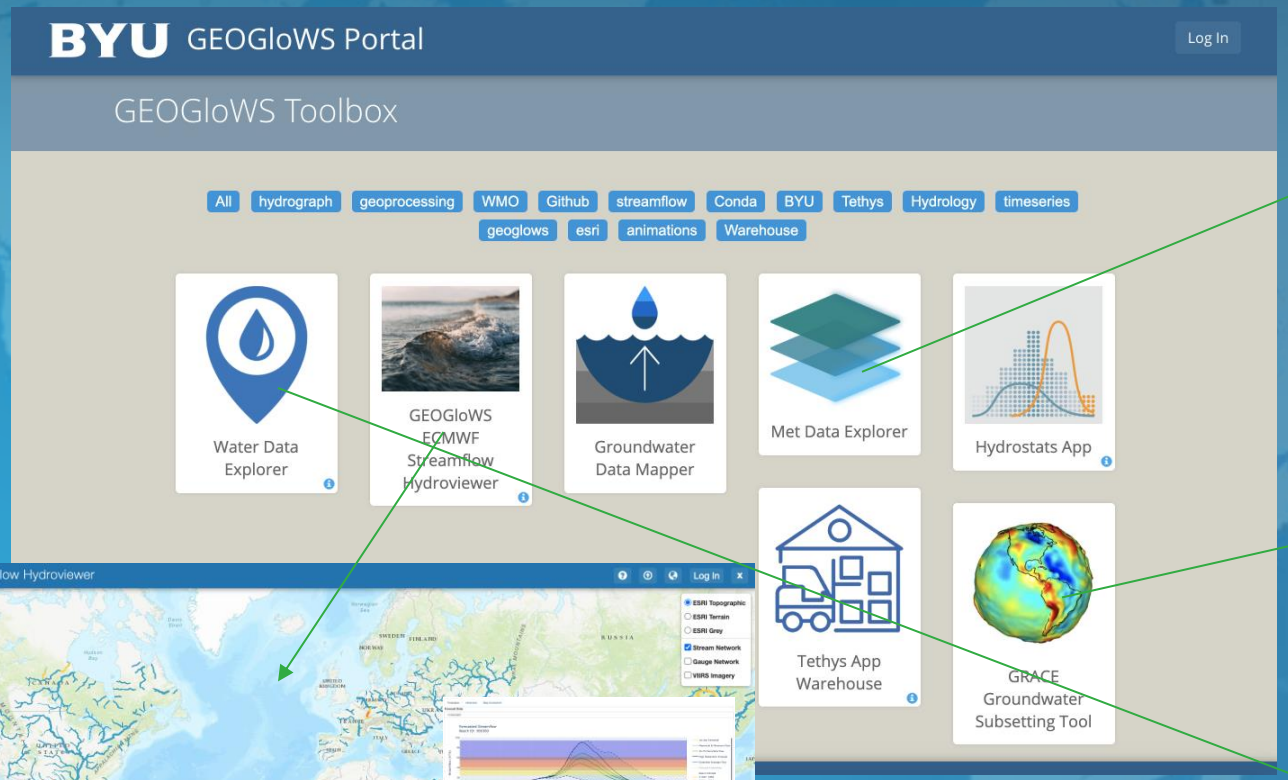
Mwasanya (R) explains how the warning system works

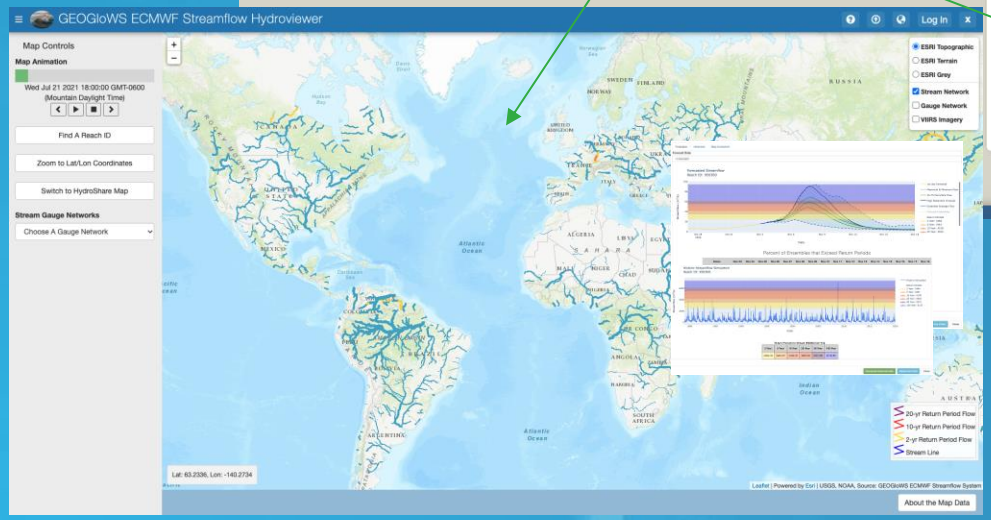
"The system saved their lives and livestock from flood this year. Previous years people were caught unaware by floods thereby losing lives. But this year no single life has been lost as people were able to escape to the uplands on time following alerts from the gadget." Community Chairman – Karango District

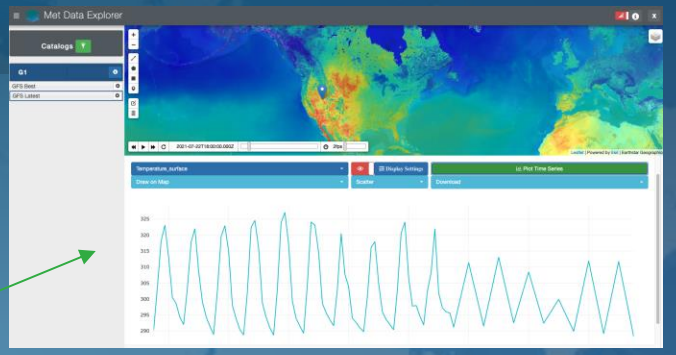
Tweet by the Vice President of Malawi, Dr. Saulos Chilima

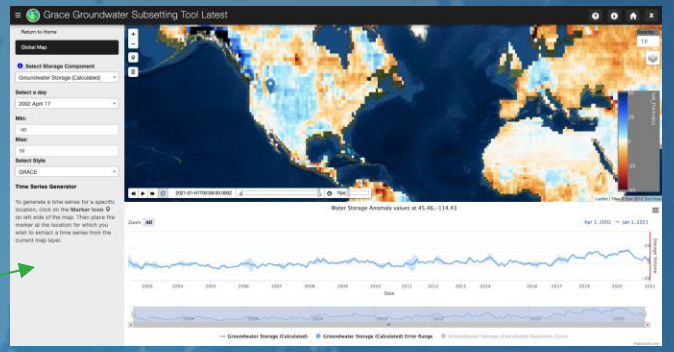
Early Warnings for All

GEOGloWS Toolbox Customization









WMO Hydrologic Observation System (WHOS)

MULTIPLE DATA PROVIDERS

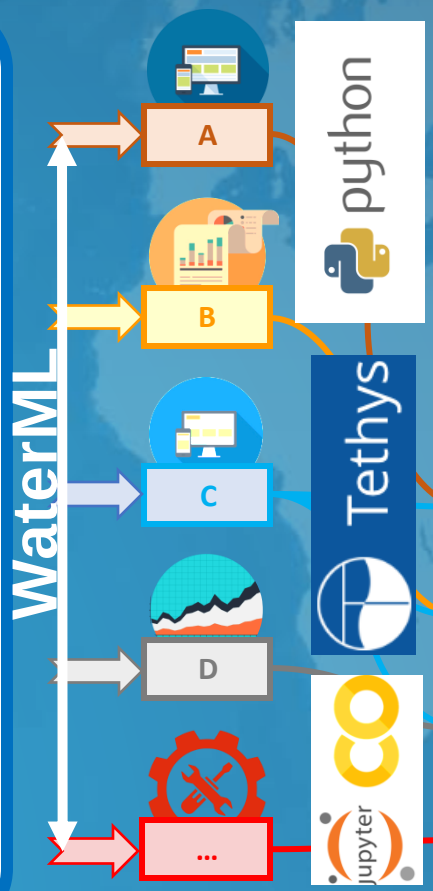
NO DATA STORED

WHOS

- Implement interoperability with exchange protocols
- Metadata mapping
- Data format convertion

24 365

TOOLS



USE

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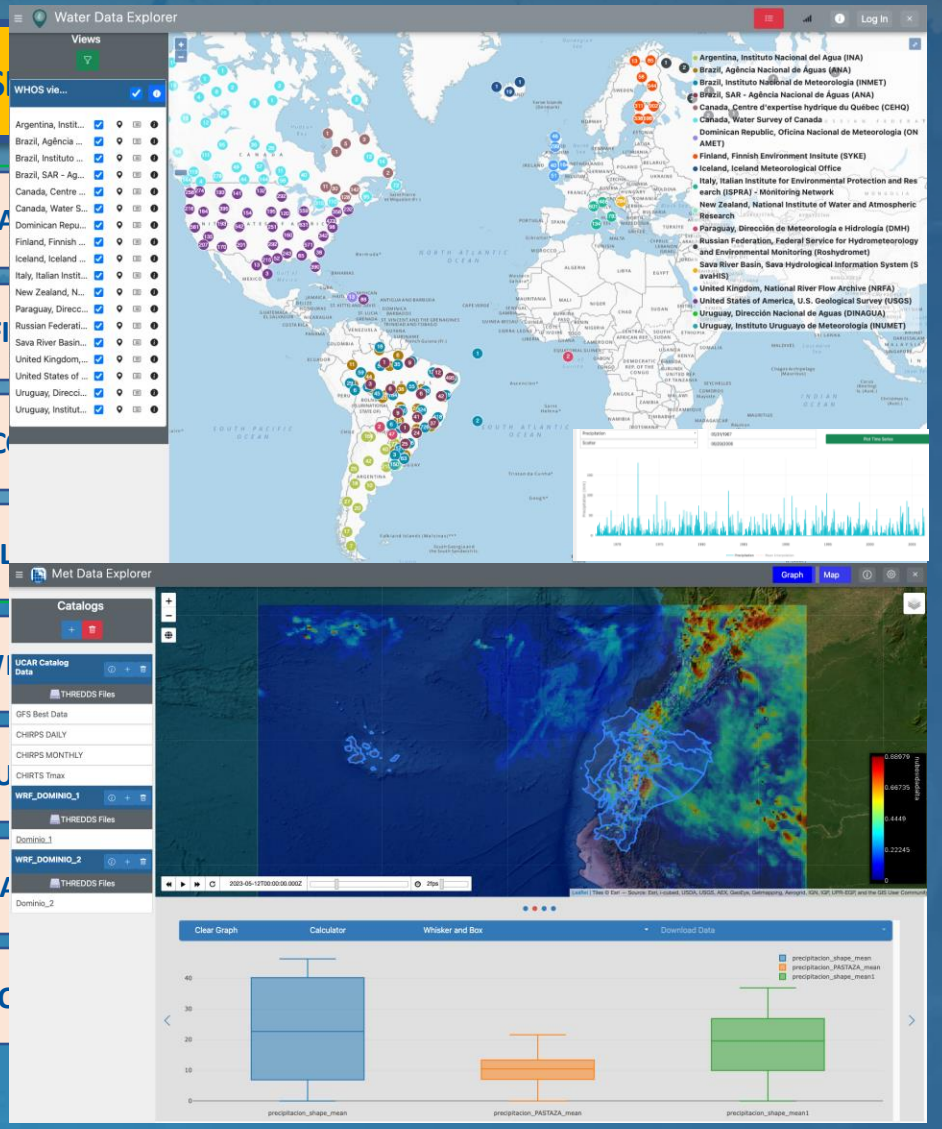
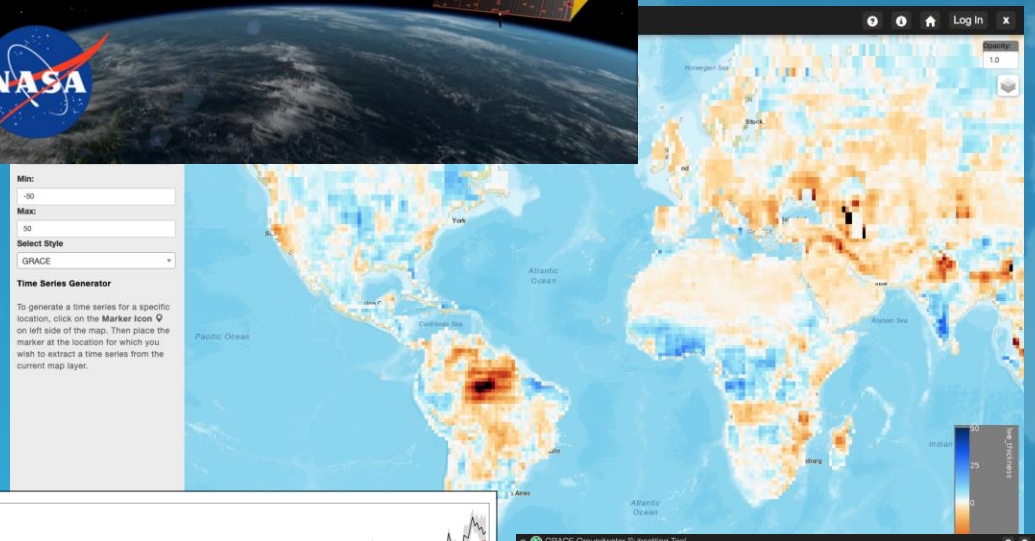
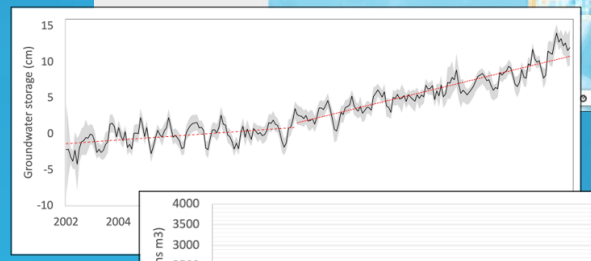
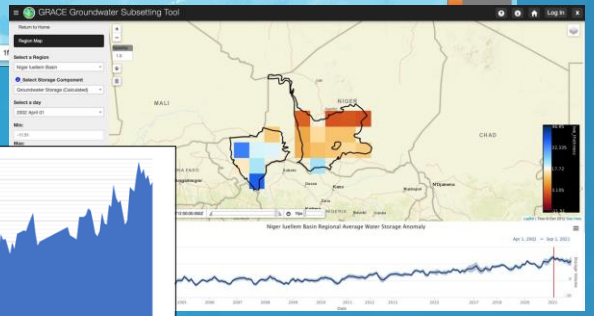


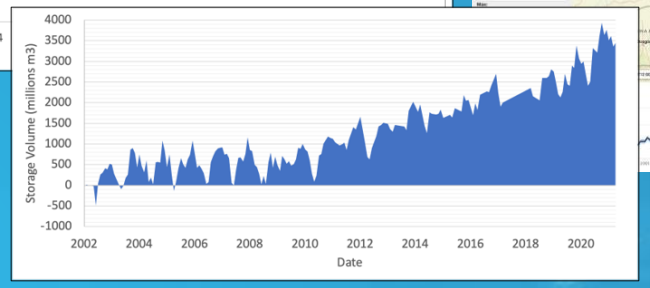
Groundwater Status and Outlook

GRACE



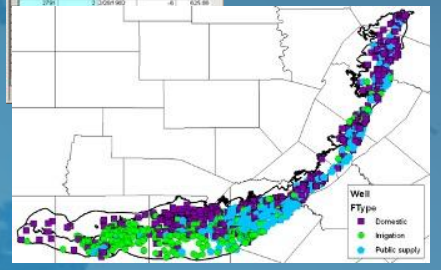






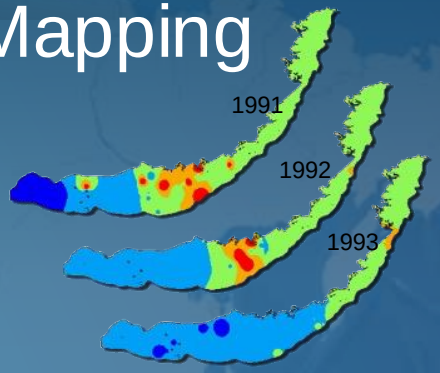
Groundwater Mapping

Water Level Measurements

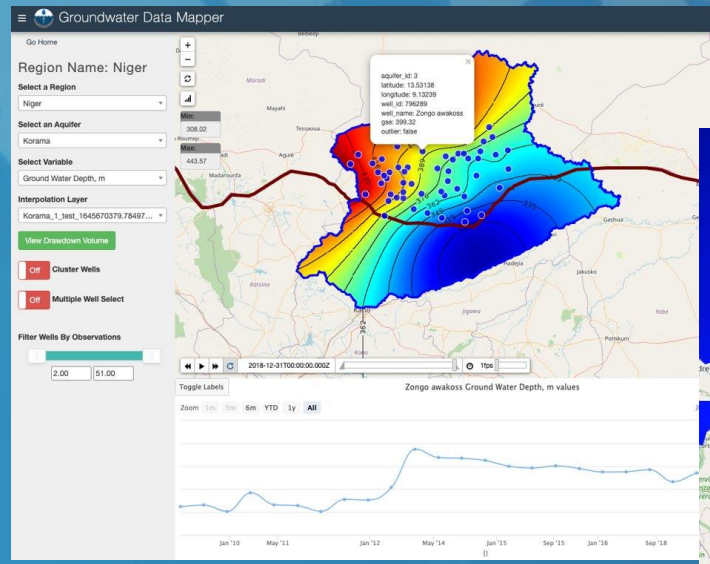


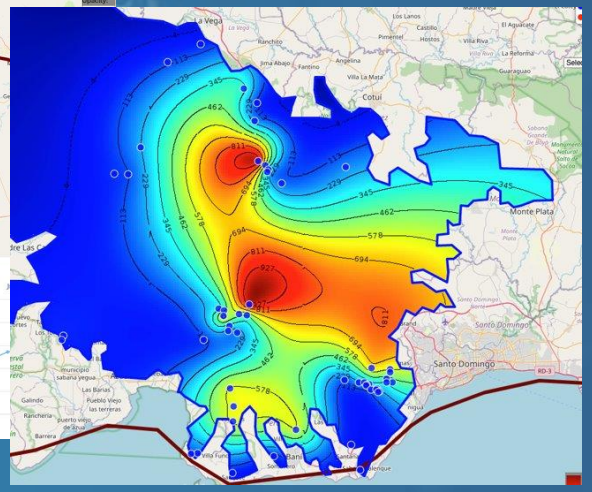
Well Locations

Time and Space Interpolation Algorithms

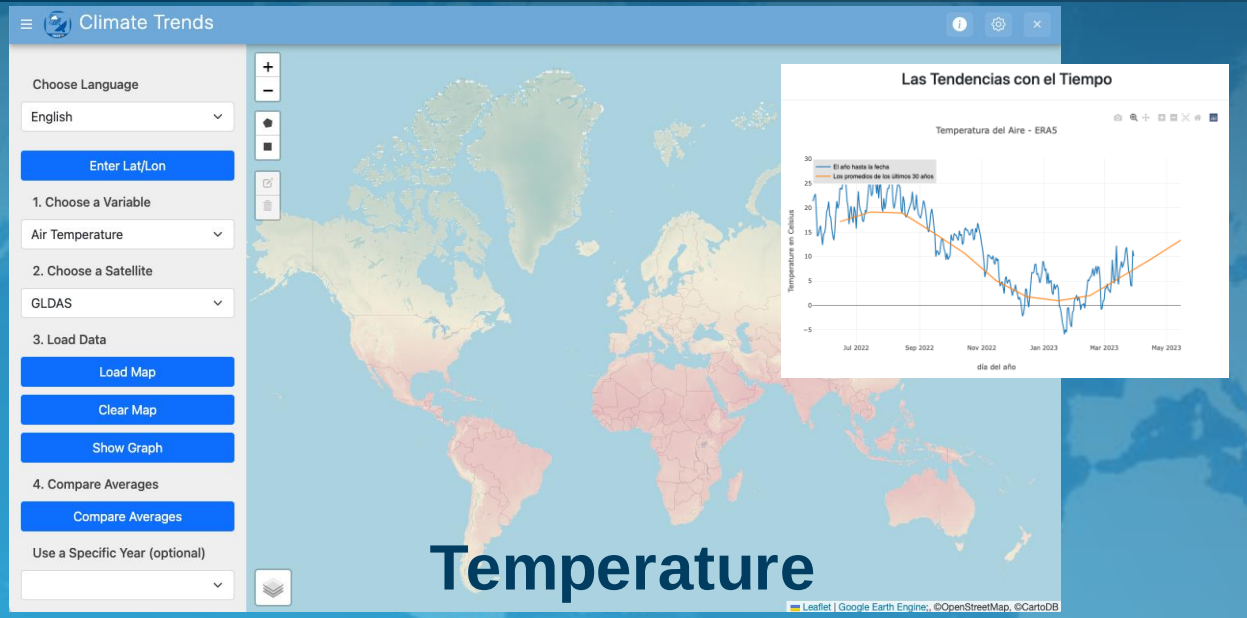


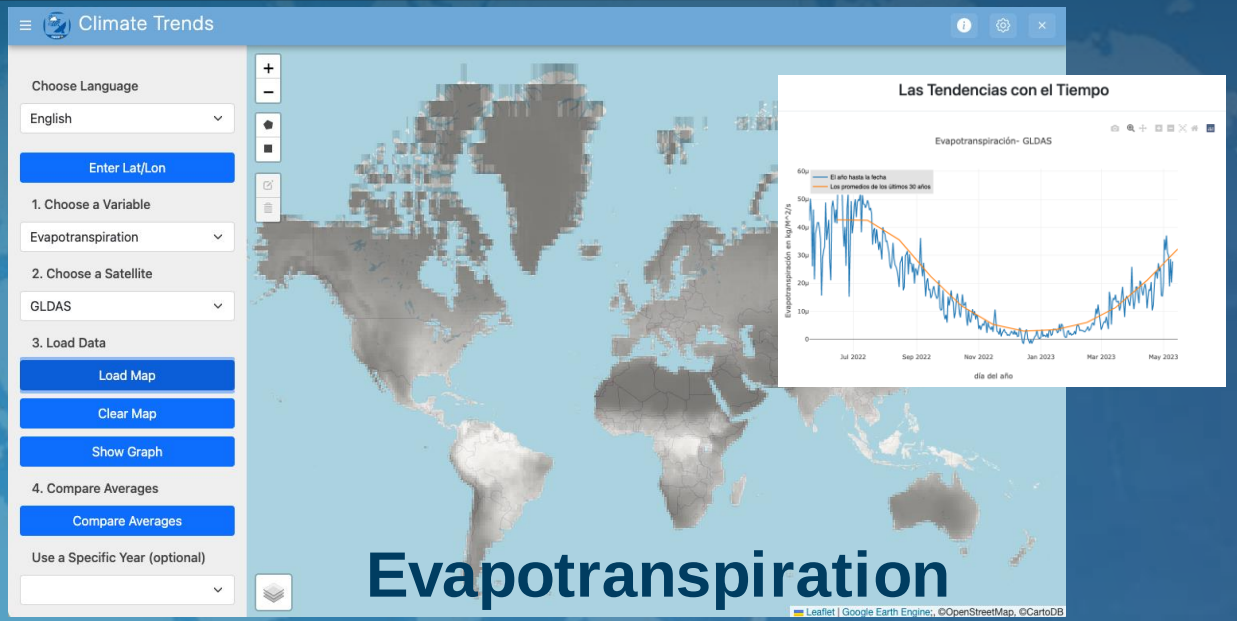
Earth Observations

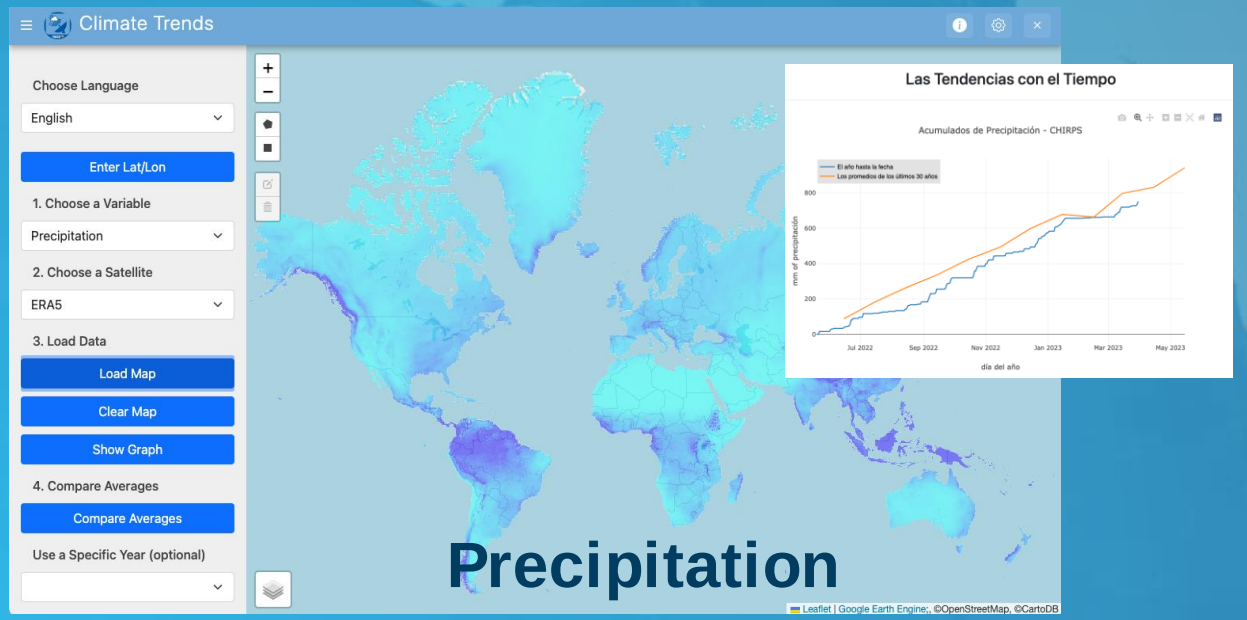


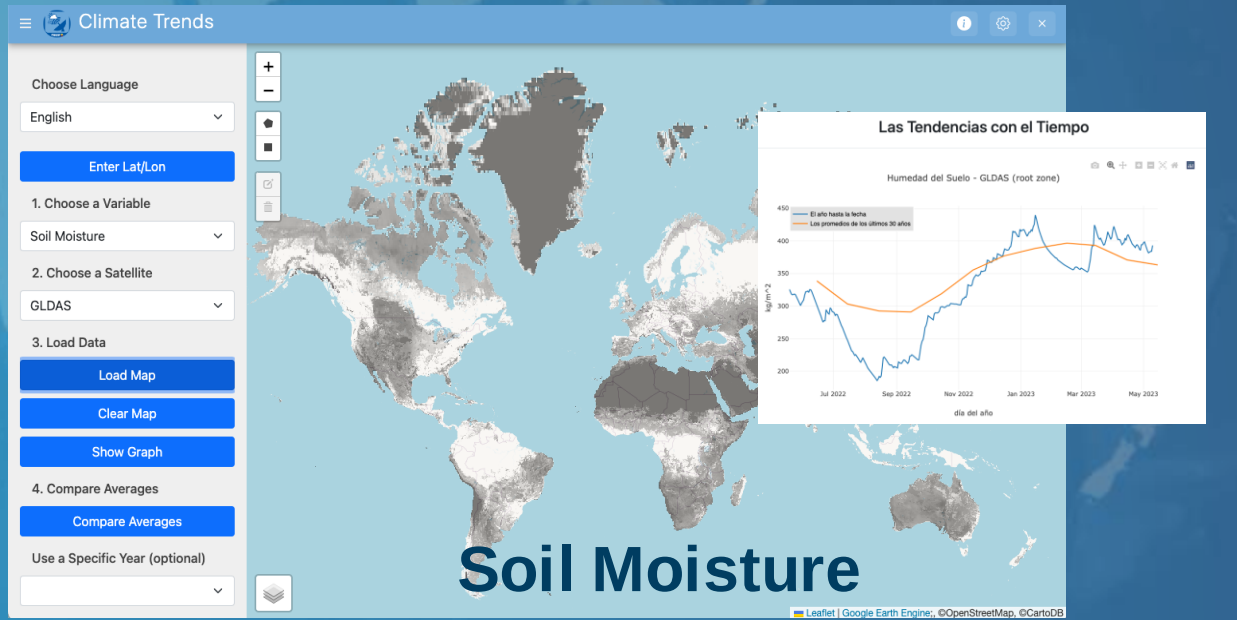


Global Hydrologic Status and Outlook





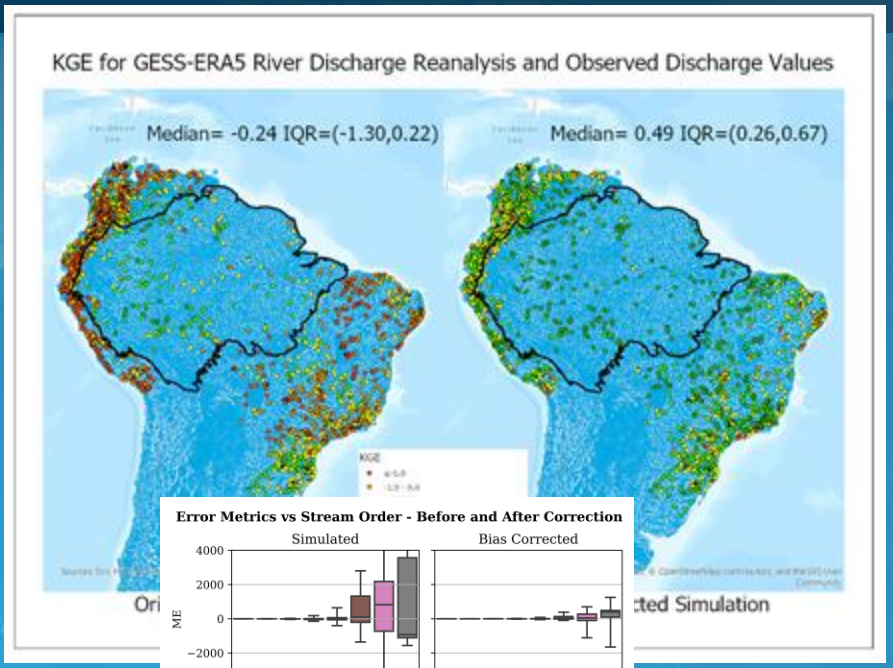


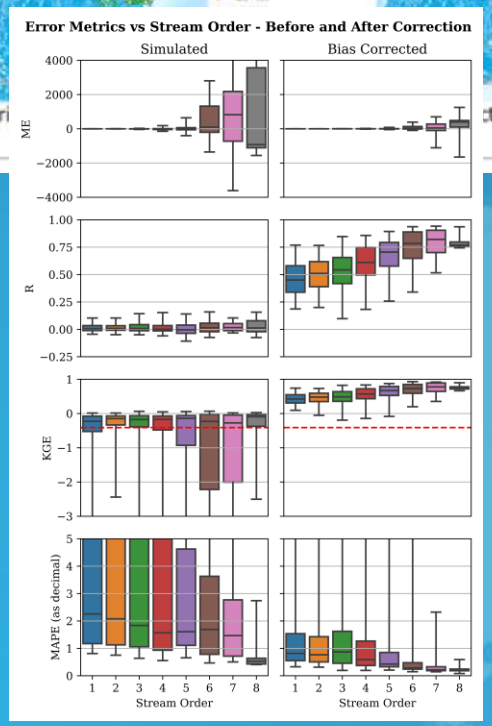


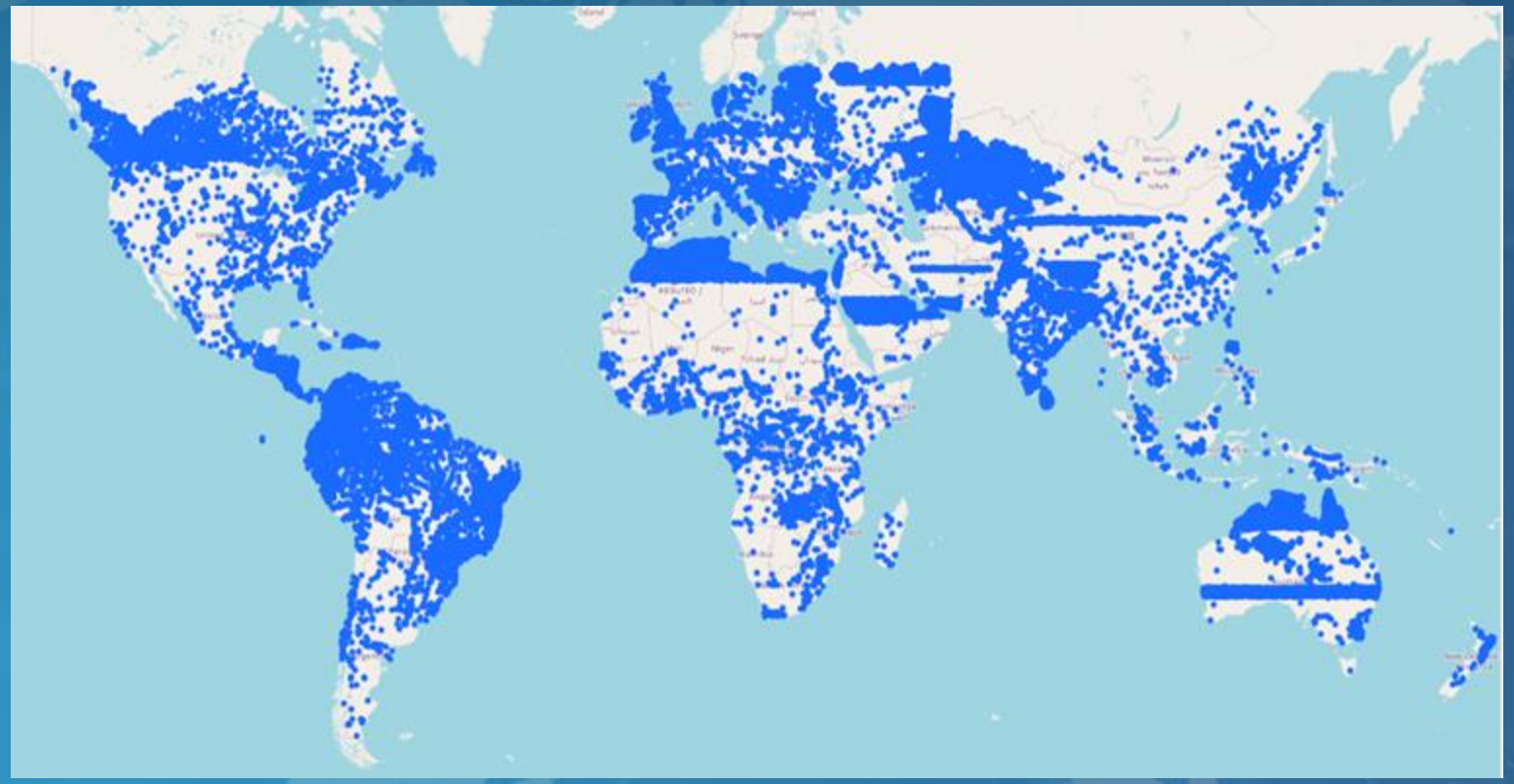
What's next? Lessons Learned

1. Imperfect models are still useful if their inaccuracies are understood
2. Local "ownership" or "branding" of global data source is essential
3. Need a better stream network
    1. Closer align model reporting points to gauges, POIs
    2. Increase trust if mapping true river locations (e.g. compared to basemap)
    3. Enable flood extent modeling on same network as hydrologic model
4. Better flow magnitude predictions increases application potential
5. Flow status and outlook products are useful for monitoring

1 – Imperfect Models are Still Useful Locally



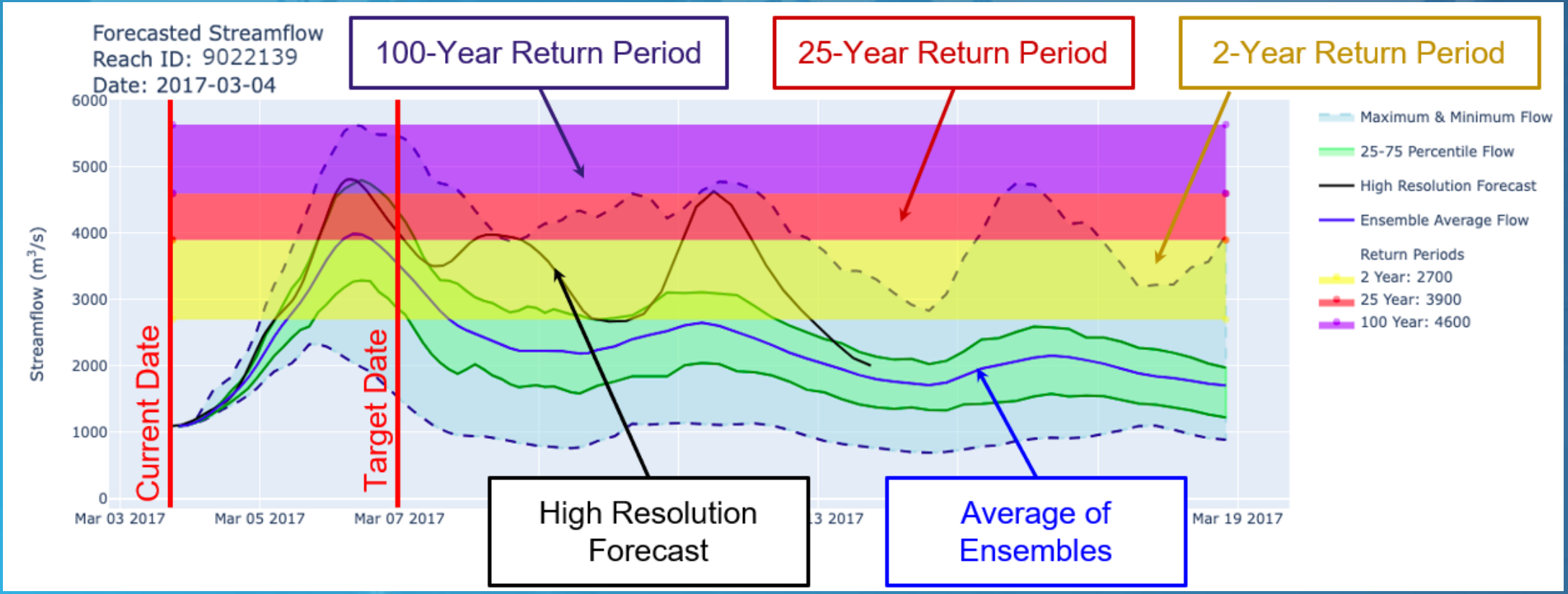




- 6,000,000 requests annually
- or ~16,500 requests daily

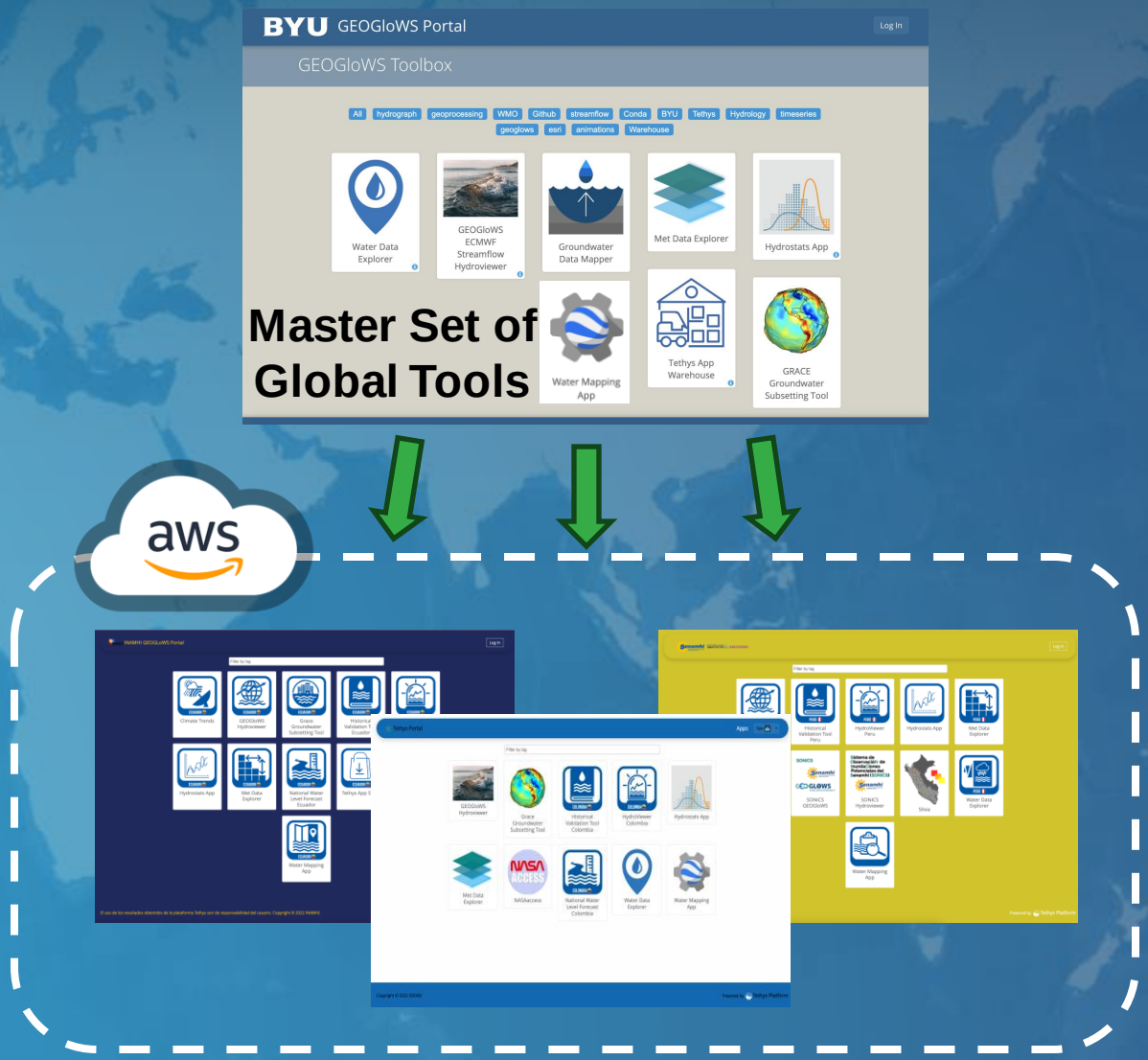
2 – Serious Game Training is Important

- Handle uncertainty in magnitudes
- Risk of false positive/negative
- Simulate Financial Costs of Disaster
- Decide to wait or take actions



3 – Local “Ownership” is Critical

- **Redistribute global data through branded web pages, domain names**
- **Customize interface and include data for local needs, legal requirements**
- **Amazon Web Services & GEO/GEOGloWS Collaboration**
- **2 years credit and IT support to build, run, cloud optimize GEOGloWS tools**
- **~20 countries enrolled in program**



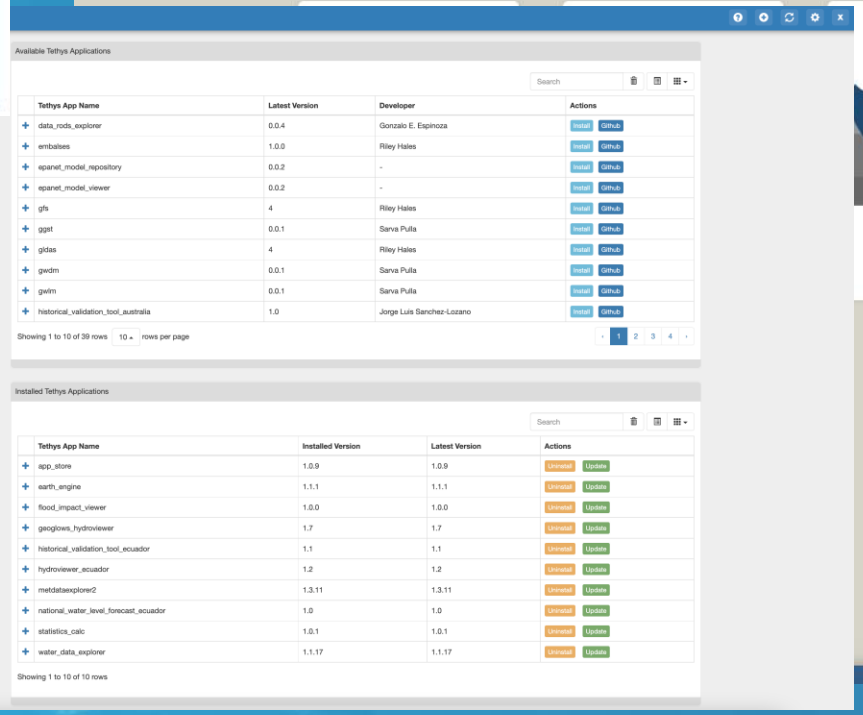
The App Store – Sharing Resources

BYU GEOGloWS Portal

Log In

GEOGloWS Toolbox

All | hydrograph | geoprocessing | WMO | Github | streamflow | Conda | BYU | Tethys | Hydrology | timeseries | geoglows | esri | animations | Warehouse

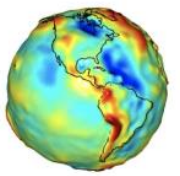


Groundwater Data Mapper

Met Data Explorer

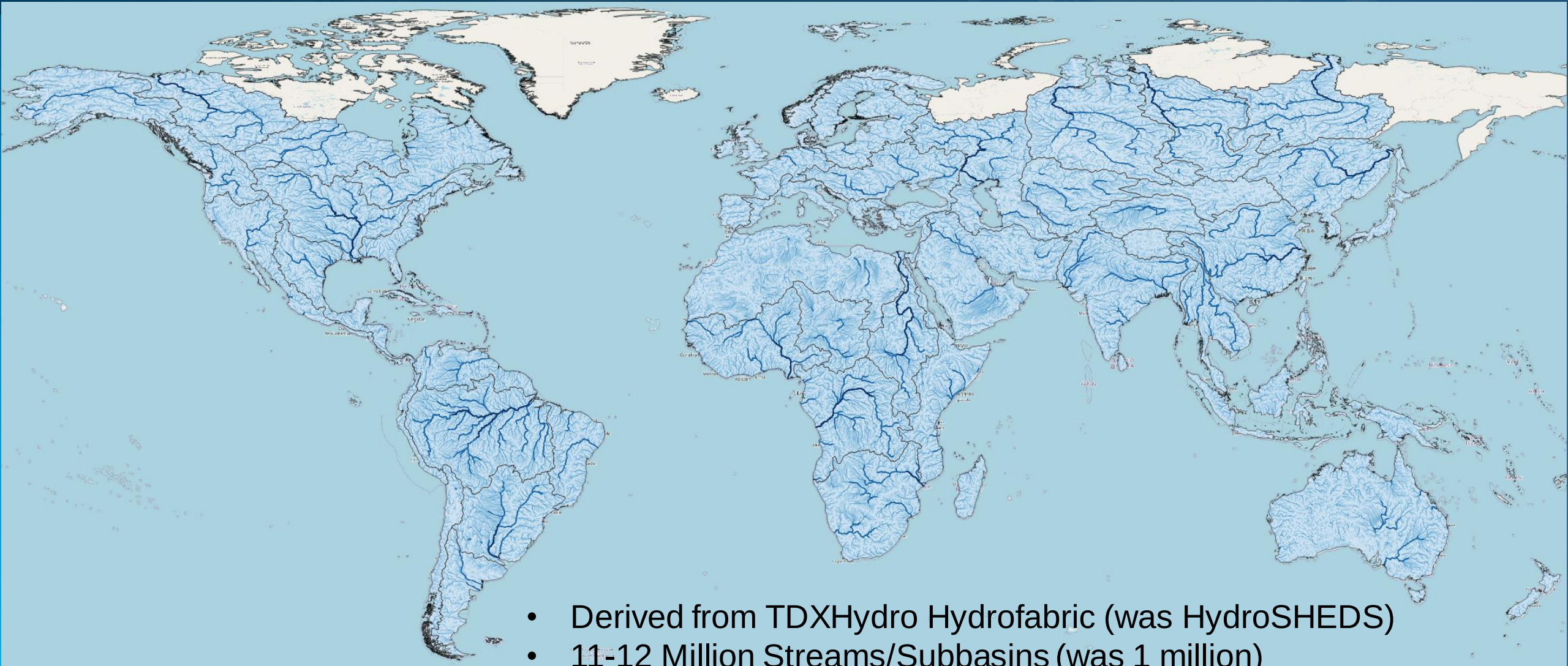
Hydrostats App

Tethys App Warehouse



GRACE Groundwater Subsetting Tool

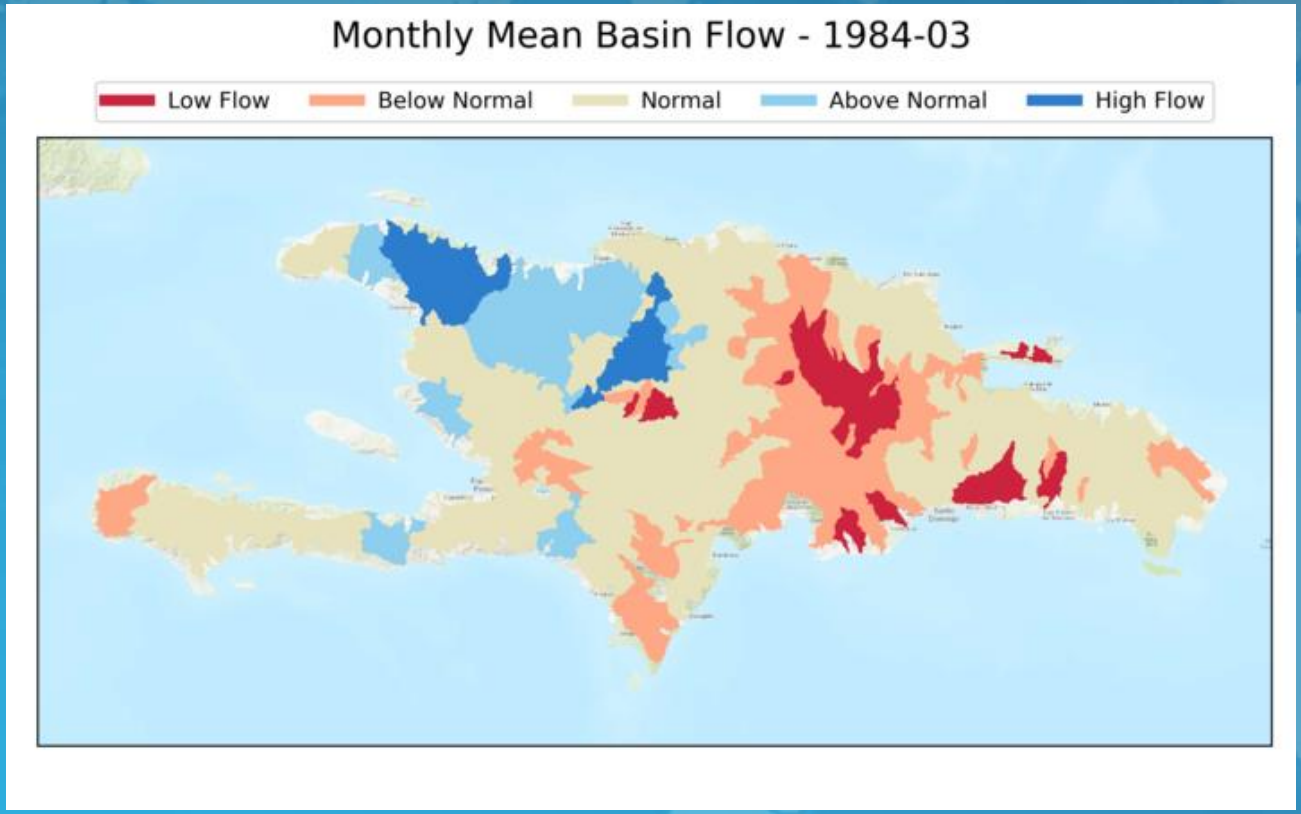
4 – Better Stream Network Needed



- Derived from TDXHydro Hydrofabric (was HydroSHEDS)
- 11-12 Million Streams/Subbasins (was 1 million)
- About 150-200 Processing Units (Groups of Watersheds)
- Covers area at northern latitudes than current

TDXHydro Derived from same Underlying DEM as FABDEM

5 – WMO Status and Outlook (HydroSOS)



- Summary products of current and recent past add context
- Collaboration with WMO's HydroSOS for calculating status
- Collaborate with WMO's call for Early Warnings for All challenge
- Each basin classified as normal or above/below average using monthly flow and historical simulation.

GEOGloWS 2.0 Summary

Model Parameter	Hindcast	Forecast
Temporal Coverage	~~1980 -> 2 Months Lag~~ **1940 -> <1 Week Lag**	15 days
Temporal Resolution	Daily average flow	3 hours
Simulation Type	Deterministic	Ensemble (52)
Update Frequency	~~Monthly~~ **Weekly**	Daily
Reporting Points	~~1 Million Basins~~ **11.5 Million Basins**	~~1 Million Basins~~ **11.5 Million Basins**

Conclusions

- GEOGloWS has significant impact despite shortcomings and challenges common to all large/global models.
- Lasting impact is more likely achieved when the model developers intentionally address specific needs of local implementers.
- Next generation model is driven by lessons learned in case studies of early implementers of GEOGloWS streamflow products.
- Document attempts to implement your model, tools, etc whether they succeed or not so you can find patterns and good strategies.


GEO GLOWS
GLOBAL WATER SUSTAINABILITY
Thank You!
Jim Nelson – jimn@byu.edu
NASA
USAID
SERVIR
AQUAVEO
THE WORLD BANK
BYU
NOAA
aws
esri
ECMWF
copernicus