Developing Essential Water Variables (EWVs) to Support Water Cycle Research and Water Sustainability Applications

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Abstract

The initial list of Essential Water Variables (EWVs) evolved from wide meta-surveys of water data needs for research and applications that were carried out in 2010 to support GEO Societal Benefit Areas (SBAs). These EWVs were formalized in the Group on Earth Observations System of Systems (GEOSS) Water Strategy Report (WSR) "From Observations to Decisions", released in 2014. Subsequently, discussions with additional user communities have augmented the list, for example with Surface Water Extent. Besides "primary" EWVs that identify key water variables, including precipitation, soil moisture, and water quality, a set of "supplementary" EWVs is also needed to complete the information that the formal list of primary EWVs should provide, such as Digital Elevation Models. It is clear that all available observing systems, employing both remote sensing and in situ observing instruments and networks are required to address the range of space/time resolutions, accuracies, and data latencies that the end-user applications require. In fact, there are still gaps in our ability to deliver all variables as required. In some cases this is a technical challenge, such as remote sensing capabilities for some water quality variables, while in many other cases it is a matter of administrative and resource challenges. This paper summarizes EWVs as currently defined and required by key end-user research and applications sectors. As a follow up to the WSR, we highlight the relevance of EWVs to the indicator monitoring objectives of the UN Sustainable Development Goals (SDGs), various international Conventions and Frameworks, and the GEO Global Water Sustainability (GEOGloWS) priority thematic communities.

Developing Essential Water Variables (EWVs) to Support Water Cycle Research and Water Sustainability Applications

AGU-Session HO49 - Essential Water Variables (EWVs) observations and applications for research, water resources management, and operational decision support

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Dr Gutierrez is a Lead scientist at NOAA, with over 25 years of experience in the fields of hydrology, water quality, and environmental policy. She is a member of the Ambassador's Water Experts Program (AWEP), where she serves as an expert hydrologist on behalf of the U.S. around the world, a Program in support of the U.S. President's Global Water Strategy.

Within the Group on Earth Observations (GEO), she is a Co-chair of the regional GEO in the Americas (AmeriGEO) and a co-chair of the Global Water Sustainability (GEOGloWS) Initiative. She is the recipient of the GEO Individual Excellence Award 2019 for her exceptional contributions to the work of GEO by improving water sustainability in multiple countries, and pioneering scientific and regional collaboration. She holds a Ph.D. in Civil and Environmental Engineering from the University of Maryland and an M.S. in Technology Management and Public Policy from Stony Brook University.

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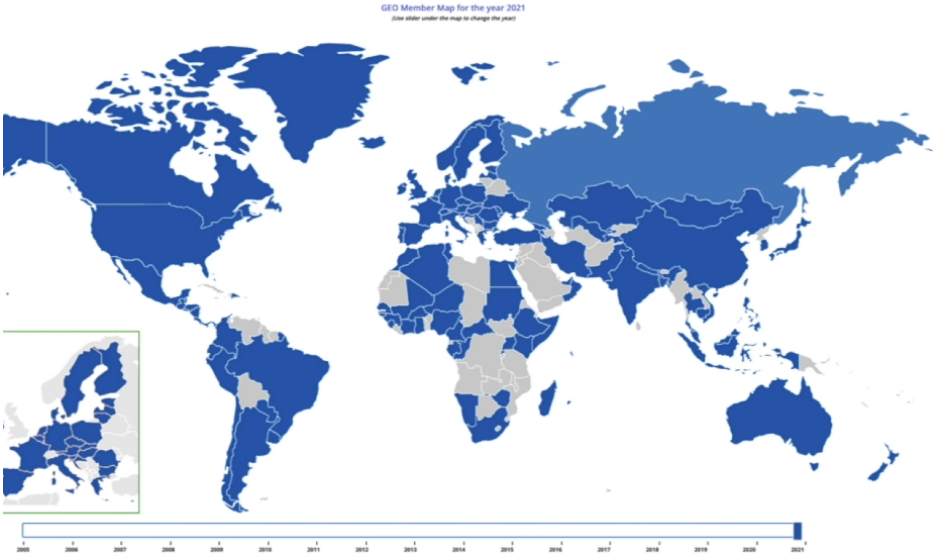
GROUP ON
EARTH OBSERVATIONS



Number of Members (2021)

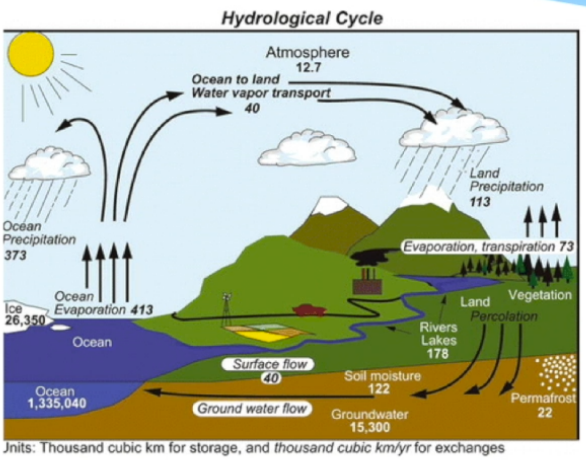
Africa:	30
Americas:	20
Asia/Oceania:	22
C.I.S.:	6
Europe:	35
Total:	113

THE GEOSS WATER STRATEGY
FROM OBSERVATIONS
TO DECISIONS

The Strategy's goal

To provide a framework for guiding decisions regarding priorities and strategies for the development, maintenance, and enhancement of water observations and data products, and plans for expanding the use of these data sets and products.

Developing the Essential Water Variables – 1



Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

(Trenberth et al. 2007); © **American Meteorological Society. Used with permission.**

Initial research on closing the global water budget showed that

- certain variables were essential for describing the water storage and flux terms in the water cycle
- observations of the different variables had very different levels of maturity, resolution, coverage, and availability
- these variables came from / were needed by many different communities

Developing the Essential Water Variables – 2

A wide survey of water data needs for research and applications provided the background data for the initial EWV definitions:

- Water Needs Societal Benefits Areas Report, Unninayar and Friedl, 2010 (*http://sbageotask.larc.nasa.gov/Water_US0901a-FINAL.pdf*)

* every variable has needs that range from very short/local to climatological/global

The list of EWVs was formalized in a report on the status and prospects for water information:

- GEOSS Water Strategy Report, R. Lawford (ed.), 2014: (*https://ceos.org/document_management/Ad_Hoc_Teams/WSIST/WSIST_GEOSS-Water-Strategy-Full-Report_Jan2014.pdf*)
- as noted above, observations of the different variables had very different levels of maturity, resolution, coverage, and availability

Additional discussions have brought in water quality and surface water variables

R. Lawford is leading a status update report on the Water Strategy Report

Key international Concepts, Frameworks, and Conventions Require Water Information

GEO Flagships, Initiatives, Community Activities and heritage Societal Benefit Areas

UN Sustainable Development Goals

Sendai Framework for Disaster Risk Reduction

The Ramsar Convention on Wetlands

The Aichi Convention on Biological Diversity

The Framework Convention on Climate Change (UN-FCCC)

Key Organizations Working on EWVs

Integrated Global Water Cycle Observations (IGWCO) Community of Practice

GEO Global Water Sustainabilty (GEOGloWS)

GEO AquaWatch

EWVs support all 17 UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment/)

SDG 6 (Clean water and sanitation)—Themes:
- **Safe drinking water**
- **Sanitation and hygiene**
- **Water quality**
- **Water use efficiency**
- **Integrated water resources management**
- **Water-related ecosystems**
- **International cooperation**
- **Local community support**

[With permission from UN Dept. Global Communications: https://www.un.org/sustainabledevelopment.

Current List of Primary and Supplemental EWVs (Updated from GEOGLOWS-WG3)
Followed by Tables Summarizing End-Users Served and Specifications of Requirements

Primary EWVs	Supplemental EWVs (apply to Water and related disciplines)
Precipitation	Surface meteorology
Evaporation and evapotranspiration	Surface and atmospheric radiation
Snow cover (including snow water equivalent, depth, freeze thaw margins)	Water vapor and clouds
Soil moisture/temperature	Permafrost
Groundwater	Land cover, vegetation, and land use
Runoff/streamflow/river discharge	Elevation/topography/bathymetry and geological stratification
Lake/reservoir levels, water storage, and aquifer volumetric (or mass) change	Surface altimetry
Surface water extent	Bathymetry
Mass balances of glaciers and ice sheets	Surface radiation
Water quality	Aerosols
Water use/demand (agriculture, hydrology, energy, urbanization, others)	Atmospheric radiation

Different uses/users of EWV data require very different space/time sampling and latency
Below are examples for Soil Moisture specifications at 3 levels (WMO/OSCAR): Goal/Breakthrough/Threshold

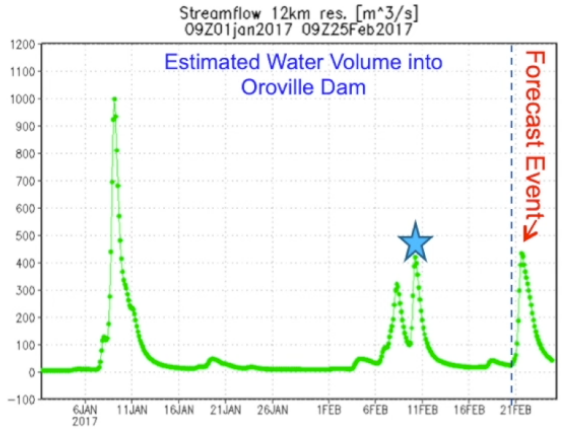
Soil Moisture requirements by different users. (adapted from WMO-OSCAR, 2021): https://space.oscar.wmo.int	Horizontal Resolution range	Time Resolution range	Vertical Resolution Height/Depth range	Accuracy/Units—Uncertainty range	Latency range
Soil moisture at surface-Agricultural Meteorology	0.1 /0.215 /1.0 km	24h/46h/7d		0.01/0.017/0.05 m**3/m**3	24h/41h/5d
Soil moisture at surface-GEWEX (deprecated)	15/50/250 km	24h/3d/10d		0.01/0.02/0.05 m**3/m**3	10d/15d/30d
Soil moisture at surface-Global NWP	5/15/100 km	3h/24h/5d		0.02/0.04/0.08 m**3/m**3	3h/24h/5d
Soil moisture at surface—High Res NWP	1/5/40 km	60min/3h/8h		0.02/0.04/0.08 m**3/m**3	30min/60min/6h
Soil moisture at surface--Hydrology	0.01/0.3/250 km	24h/34h/3d		0.01/0.017/0.05 m**3/m**3	24h/5d/144d
Soil moisture at surface—Nowcasting/VSRF	5/10/50 km	60min/6h/24h		0.01/0.02/0.05 m**3/m**3	60min/6h/24h
Soil moisture at surface—Climate-TOPC (deprecated)	50/60/100 km	7d/11d/30d		0.005/0.007/0./01 m**3/m**3	360d/1 y/2 y
Soil moisture at surface—Climate monitoring (GCOS)	1/--/25 km	24h/--/--		0.04/--/-- m**3/m**3	--/--/--

Observations to Decisions

* The main challenge confronting observing systems is to deliver the end-user products required by decision makers
* There are several recent developments in this area. Examples of systems to deliver EWV products to end-users follow

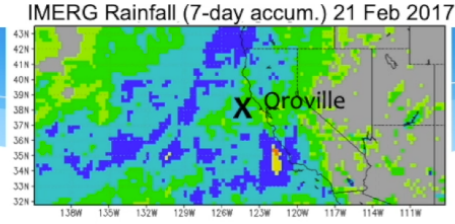
Example: Flood Estimation for Oroville Dam (California, USA), February 2017

The Global Flood Monitoring System (GFMS) uses IMERG and model output to detect potential flooding conditions and estimate intensity

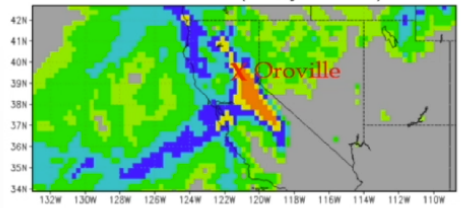


Adler (Univ. of Maryland) *http://flood.umd.edu*

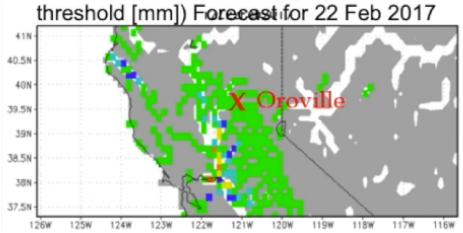
IMERG Rainfall (7-day accum.) 21 Feb 2017



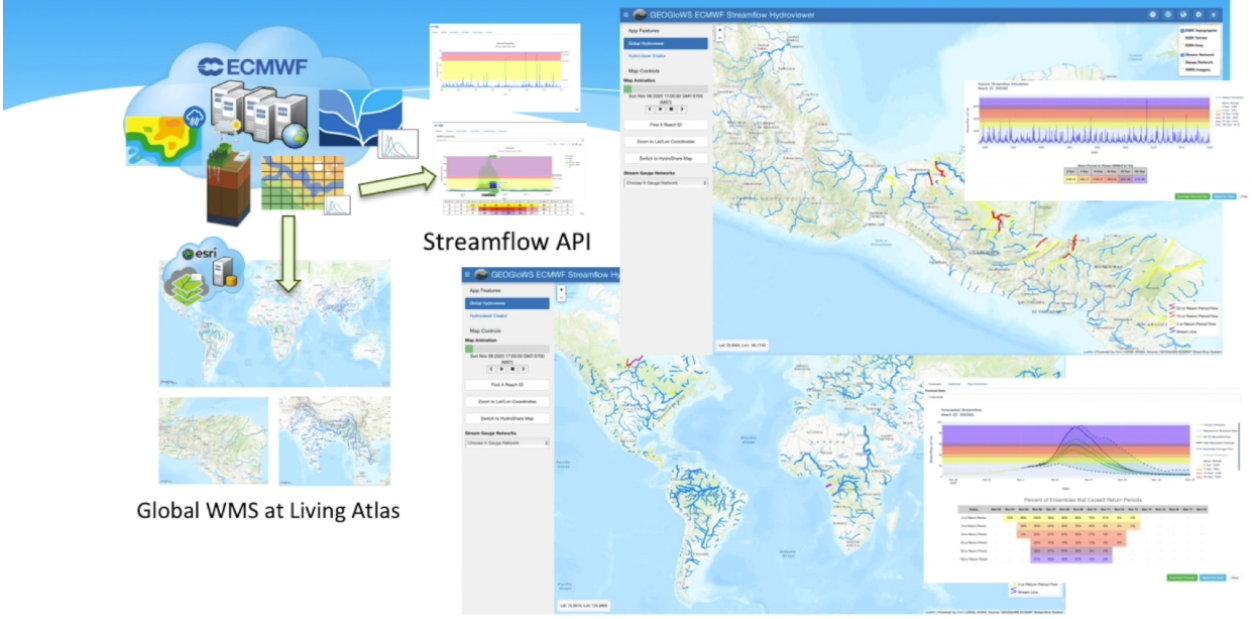
GEOS-5 Rainfall Forecast (3-day accum.) 22 Feb 2017



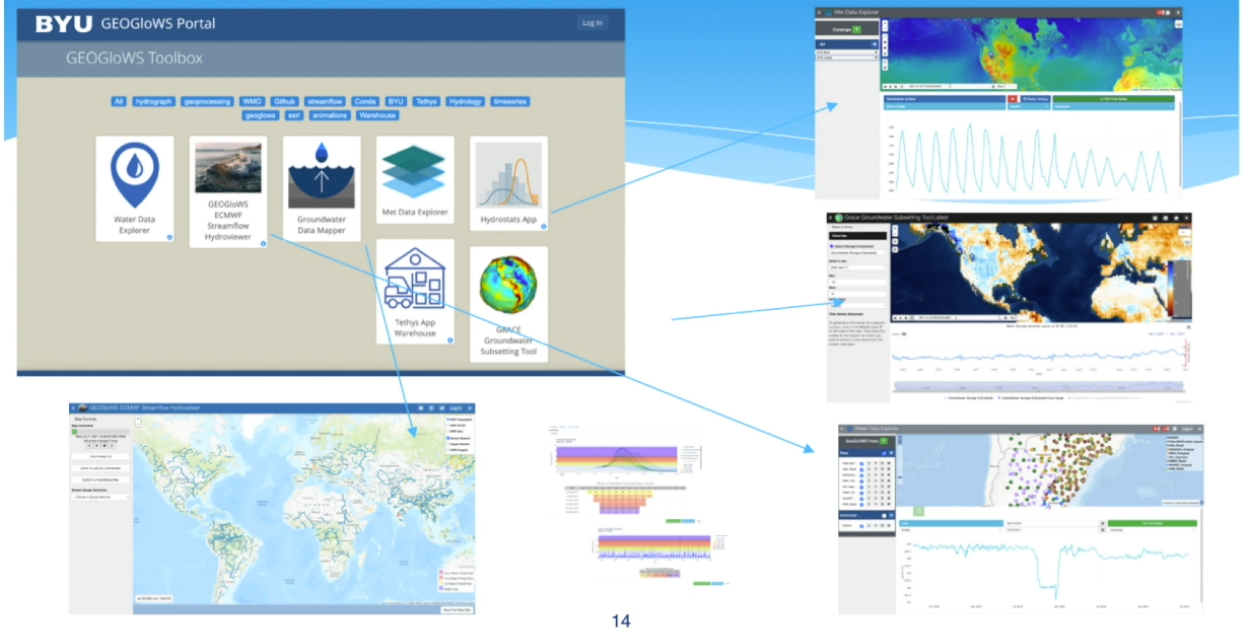
Flood Detection/Intensity (depth above threshold [mm]) Forecast for 22 Feb 2017



GEOGloWS ECMWF Streamflow Services. Source: Jim Nelson, Brigham Young University; https://geoglows.ecmwf.int/



GEOGloWS Toolbox for EWV's (apps.geoglows.org). Source: Jim Nelson, BYU



Conclusions/ Recommendations

Conclusions:

- EWVs need to address water cycle research and a broad range of end-user applications.
- EWVs are required at a range of observational space/time resolutions and latencies to monitor the global water cycle storages and fluxes, warn/predict extremes, and support strategic and operational decision-making.
- To ensure the stability of existing systems and for the development of next-generation observational platforms, it is important that a concise set of EWVs are recognized and adopted by international and national community and programs.

Recommendations:

- The water community is invited to review, revise, and endorse/ recommend EWVs for the consideration of GEOGLOWS and GEO
- Suggest next steps for the elaboration of more specific observational requirements for EWVs such as observing instruments and networks, data analytics, and product support for water cycle research and applications in decision support systems.
- Work with “GEO Initiative on EV” to identify best custodians of each EWV.