

# Discovery and Access to Global Water Data, Maps and Services

**David K. Arctur**

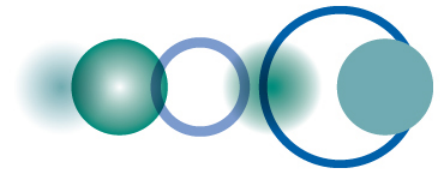
University of Texas at Austin  
Open Geospatial Consortium (OGC)

**OGC/WMO Hydrology Domain Working Group Workshop**

City College New York, August 11-15, 2014

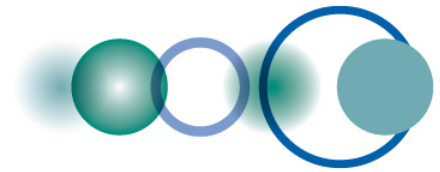
Research & development sponsored by  
U.S. National Science Foundation, NASA,  
Esri, Kisters AG, Microsoft Research





## Outline

- GEOSS project intro
- Finding, browsing, and accessing water data time series
- Federating regional and national water data
- NASA land surface dynamics modeling and viz
- Integrating flood apps for monitoring & prediction
- Water quality data services
  
- Coming: WMO Hydrological Observing System and other connections to UN agencies



# GEOS Introduction

- **GEOS: Global Earth Observation System of Systems**
  - Hosted by GEO (Group on Earth Observations) to publish Earth observation datasets from 92 member countries
  - GEO home page: <http://www.earthobservations.org/>
  - GEOS search portal: <http://www.geoportal.org/>
  - Enables distributed search among dozens of catalogs, accessing millions of data services, **following international data exchange standards (ISO, WMO, OGC, ...)**
  - Data is organized around **9 Societal Benefit Areas (SBAs): Water, Weather, Climate, Biodiversity, Ecosystems, Energy, Agriculture, Health, Disasters**
- **GEOS AIP (Architecture Implementation Pilot)**
  - Series of 1-year project cycles to implement GEOS, started in 2007; AIP-6 complete in 2013; AIP-7 in progress.



## **GEOSS Water Services: Key Objectives**

Current international data exchange standards work mainly at the Internet level, still need refining for consistency of terms and usage within and across international hydrology communities...

**This project advances water data sharing by:**

1. Improving cross-domain **discovery and access** to global hydrology data
2. Integrating **global drought and flood awareness** capabilities among multiple international agencies and research centers
3. Enabling **federation of regional & national water data** around a common information model and service architecture, to enable national-level **situation awareness on-demand**
4. Working with **WMO data centers (GRDC, GPCC), UNEP GEMS/Water,** and **UNESCO Institute for Hydrology Education (Delft)** to advance & leverage authoritative sources with global outreach
5. Active **capacity building** in Latin America for a GEOSS of the Americas





COLLEGE

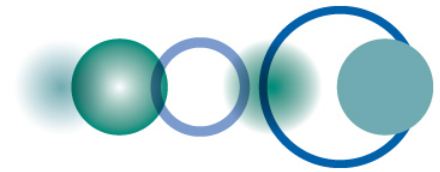
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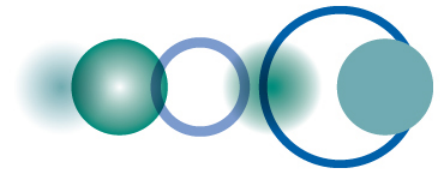
# **GEOSS AIP Water Services Team** (\* new members)

## **Academic**

- University of Texas at Austin, USA
- Brigham Young University, USA
- University of Saskatchewan, Canada
- Feng Chia University, Taiwan \*
- George Mason University, USA \*

## **Community Labs, Portals**

- CUAHSI Water Data Center, USA
- Dartmouth Flood Observatory, USA \*
- NASA Goddard Hydrological Science Lab, USA
- NASA Goddard Earth Sciences DISC, USA
- Federal Institute of Hydrology, Germany \* (supporting GRDC, GPCC, GEMS/Water)
- EC Joint Research Centre (JRC), Italy
- European Centre for Midrange Weather Forecasting (ECMWF), UK
- Centre for Ecology and Hydrology, UK \*
- CEOS Water Portal (JAXA), Japan



# **GEOSS AIP Water Services Team, cont'd**

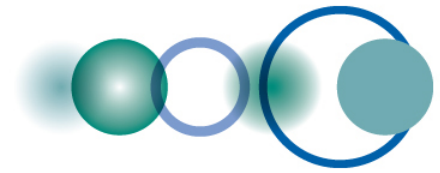
## **National and regional agencies**

- Italian National Institute for Environmental Protection and Research (ISPRA)
- Regional Agency for Environmental Protection in Emilia-Romagna (ARPA-ER), Italy
- New Zealand National Institute of Water and Atmospheric Research (NIWA)
- Horizons Regional Council (HRC), New Zealand

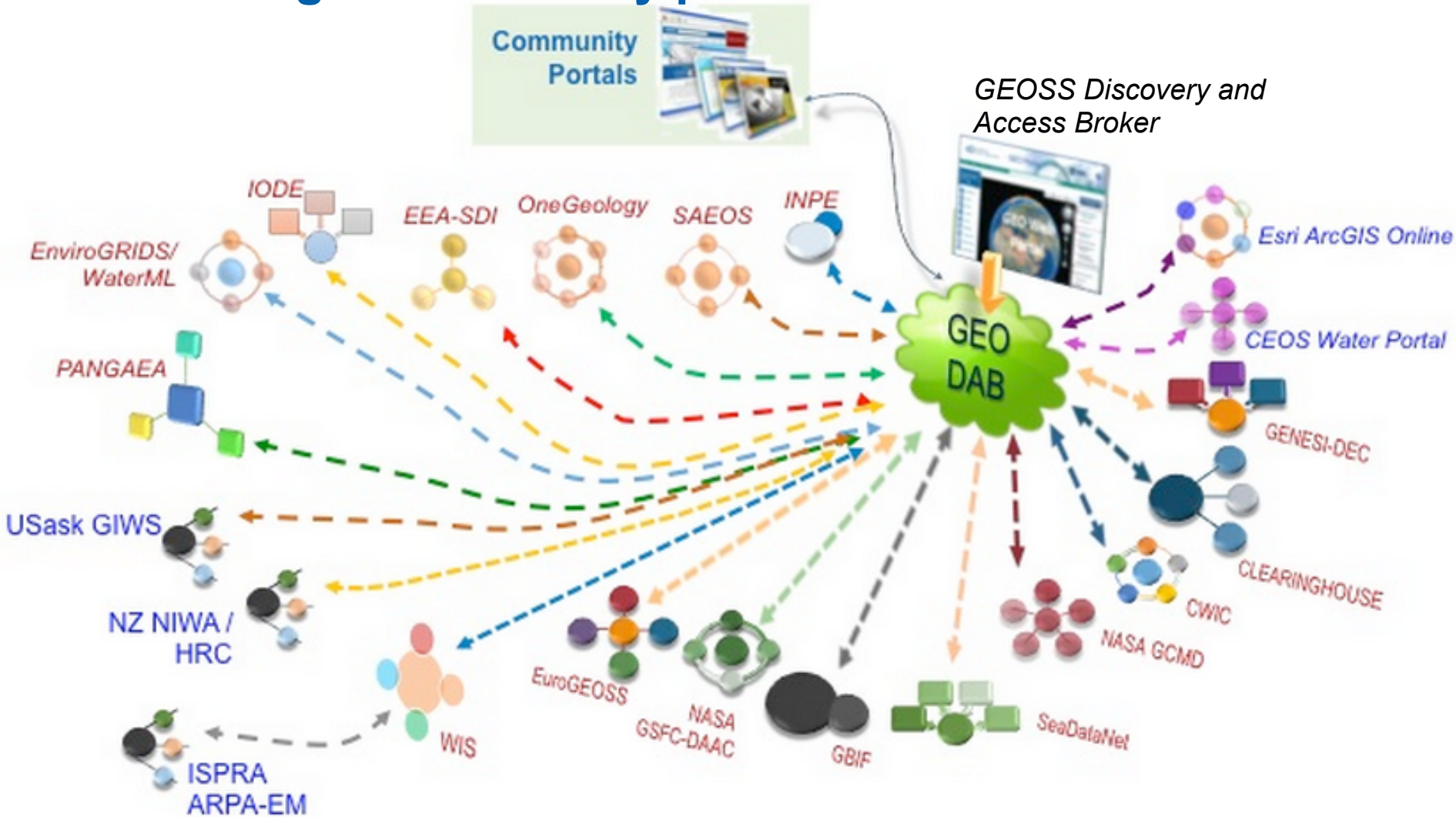
## **Commercial Engineering & Software**

- Esri, USA
- Kisters AG, Germany
- Microsoft Research, USA





# GEOSS Portal: connecting to community portals and other resources





HOME

VIDEO TUTORIAL

SEND FEEDBACK

Focus on: Precipitation (DAB) +

SEARCH

GWS x

Related Topics x

+ Themes

+ Country/Geography

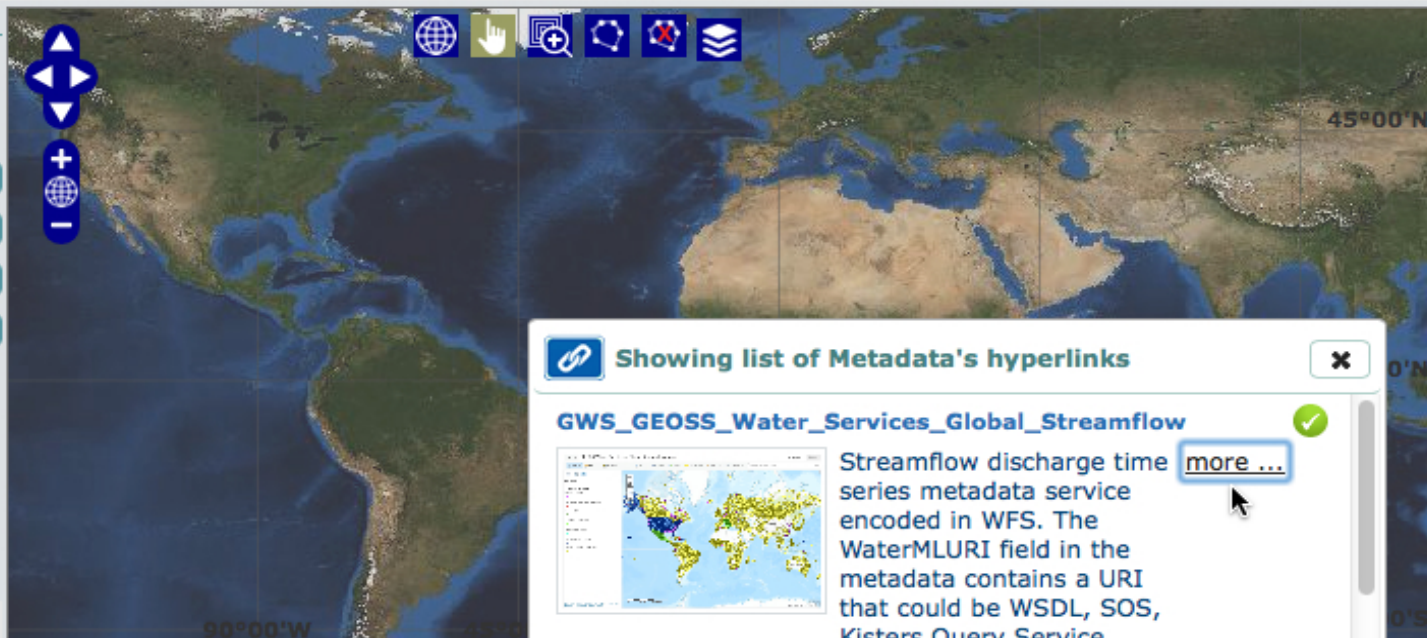
+ Data Access Conditions

+ Earth Observation Catalogs

Start Date   End Date


CLEAR

SEARCH



**Showing list of Metadata's hyperlinks** x

**GWS\_GEOSS\_Water\_Services\_Global\_Streamflow** ✓




Streamflow discharge time series metadata service encoded in WFS. The WaterMLURI field in the metadata contains a URI that could be WSDL, SOS, Kisters Query Service (KiQS), USGS WaterML Service, or other web service endpoint for stream discharge content in WaterML 1.x or WaterML 2.0 encoding. CAVEAT: This



[more ...](#)

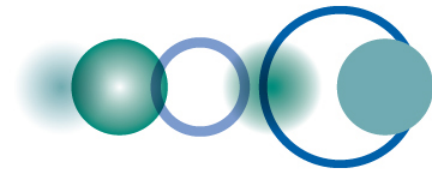
**Total Results: 5**

- All
- Analysis and visualization
- Websites and documents
- Datasets

Legend ▾

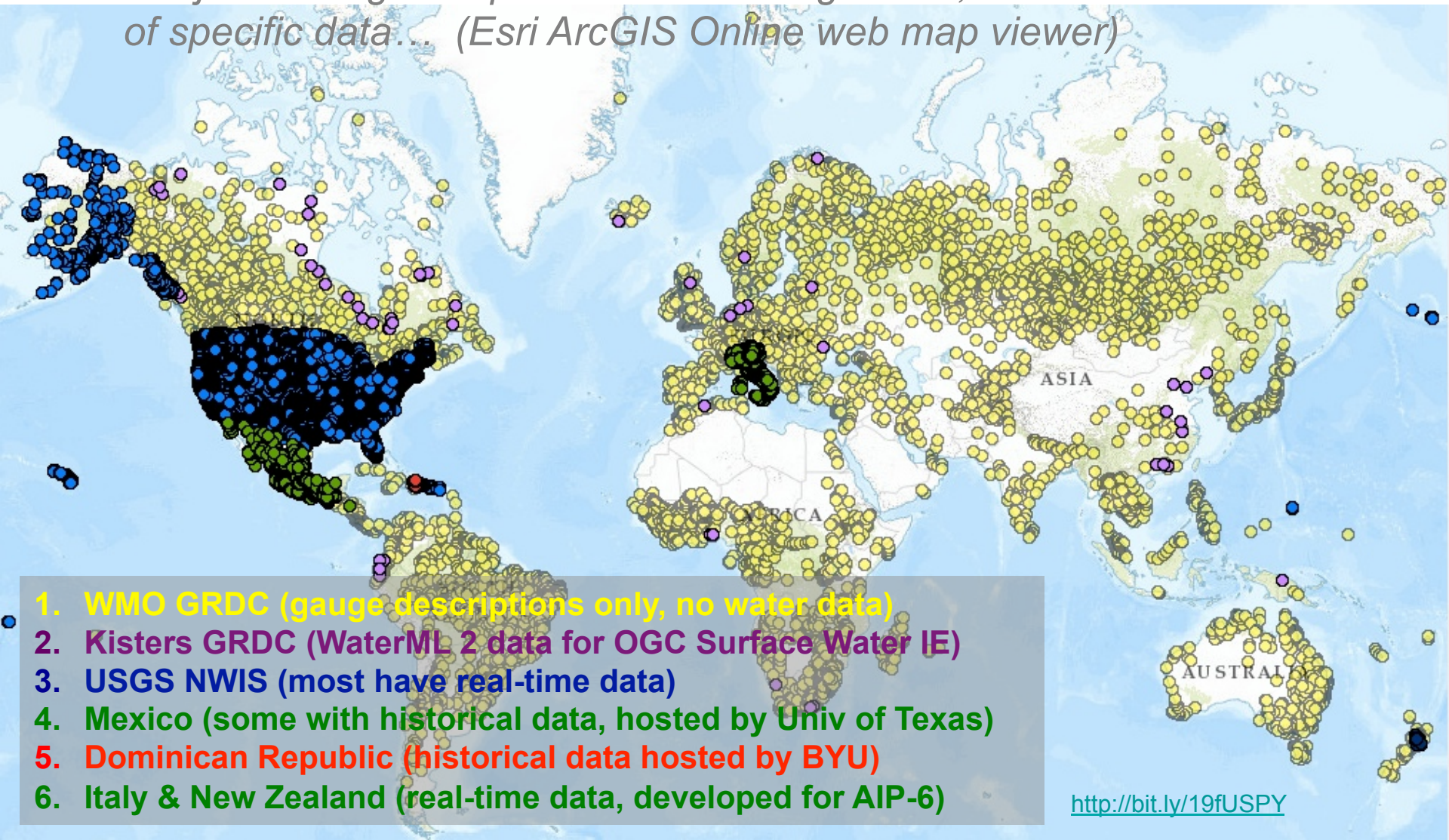
  **GWS\_GEOSS\_Water\_Services\_Global\_Streamflow**  
Streamflow discharge time series metadata service encoded in WFS. The WaterMLURI field in the metadata contains a URI that could be WSDL, SOS,  
[Click to read more...](#)

  **EOSD-GWS: EOSD Forest Landcover of Canada - Grid-enabled WMS**  
GWMS provides landcover classification maps of Canada, created from Landsat-7 ETM+ data (circa 2000). The Landcover products were produced



# Water Data Maps: Global Stream Gauges

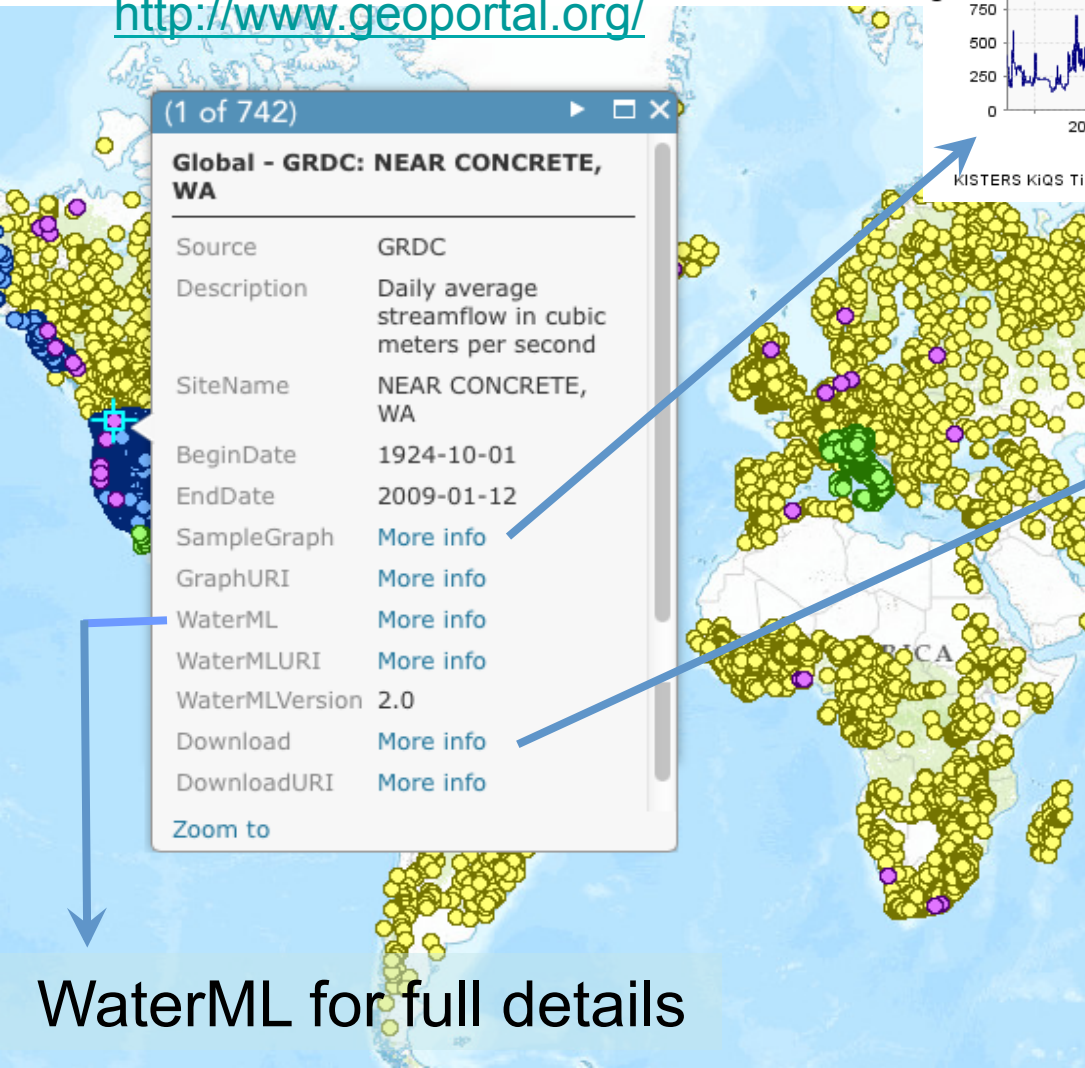
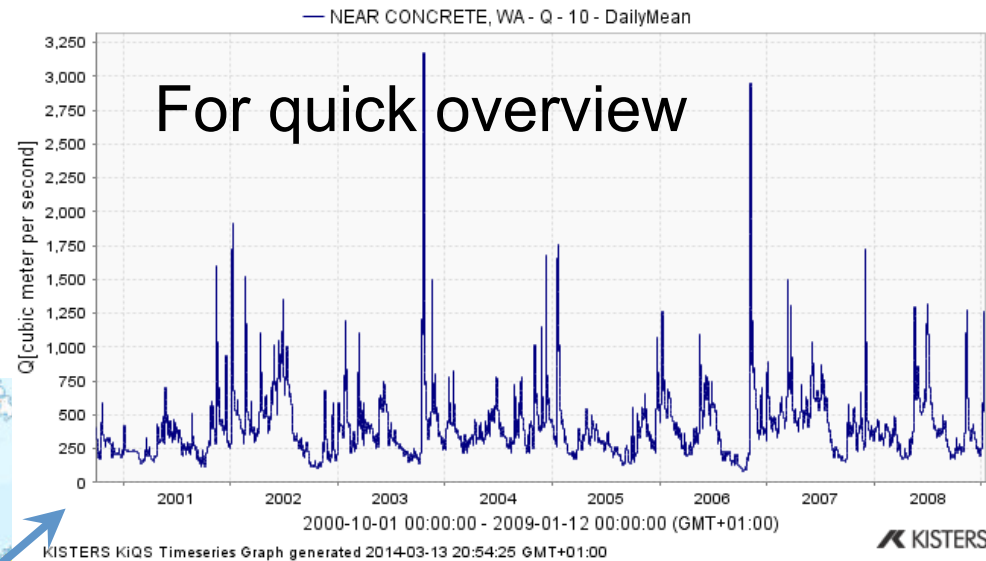
*Not just seeing data providers' bounding boxes, but actual locations of specific data... (Esri ArcGIS Online web map viewer)*



1. **WMO GRDC** (gauge descriptions only, no water data)
2. **Kisters GRDC** (WaterML 2 data for OGC Surface Water IE)
3. **USGS NWIS** (most have real-time data)
4. **Mexico** (some with historical data, hosted by Univ of Texas)
5. **Dominican Republic** (historical data hosted by BYU)
6. **Italy & New Zealand** (real-time data, developed for AIP-6)

# Gauge description and data links...

<http://www.geoportal.org/>



For easy analysis

#	Timestamp;Value
1	#ts_id;2634042
2	#rows;365
3	#Timestamp;Value
4	2008-01-13T09:00:00.000+01:00;442.804625
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6	2008-01-14T09:00:00.000+01:00;457.316875
7	2008-01-14T09:00:00.000+01:00;457.316875
8	2008-01-15T09:00:00.000+01:00;450.946
9	2008-01-15T09:00:00.000+01:00;450.946
10	2008-01-16T09:00:00.000+01:00;410.24025
11	2008-01-16T09:00:00.000+01:00;410.24025
12	2008-01-17T09:00:00.000+01:00;418.027375
13	2008-01-17T09:00:00.000+01:00;418.027375
14	2008-01-18T09:00:00.000+01:00;368.47325
15	2008-01-18T09:00:00.000+01:00;368.47325
16	2008-01-19T09:00:00.000+01:00;306.88375
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18	2008-01-20T09:00:00.000+01:00;342.279625
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WaterML for full details

```

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</wml2:Collection>

```

## WaterML 2.0

### Document metadata

### Observation description

#### - Phenomena time

#### - Result time

#### - Procedure

#### - Observed property

#### - Feature of interest

#### - Result

#### - Time series metadata

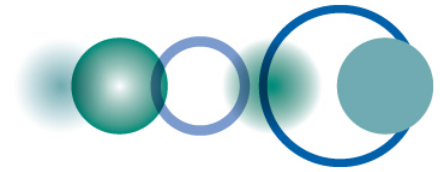
#### - Time series data

```

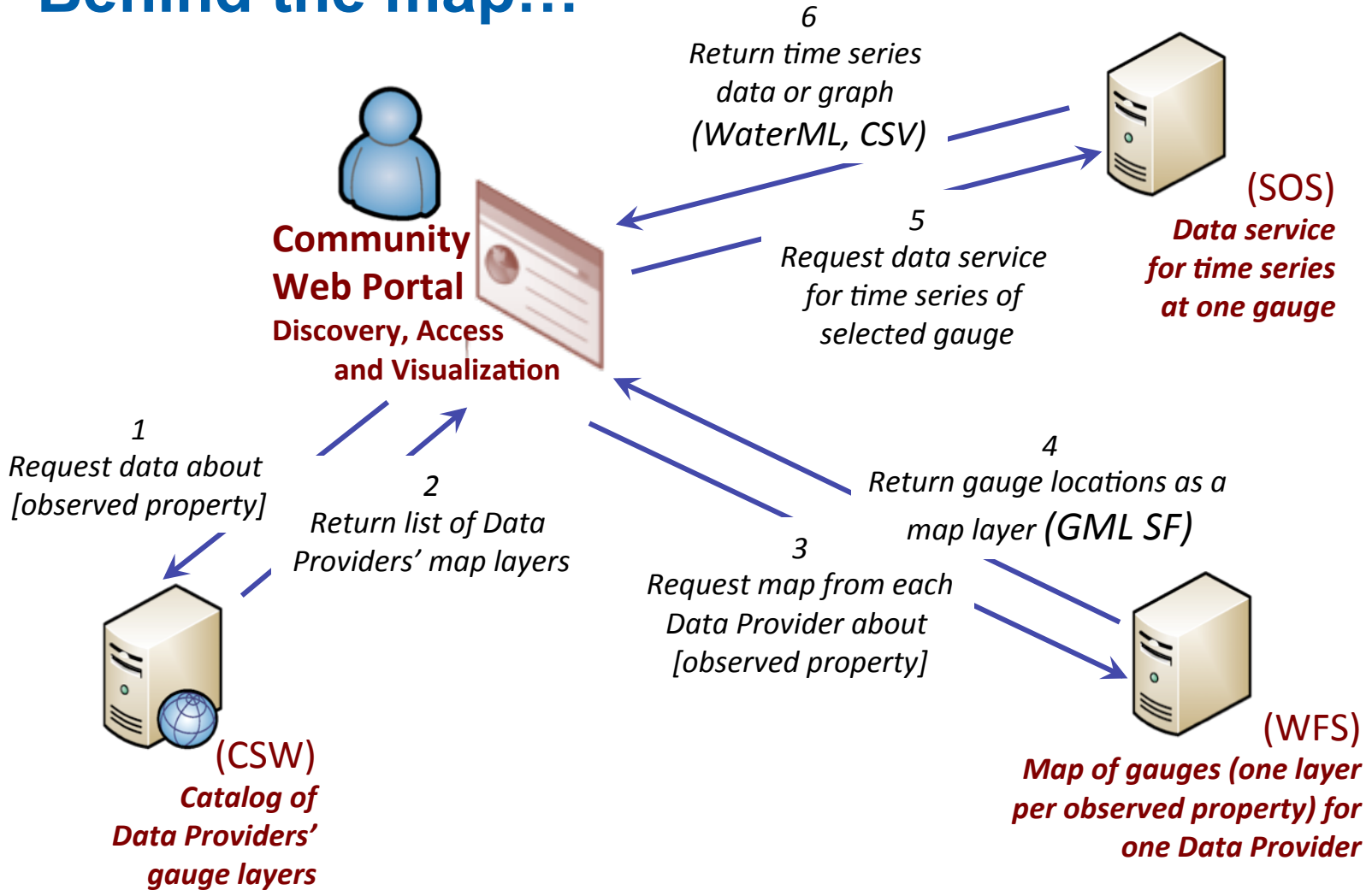
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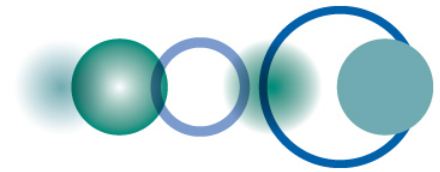
```

### Time series data, cont'd



# Behind the map...

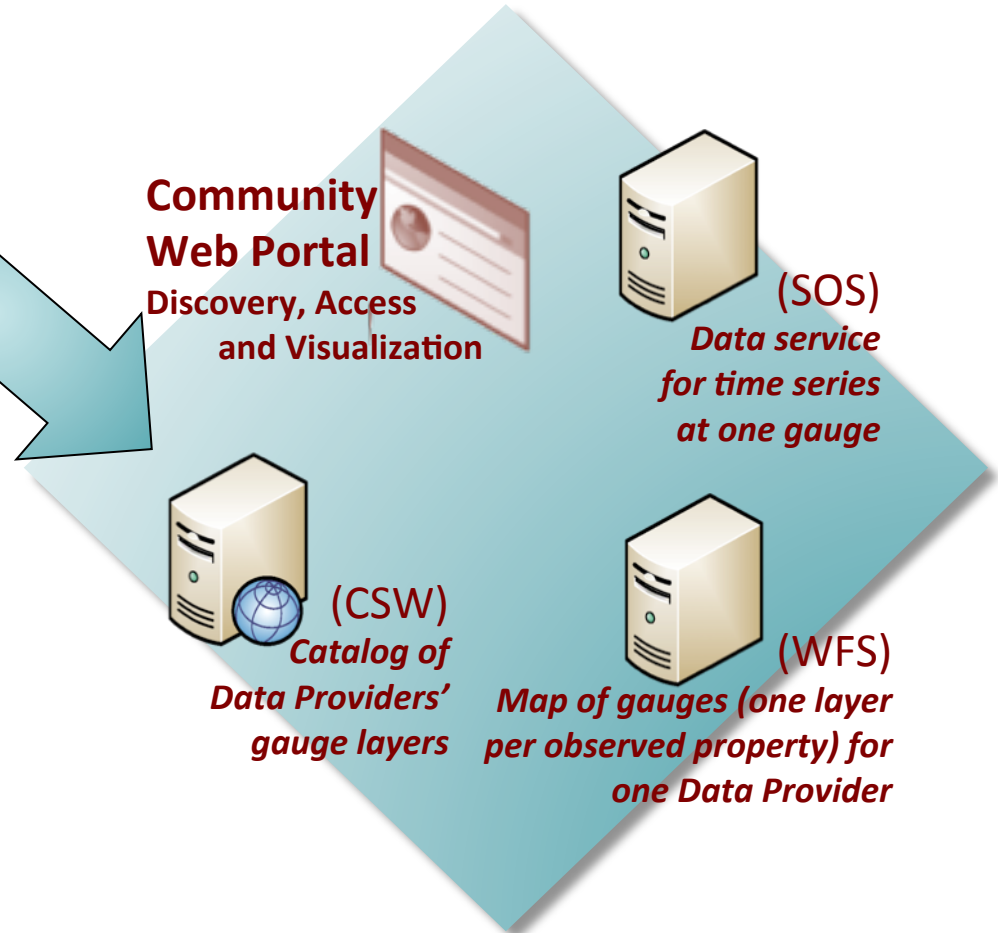


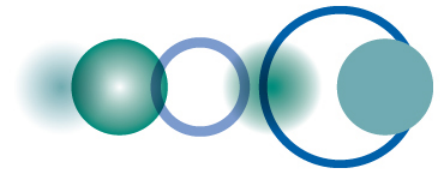


# GEOSS promotes interdisciplinary discovery



***By registering the community portal and its catalog in GEOSS, interdisciplinary users can more easily discover these resources***





## Federating regional & national water data

- Without **consistent use of standards for data content and description**, every water management agency would have a different way of telling their story
- In this project, we have started convergence toward a common way of describing water data time series among these countries:
  - United States (USGS NWIS)
  - Italy (ISPRA/ARPA-ER)
  - New Zealand (NIWA/HRC)
  - Canada (USask GIWS for Environment Canada)
  - Dominican Republic (through BYU)
  - Honduras (through BYU)
  - Nicaragua (through BYU)
  - Guatemala (through BYU)

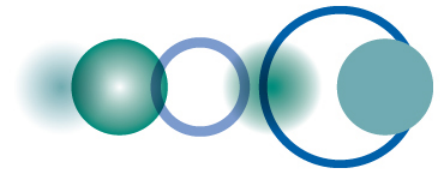




## Summary of Recommendations

1. **Use OGC WaterML 2** for water-variable time series data (streamflow, precipitation, runoff, etc).
2. **Use OGC WFS** or similar feature layer of water data sites; one WFS service per data layer / producer.
3. **Use consistent & minimal subset** of time series description fields in the WFS data service (*this is a current discussion topic*).
4. **Use OGC SOS 2** as the web data service for WaterML 2, ***but be prepared for the many sites running CUAHSI WaterOneFlow*** (WOF) web service for WaterML 1.x data, and even WFS for WaterML time series data. **Use ISO 8601 for time expressions** in the data service.
5. **Each data provider could install and manage a catalog registry** of relevant time series descriptions (WFS feature layers), or use an established community catalog for that purpose (eg, CUAHSI HIS Central). This catalog should itself be registered in GEOSS.

***WMO is advancing that the core WaterML be renamed TimeSeriesML, and the hydrology-specific portion (still to be called WaterML) become a profile of TimeSeriesML.***



# Water Map Service Guidelines

*There needs to be a consistent way of describing water data time series, that would be followed by data producers and software developers.*

With this project we are defining a minimal set of feature attributes which characterize time series, for use between map viewer/client and WFS data service:

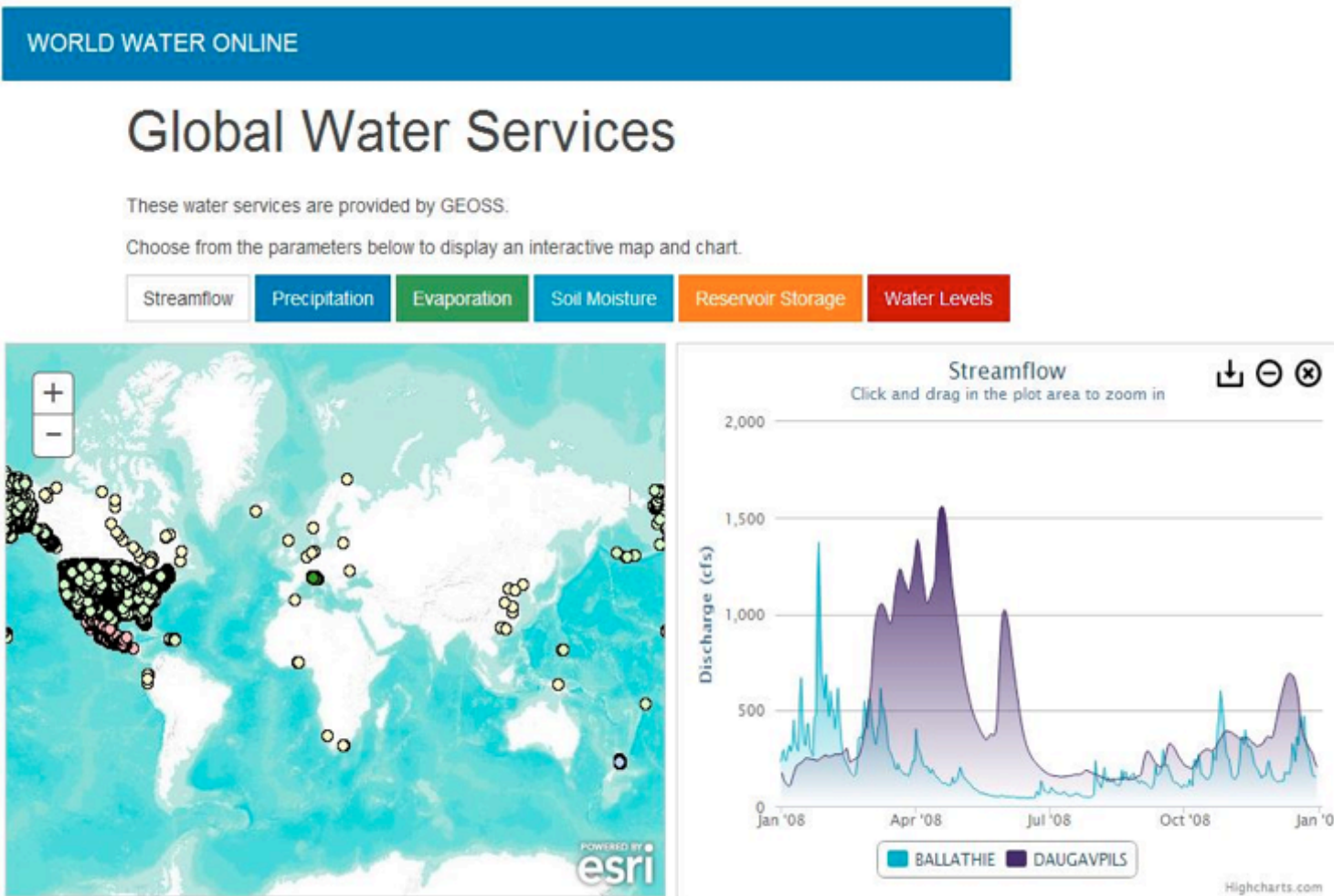
- **WaterMLURL** for a REST call to a separate data service endpoint, that enables a time series to be queried from this location.
- **GraphURL** and **DownloadURL** for graphing or downloading the data, if available.
- **BeginDate** of the data (the time of first information, using ISO 8601 time format).
- **EndDate** of the data (make Null if this is current time).
- **Descriptor** – text descriptor of this feature (e.g. Site name for gaging station, COMID for NHDPlus, etc)
- **Source** – text field that specifies the source of the data e.g. USGS, etc.
- **If the EndDate field is empty (null)**, this means the data service is a near-real-time feed, not just an historical dataset.
- The WaterML time series data is served by OGC Sensor Observation Service (SOS), or in some cases, WFS as well.
- **FP7 GEOWOW (<http://www.geowow.eu/>) developed Hydrology Profile for SOS 2.0, to provide unambiguous conventions for data service REST calls (OGC 14-004)**

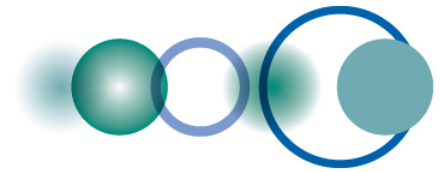




# Open source client apps in progress...

A browser-based WaterML Viewer (for all versions) is in development at UT Austin: <https://github.com/crrw/wmlviewer>





# Flemish Water Resources

<http://www.waterinfo.be/>

**WATERINFO.be**  
Portal of the Flemish Water managers

Search for street, waterinfomessage, documents,...

PRESS EN

login



Maps and graphs ▾ Reports About waterinfo.be ▾

## Current situation

**Information**

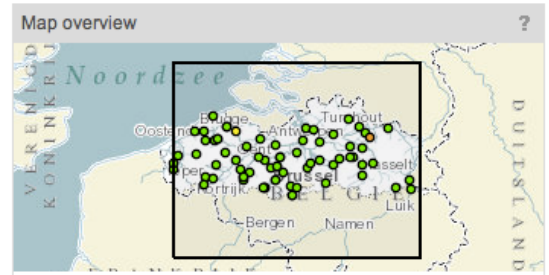
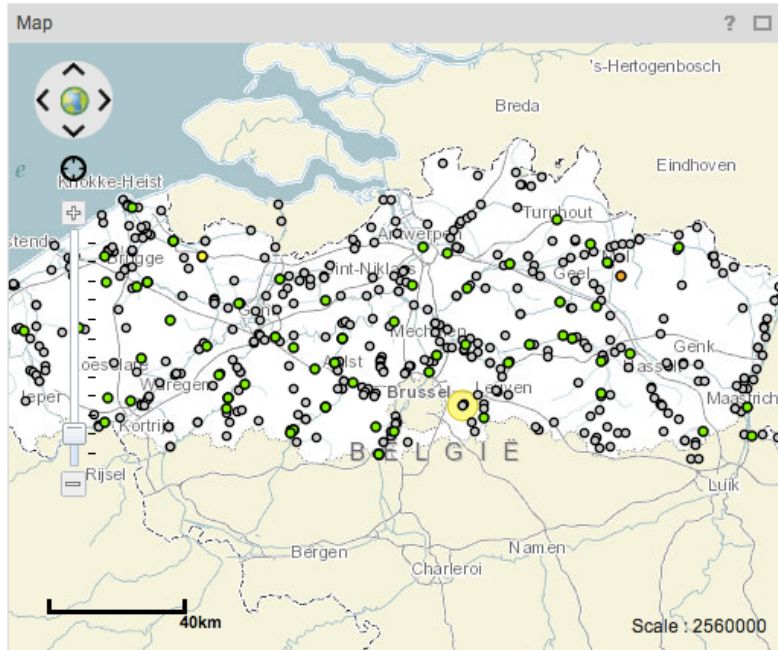
Numerous gauging stations keep close watch on the Flemish watercourses. They continuously register water levels, flows and precipitation.

- Waterinfo messages**
- Tijd ▾ Ernst
- Toestand onbevaarbare waterlopen op 11/8/14 om 19u**  
Geen kritieke overstromingen langs de onbevaarbare waterlopen  
Interpretatie van de Operator - 11/08/2014 19:00
  - Hydrologische situatie op 11/8/2014 om 8 uur**  
De afvoersituatie op de bevaarbare waterlopen is en blijft de komende 48u normaal.  
Hoogwaterbericht - 11/08/2014 08:00
  - MONEOS Jaarrapport 2013 beschikbaar**  
Je kan het "MONEOS jaarrapport 2013" terugvinden onder Rapporten > 1.Jaarrapporten > Moneos-rapporten HIC  
Locatie:  Thema:

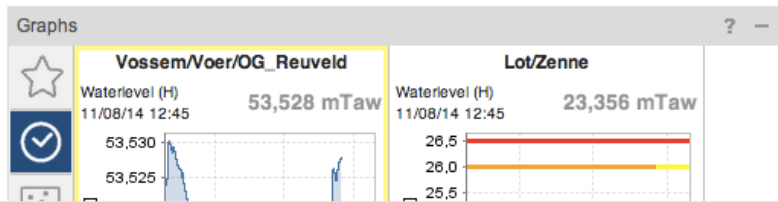
**Twitter**

**Tweets**

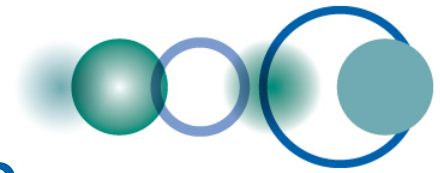
**Andy Engel @Andy\_Engel** 14m  
Gemeentelijke rol bij voorkomen van #wateroverlast #vng #lokalekeuzes #ruimtelijkeinrichting #klimaatadaptatie <http://t.co/kgb8CCGngi>



- Legend**
- Current Status**
- Alarm
  - Waak
  - Pre-Waak
  - Normaal
  - Geen Waarde
  - Oude Waarde

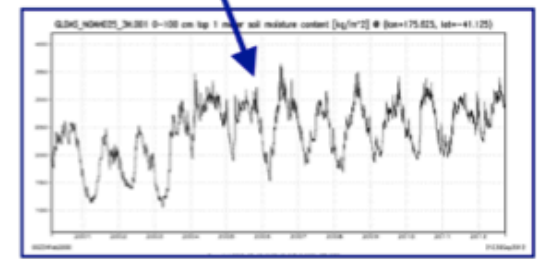
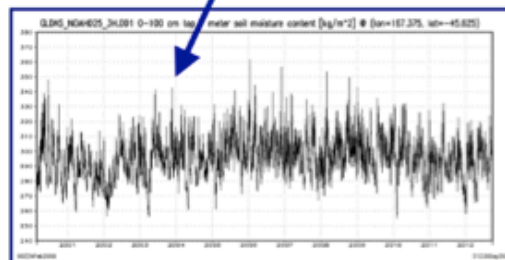
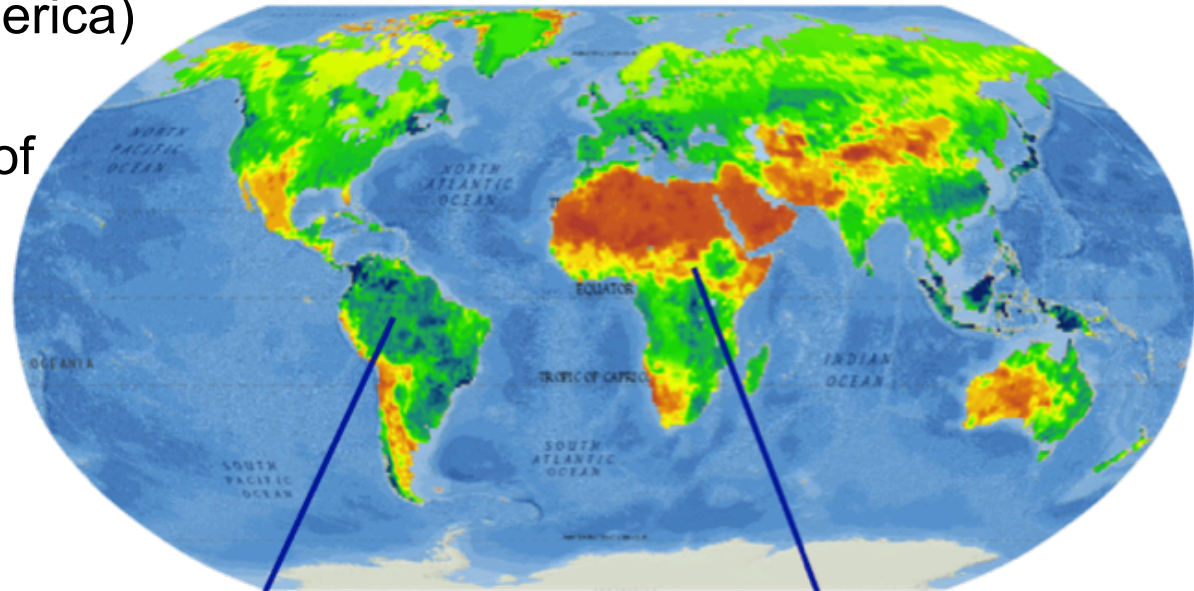


- Kaartlagen**
- Current Status
  - Water level/discharge
  - Structures on unnavigable watercourses
  - Achtergrondkaart
- Table overview current status**



## Integrating gridded data and time series to understand and prepare for drought and floods

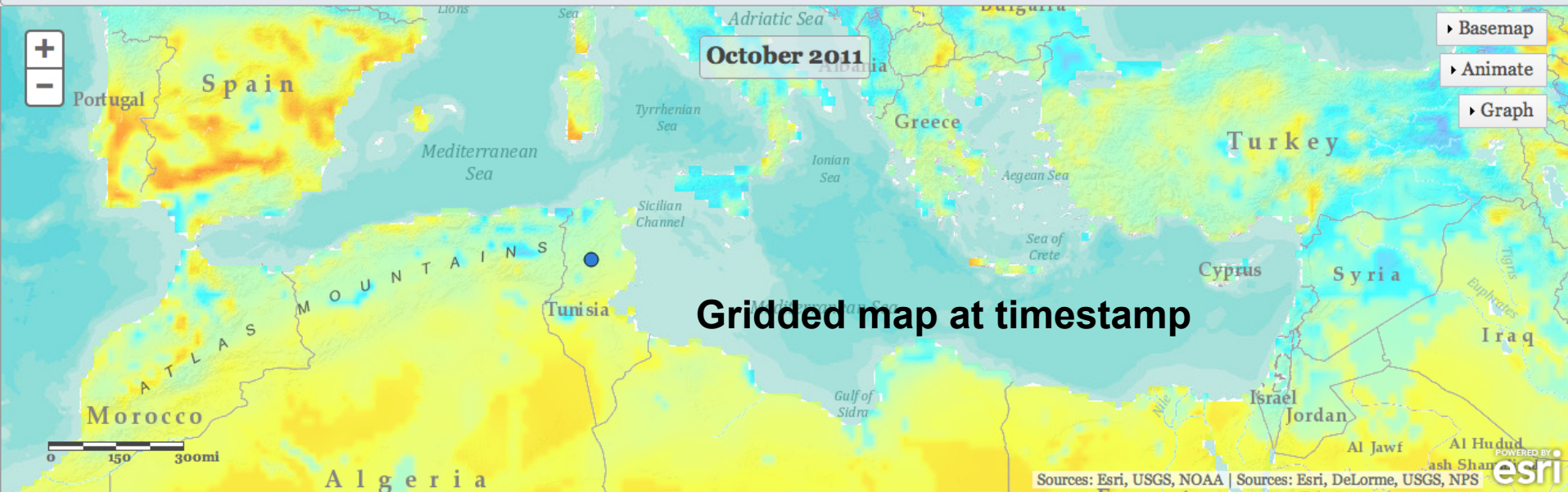
- NASA provides 28 (global) & 52 (N.America) water modeling outputs from the **Land Data Assimilation System (LDAS)**
- These are gridded at 1/4-degree / 3-hr intervals (global) or 1/8 degree / 1-hr (N.America) from 1979-present.
- NASA replicates many of these model outputs as time series at discrete locations (**data rods**)
- Variables include:
  - Soil moisture
  - Soil temperature
  - Evapo-transpiration
  - Rainfall
  - Runoff



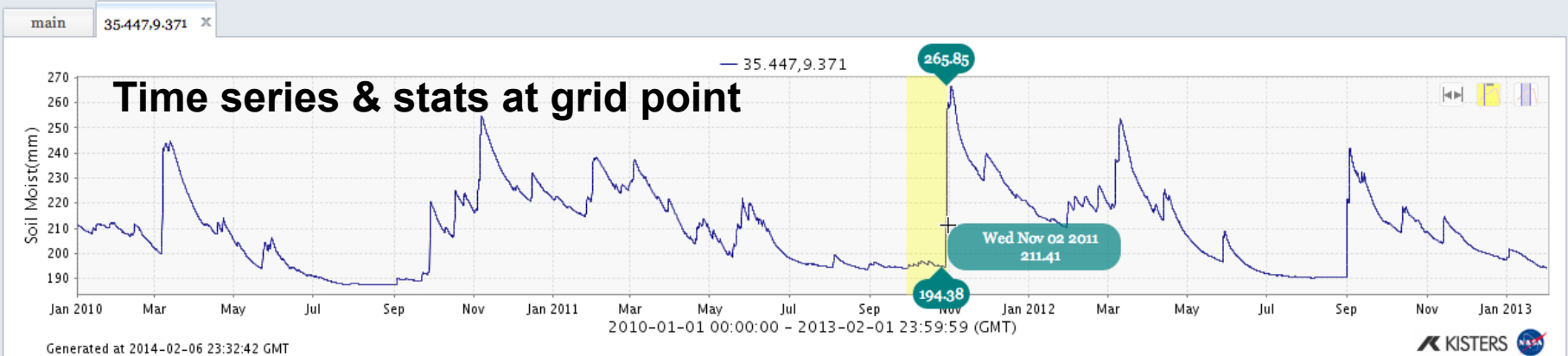
# Viewing & comparing time series values

## World Soil Moisture Explorer

Monthly mean soil moisture 2003 – 2013, upper 100cm, from NASA GLDAS NOAH model



1m 3m 6m 1y 3y From: 31/12/2009 To: 31/01/2013



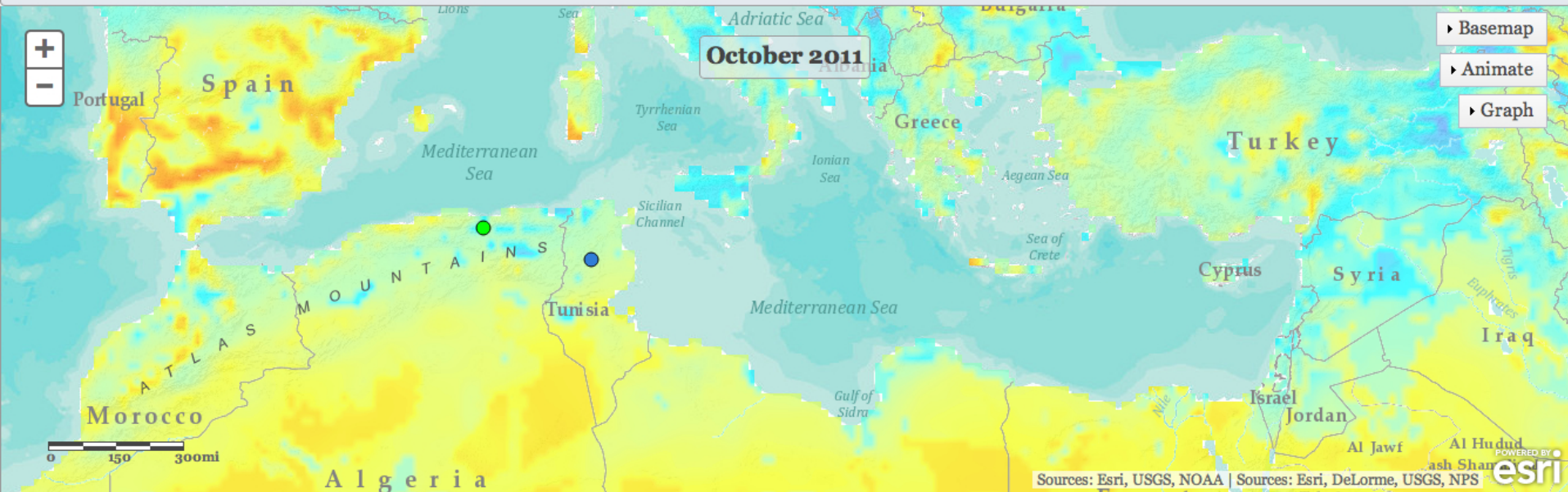
October 2011



# Comparing time series for multiple locations

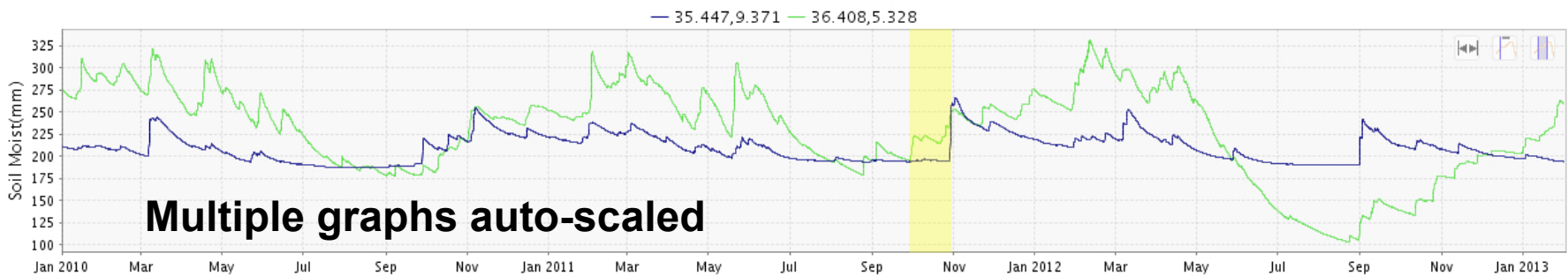
## World Soil Moisture Explorer

Monthly mean soil moisture 2003 – 2013, upper 100cm, from NASA GLDAS NOAH model



1m 3m 6m 1y 3y From: 31/12/2009 To: 31/01/2013

main 35.447,9.371 x 36.408,5.328 x



2010-01-01 00:00:00 - 2013-02-01 23:59:59 (GMT)

Generated at 2014-02-06 23:40:24 GMT



October 2011

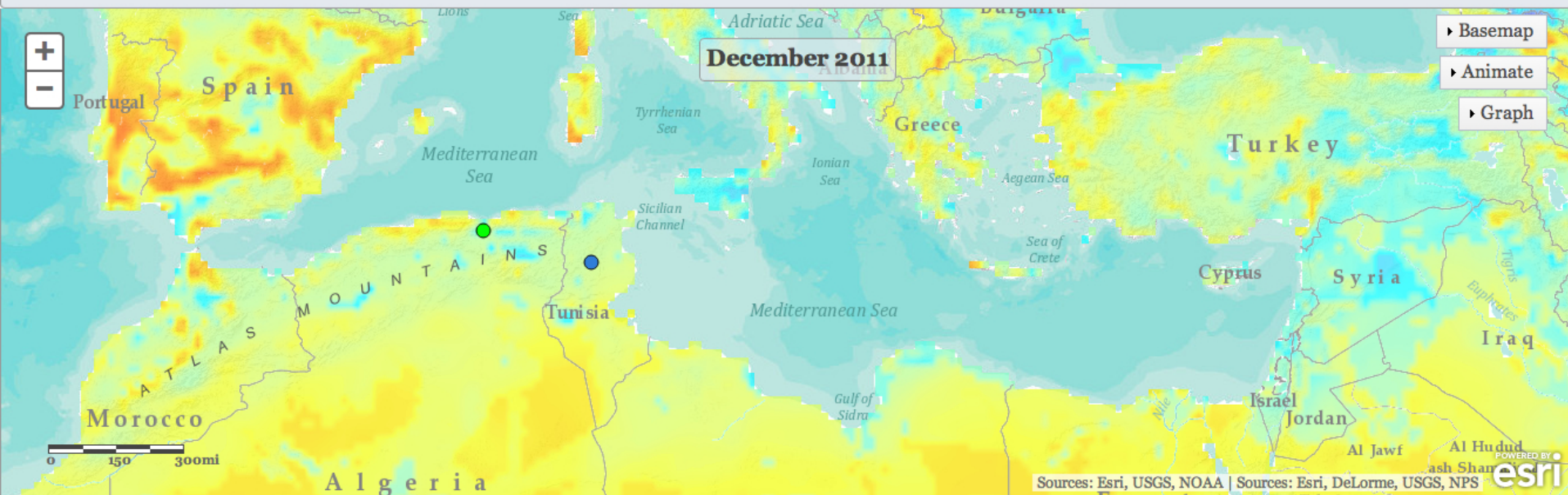




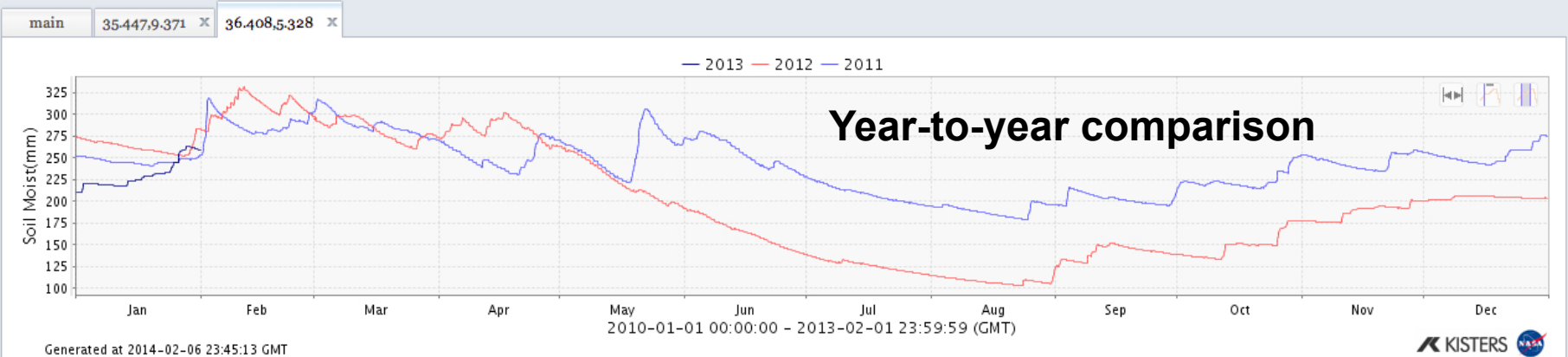
# Comparing time series for multiple years

## World Soil Moisture Explorer

Monthly mean soil moisture 2003 – 2013, upper 100cm, from NASA GLDAS NOAH model



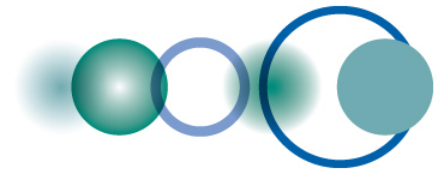
1m 3m 6m 1y 3y From: 31/12/2009 To: 31/01/2013



Generated at 2014-02-06 23:45:13 GMT

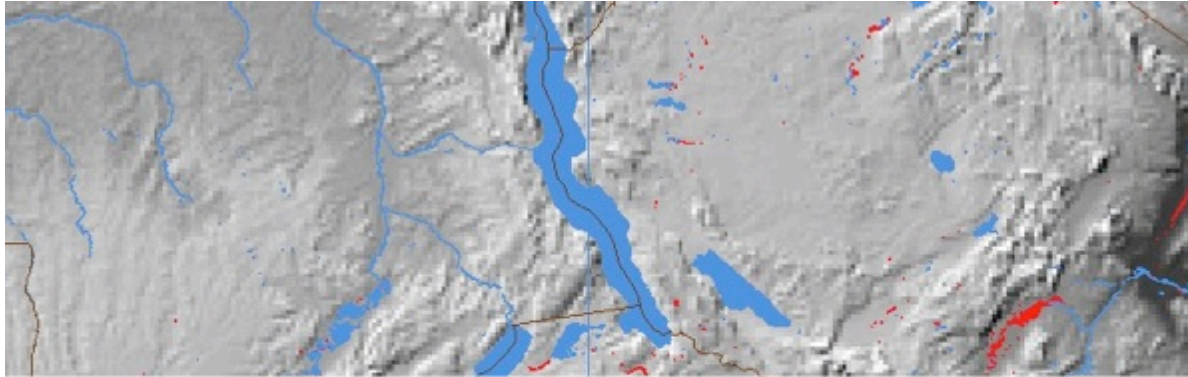
December 2011

2010 2011 2012 2013

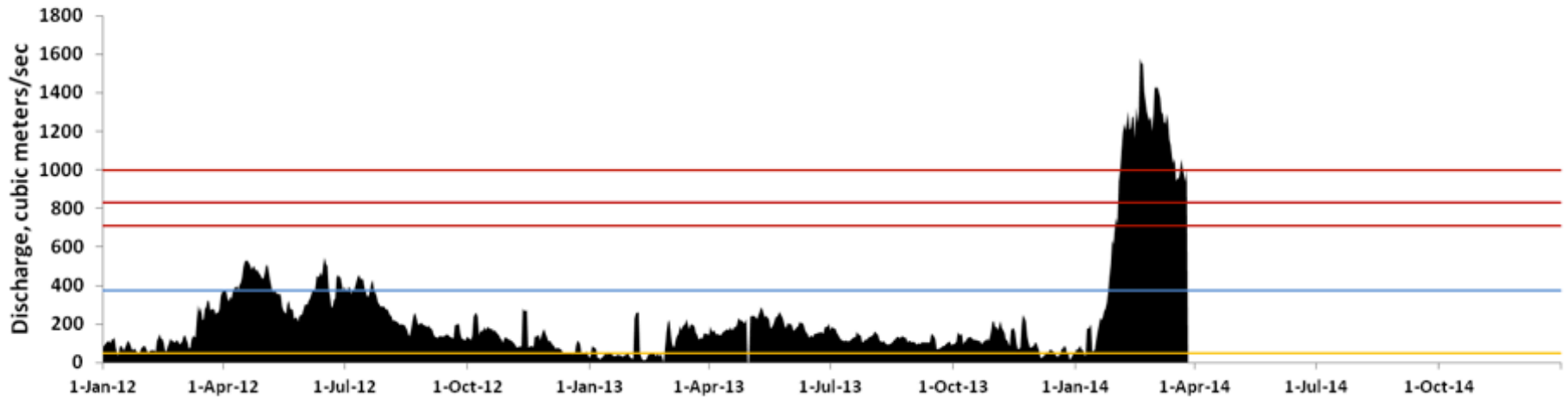


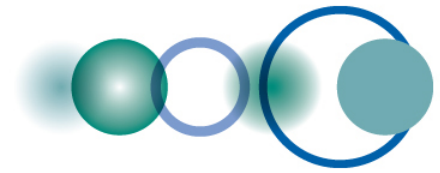
# Flood Monitoring

The Dartmouth Flood Observatory maps flood extents globally, based on pre- and post-event imagery from NASA MODIS



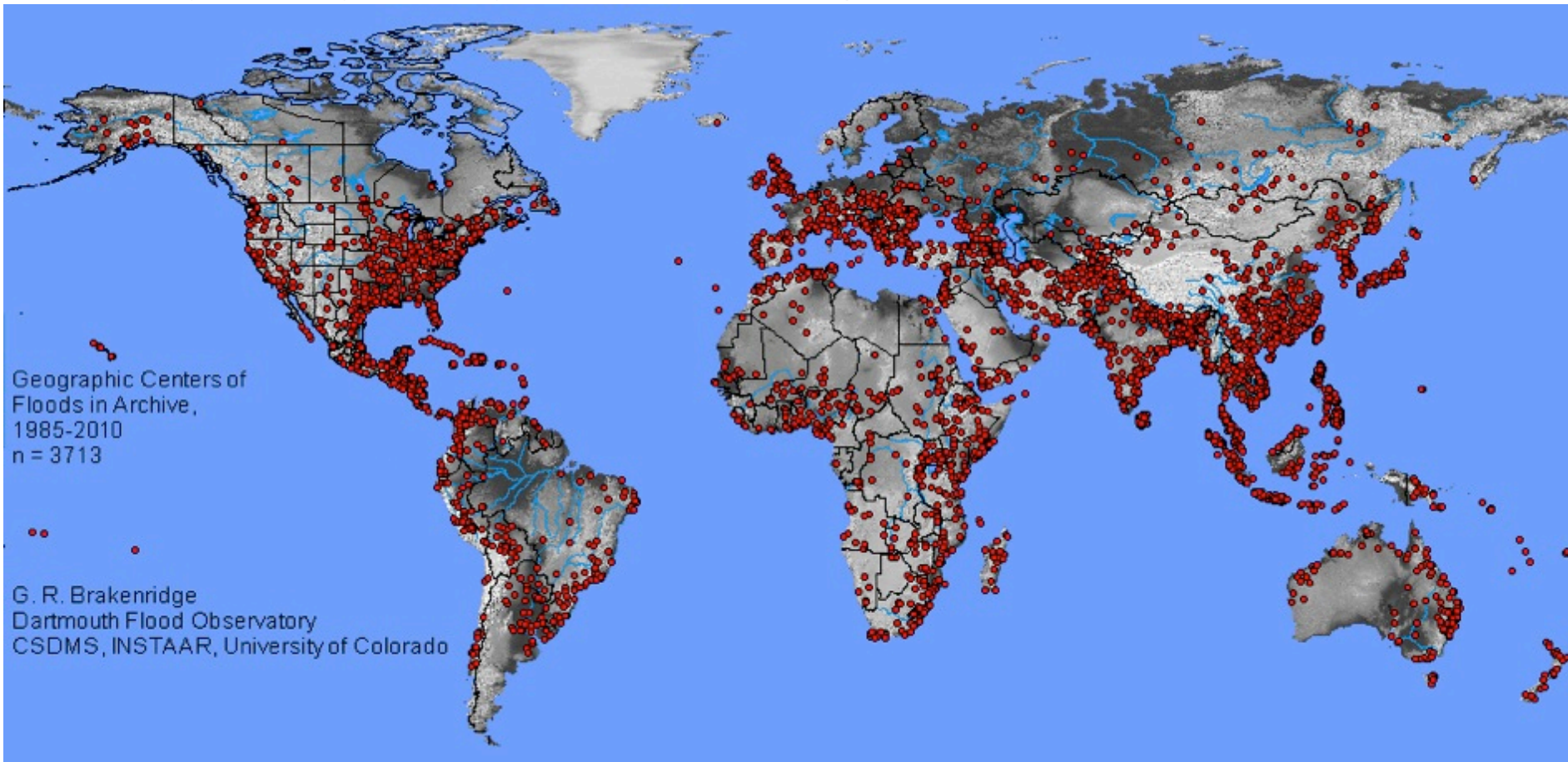
■ Satellite Discharge    — Low Flow    — 1.33 yr Flood    — 5 yr Flood    — 10 yr Flood    — 30 yr Flood

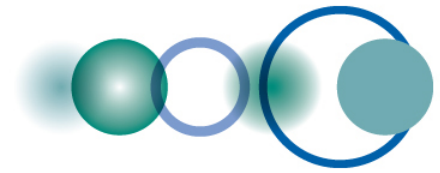




# Flood Monitoring

The Dartmouth Flood Observatory preserves the record of each major flood event, for posterity and for use in global flood hazard modeling, to help identify severity of current flooding

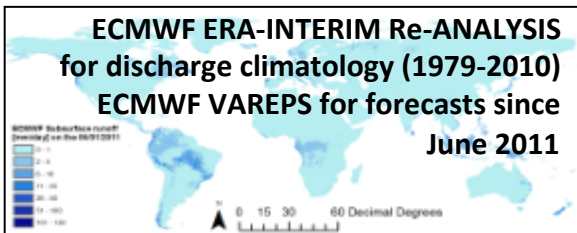
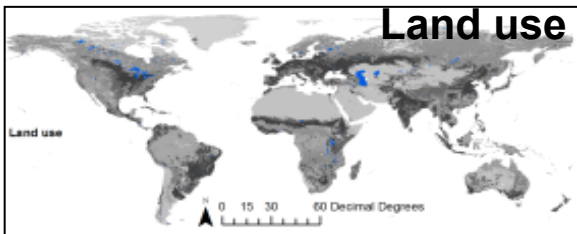
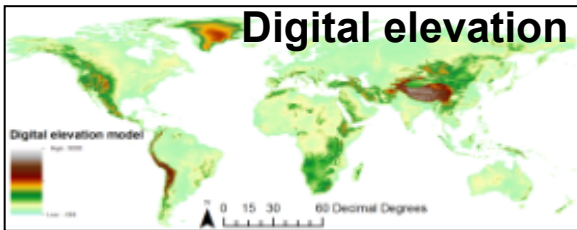




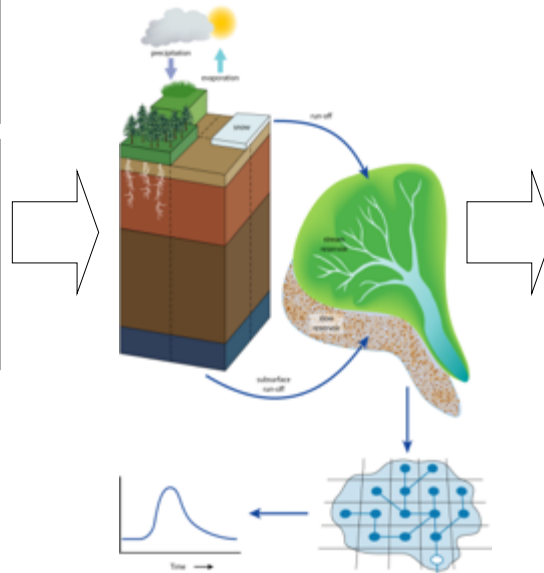
# Flood Prediction

**Global Flood Awareness System (GloFAS)** from the European Centre for Medium-Range Weather Forecasting (ECMWF) and the Joint Research Centre (JRC)

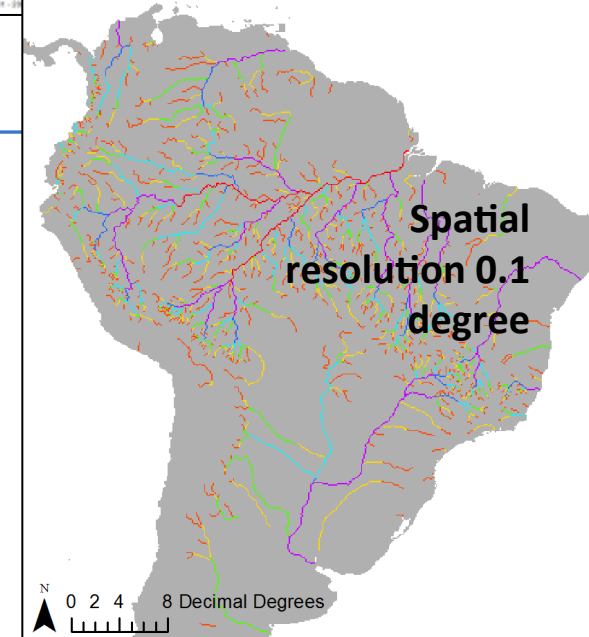
Inputs: global spatial data

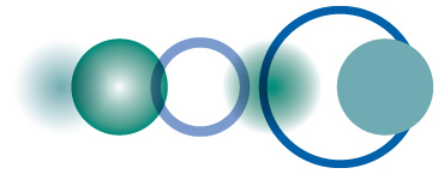


Hydro-Meteo model with grid-based routing (**LisFlood**)



Output: global daily discharge

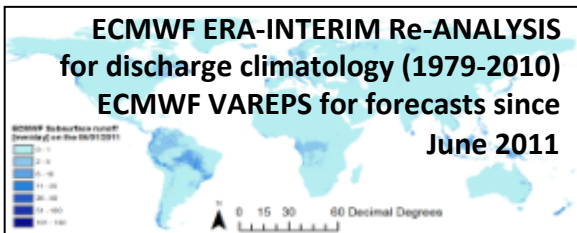
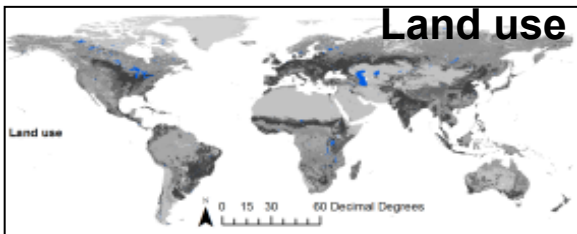
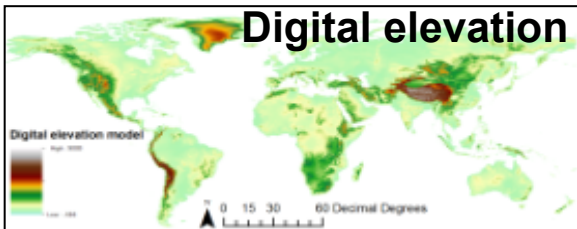




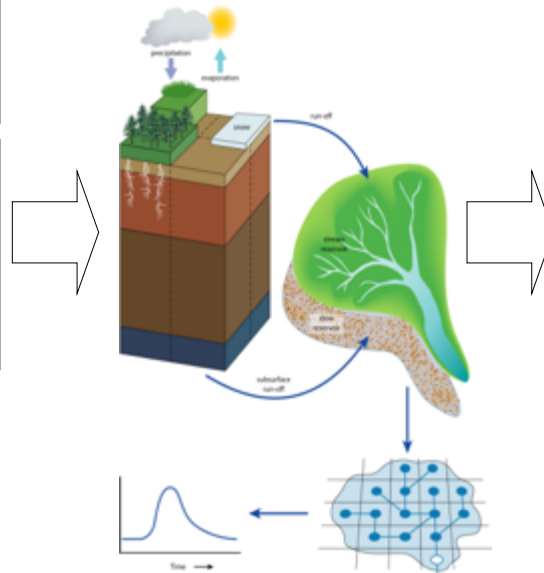
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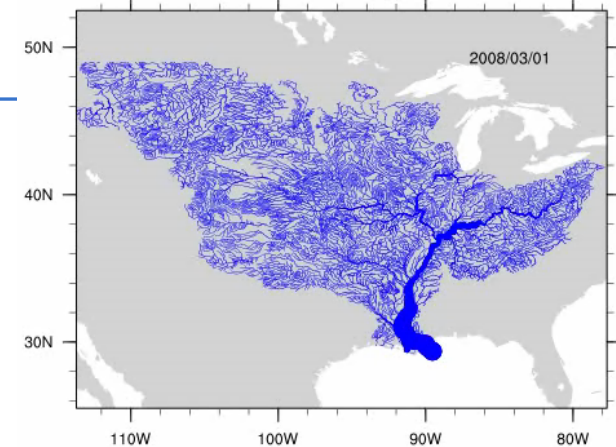
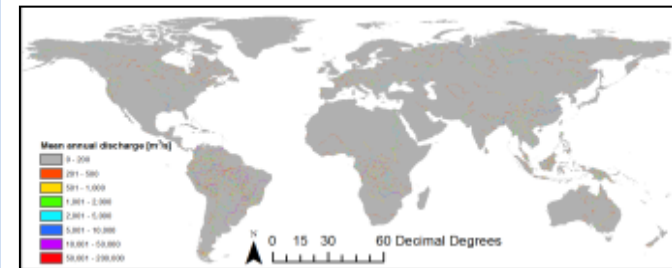
Inputs: global spatial data



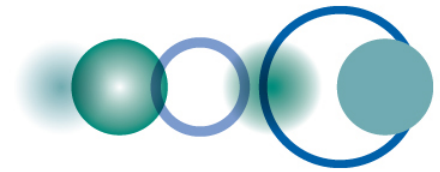
Hydro-Meteo model with grid-based routing (**LisFlood**)



Output: global daily discharge

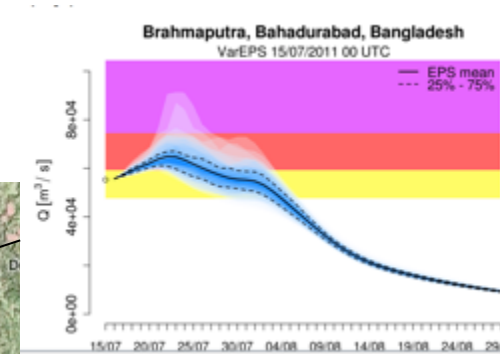


**Downscaling the river routing through integration with RAPID**



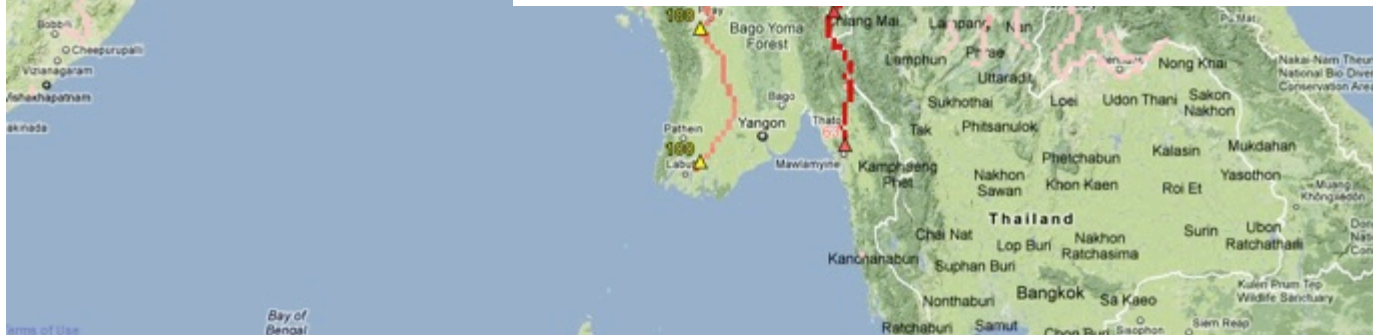
# Target: 2-week advance forecasting of major floods

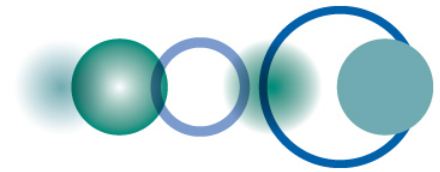
GloFAS provides probabilistic forecasts of flooding events for large basins



High Alert Level

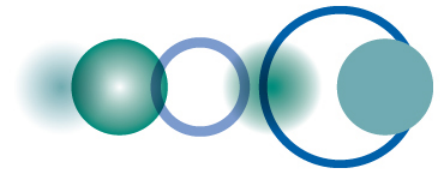
Forecast Day	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
08/07/2011								4	10	18	20	20	27	29	25	22	14	10	2	2				
09/07/2011								2	24	31	37	45	29	20	14	14	4	4						
10/07/2011									6	12	24	25	25	22	16	14	8	8						
11/07/2011								4	18	25	25	24	25	14	12	8	4	2						
12/07/2011							2	10	29	45	49	63	63	45	31	18	10	6	8	6	4			
13/07/2011								10	27	33	57	67	61	53	45	33	31	33	33	33	22	16	4	
14/07/2011								16	31	43	59	73	78	78	63	53	33	29	20	14	12	12	10	
15/07/2011									41	71	92	98	86	80	71	65	51	37	31	31	25	24	25	





## Integrating DFO & GloFAS

- Current project is helping integrate Dartmouth Flood Observatory and GloFAS by:
  - DFO providing historical flooding records for many more basins than previously available to GloFAS
  - GEOSS AIP project participants from New Zealand, Taiwan, Italy, and Latin America will provide observation data for comparison and validation



## Water Quality Services

- OGC 14-004 WaterML – WQ Profile Best Practice
  - Single variable per time series
  - Keep the XML simple, if verbose
  - Use CSV/Excel format for multi-variable applications
- Numerous application areas
  - Health, wastewater monitoring
  - Residential, industrial point sources
  - Stream nutrient loading





# New Zealand WQ Browser: LAWA



<http://www.lawa.org.nz/>

EXPLORE DATA | LEARN | GET INVOLVED | ABOUT | 🔍

## LAWA connects you with New Zealand's rivers through sharing water quality data

Search for your local river



Or explore the national picture



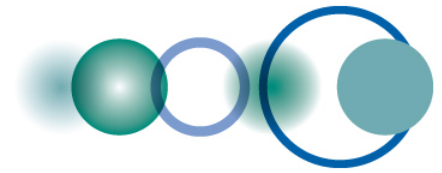
### INTRODUCING LAWA

An introduction to LAWA, who's involved and what it does



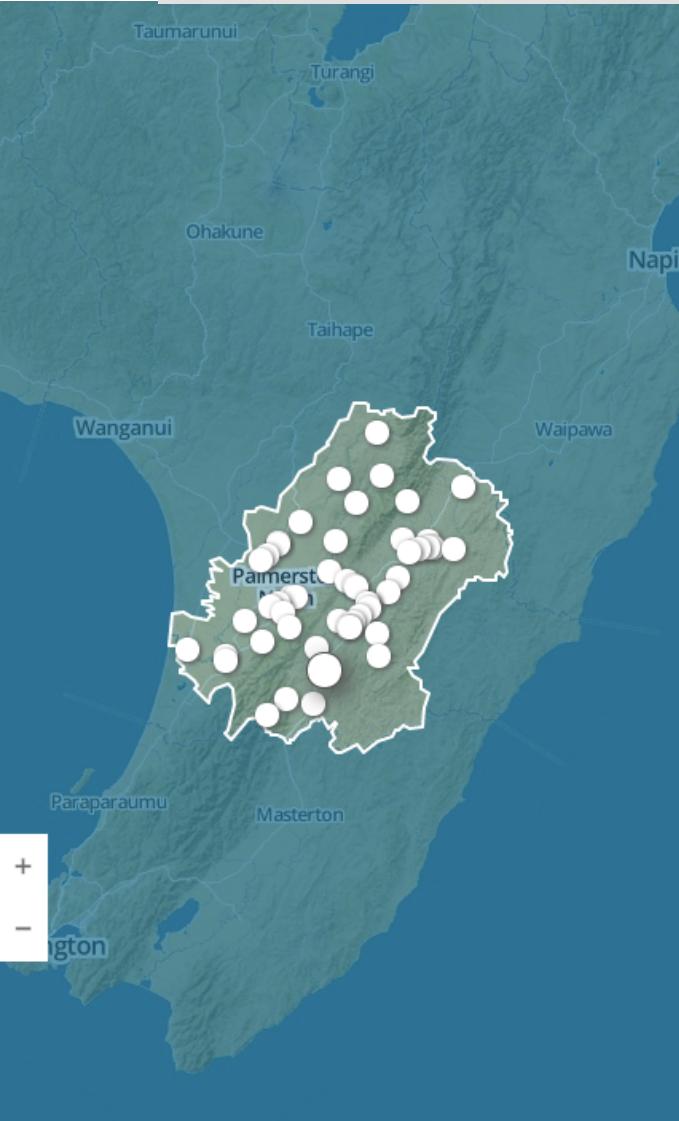
### RIVER OF THE MONTH

Guiding lights of river restoration



# New Zealand WQ Browser: LAWA

<http://www.lawa.org.nz/explore-data/manawatu-wanganui-region/manawatu/makakahi-at-hamua/>



## Scientific data for this site

Can I trust this data? ✓

This dashboard shows information on the data collected by the regional councils for nine indicators, analysed as **state and trend**.

### State ?

State shows how the **median** of samples from this site compares to other sites

This site is a **Upland Rural site**. Currently showing the state of this site compared to:

All rural sites

### Trend ?

Trend shows how the quality of water is changing over time. Depending on the sampling history duration, five and nine year timescales are available:

Showing nine year trend

### Bacteria

*E. coli* ?

215 n/100ml

STATE



In the worst 50% of all rural sites

TREND



Significant improvement

### Clarity

Black disc ?

1.8 metres

STATE



In the best 50% of all rural sites

TREND



No trend

Turbidity ?

2.02 NTU

STATE

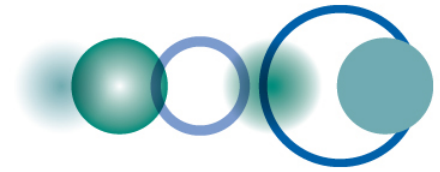


In the best 50% of all rural sites

TREND

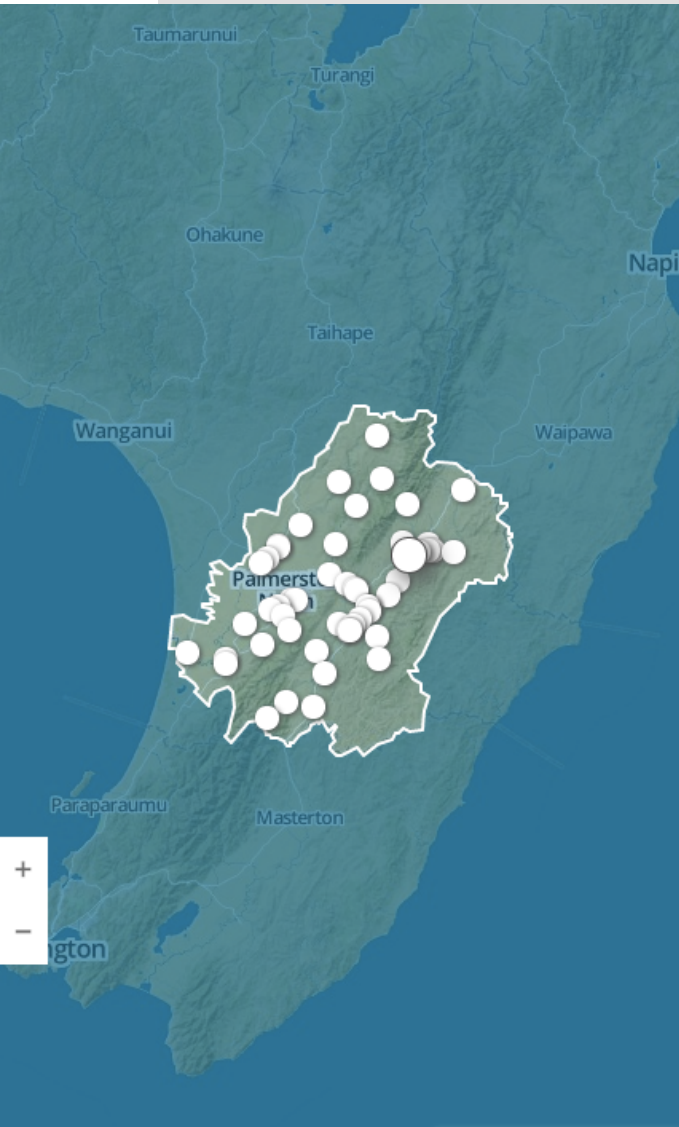


No trend

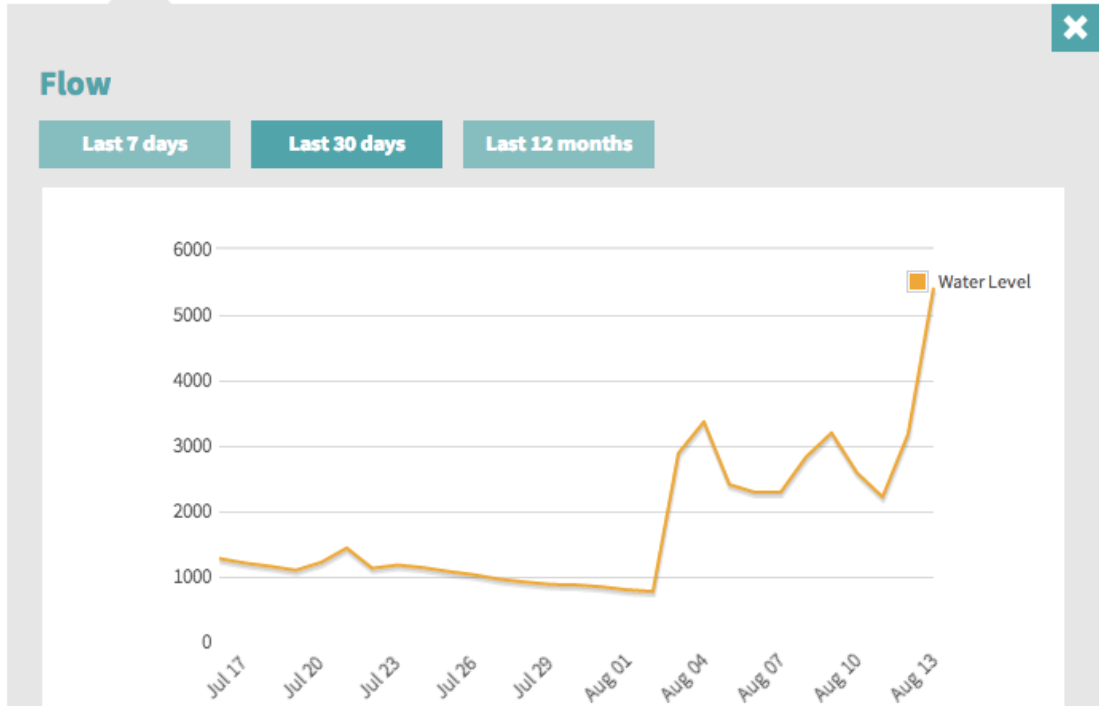


# New Zealand WQ Browser: LAWA

<http://www.lawa.org.nz/explore-data/manawatu-wanganui-region/manawatu/oruakeretaki-at-sh2-napier/#X>



Flow	Water Temperature
Latest sample: <b>7631</b> l/s 14 Aug 2014 2:35 a.m.	Latest sample: <b>7.50</b> °C 14 Aug 2014 2:30 a.m.





## **GEO coordinating with UN Agencies**

- WMO Information System (WIS)
  - Integration with GEOSS Discovery & Access Broker for harvesting & distributed search is underway
- World Health Organization + HABITAT + UNEP
  - Helping develop ways to incorporate Earth observation into UN's Sustainable Development Goals, specifically to improve water quantity & quality in developing countries
  - EO Task Team now includes NASA, NOAA, USGS, US EPA, USACE, ESA, WMO, World Resources Institute, and others



World Meteorological Organization

Weather • Climate • Water

# WMO Hydrological Observing System (WHOS)

Harry F. Lins

President, Commission for Hydrology

# Prelude

- Inter-Commission Coordination Group on the WMO Integrated Global Observing System (ICG-WIGOS)
- WIGOS is an integrated, comprehensive, and coordinated system comprised of present WMO global observing systems; i.e., Global Observing System (GOS), Global Atmosphere Watch (GAW), the observing component of Global Cryosphere Watch (GCW), and the **World Hydrological Cycle Observing System (WHYCOS)**.



# Proposal

**A WMO Hydrological Observing System (WHOS)** was proposed and agreed by the CHy Advisory Working Group as the means to provide the most comprehensive hydrological component in fulfillment of the WIGOS objective of “an integrated, comprehensive, and coordinated system which is comprised of the present WMO global observing systems.”



## Initial Implementation

Currently, a CHy expert has developed an interactive map and is in the process of incorporating links to those National Hydrological Services that make their real-time stage and discharge data available online.

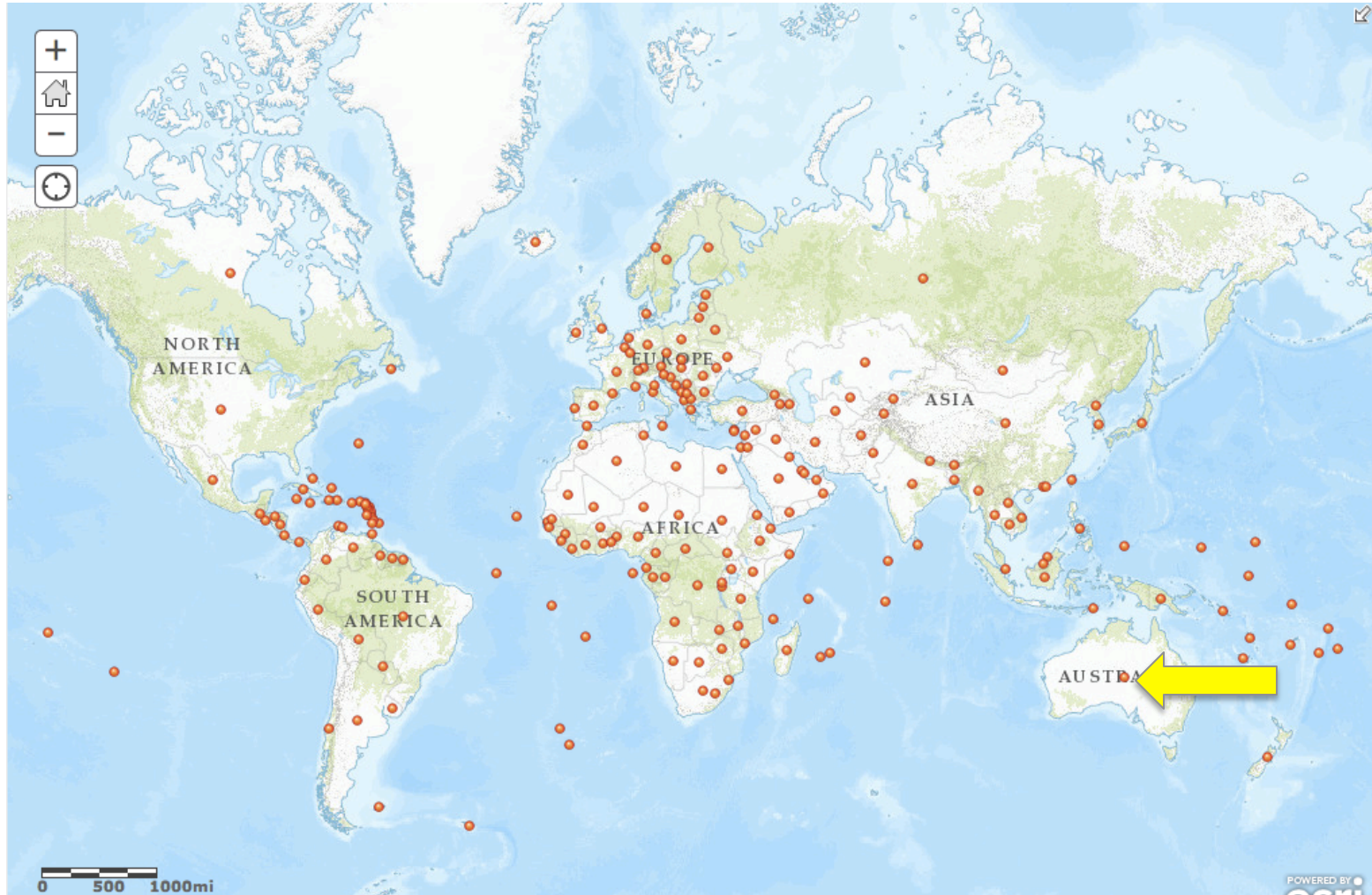
Plan is to have a preliminary version of the website online by the end of December 2014.





# The WMO Hydrological Observing System

A portal to real-time streamflow data currently available online from NHSs

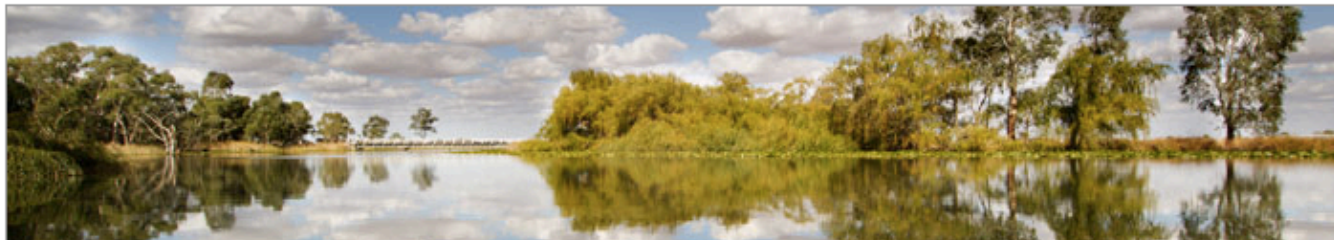


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[Water data](#) | [Water status](#) | [Water forecasts](#)

# Improving water information



## National Water Account 2013

The National Water Account contains water accounting reports for nine nationally significant regions. It provides information on water stores and flows, water rights and water use.

[» Continue reading about the Account](#)

1 2 3 4 5



### Water data

- Design Rainfalls
- Environmental Monitoring Sites
- Geofabric
- Groundwater information
- Hydrologic Reference Stations



### Water status

- Australian Water Resources Assessment
- National Water Account
- Water Restrictions
- Water Storage [↗](#)



### Water forecasts

- Floods
- Streamflow Forecasts

### Related links

- [Rain, River & Storage Data](#)

### Water links

-  [Water Act 2007](#)
-  [Water Regulations 2008](#)
-  [Water market information](#)
-  [Water Dictionary](#)
-  [Publications](#)
-  [News](#)
-  [Contact Us](#)

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Available on the  
**App Store**



## Next Steps

- Identify all NHS websites that provide free and open access to their real-time hydrological data; finalize map portal and webpage; go public.
- Encourage NHSs having data holdings not yet online to provide public accessibility.
- Evaluate a more comprehensive system for water data dissemination . . . WIS? GRDC? HIS?.

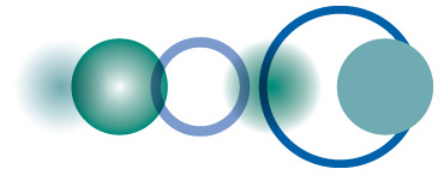




## Summary

- WHOS will provide a modern network of National Hydrologic Services for authoritative data
- GEO/GEOSS provides an organizing principle for data and map services that works across boundaries between nations, institutions, and scientific / societal domains.
- AIP-Water theme is providing a forum for developing coherent, consistent conventions and tools for data sharing that enable regional, national & global federation & cross-discipline interoperability
- We are building momentum; need to start working on training & support





# Thank you!

David K. Arctur

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