Essential Water Variables (EWVs) for the Water-Energy-Food (WEF) Nexus

AGU-GC35H-0773: Understanding & Developing Integration Pathways within the Water-Energy-Food (WEF) Nexus Framework & Beyond

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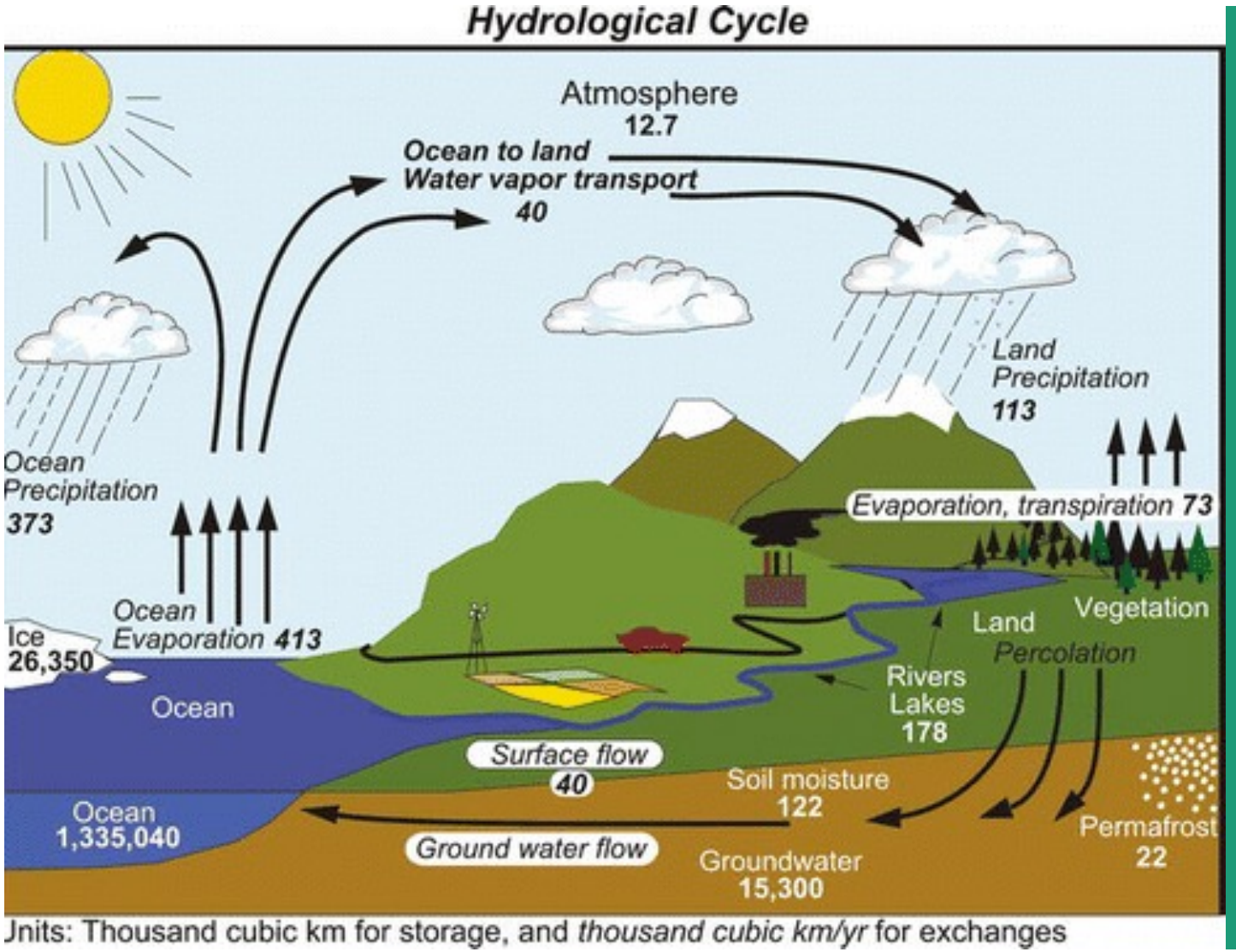
Extended Abstract
[AGU-2021 is invited to update EWVs]

- The GEOSS Water Strategy--From Observations to Decisions (Lawford et al., 2014) identifies several key water variables as Essential Water Variables (EWVs). This was based on broad meta-surveys (Unninayar et al., 2010) of water-related observational needs for GEO Societal Benefit Areas (SBAs) that included energy and agriculture among others.
- This paper summarizes currently defined EWVs required by key research and applications sectors involved in decision support within the Water-Energy-Food (WEF) Nexus. There is a notable overlap between the EWVs and a preliminary assessment of Essential WEF Variables. We also highlight EWVs that are relevant to the indicator monitoring objectives of the UN Sustainable Development Goals (SDGs), and GEOGLOWS priority thematic communities—especially those that overlap with the WEF Nexus. Besides primary EWVs such as precipitation, soil moisture, evapotranspiration and water levels/storage, supplemental EWVs are identified that support the integrated multi-sectoral information needed by WEF decision support applications. Examples of supplemental EWVs include surface meteorology and winds, solar radiation, land use/land cover and vegetation.
- Both Remote Sensing (RS) platforms and In-Situ observing networks are required to address the broad range of space/time resolutions, accuracies, and data latencies that end-users need.
- **The AGU-2021 is invited to comment on, endorse and/or recommend additional EWVs that should be considered for adoption by GEOGLOWS and the GEO (Group on Earth Observations).**



EWVs for Research: A fundamental need to onitor the Hydrological Cycle—Storages and Fluxes (Fig. Credit: Trenberth et al., 2007). © American Meteorological Society. Used with permission.

- Critical EWVs are evident from the interaction between the water cycle and the atmosphere and land systems—including food and energy production
- Different elements require observations of different space/time resolutions and latencies—especially for early warning of extremes.

EWVs are required by the 17 UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment/)

Especially:

SDG 6-Water(Clean water and sanitation)--includes:
- Integrated water resources management
- Water quality
- Water use efficiency

SDG 2-Food (End hunger)—includes:
- Food security, resilience
- Sustainable agriculture
- Improved nutrition

SDG-7-Energy (Affordable and clean energy)—includes:
- Renewable energy
- Energy intensity
- Energy consumption

[Reproduced with permission: https://www.un.org/sustainabledevelopment/news/communications-material]

EWVs are needed by regional GEO programs—e.g., AmeriGEO Thematic Communities: https://www.amerigeoss.org/ [Fig. credit: Reproduced with permission of AmeriGEO]

- **Capacity building for better monitoring, management, and maintenance of ecosystems and biodiversity they support; and to predict future changes**
- **Disaster risk reduction, particularly for data exchange associated with early warnings and for the generation of regional products.**
- **Agriculture, associated with climate variability, climate change, and food security.**
- **Water, associated with the management approach of water resources and data management.**

EWVs Are Required For Supporting the Implementation of International Frameworks and Conventions

- Sendai Framework for *Disaster Risk Reduction*: Understanding disaster risk; strengthening governance; investing in resilience; enhancing preparedness for effective response

- The Ramsar Convention on *Wetlands*: Conservation and sustainable use of wetlands. Works closely with IUCN (conservation of nature), IWMI (Water management), Wetlands International, WWF/WWT

-The Aichi Convention on *Biological Diversity*: Biological diversity; sustainable use of biodiversity; equitable sharing

- The Framework Convention on *Climate Change* (UN-FCCC): Stabilize GHGs causing global warming; Prevent human-induced interference w/climate system; linked to Aichi and Convention to combat desertification

Current List of Primary and Supplemental EWVs Followed by Tables Summarizing End-Users Served and Specifications of Requirements (Huffman et al., 2021)

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

WEF Nexus themes requiring EWVs potentially include:

- **Water resources management**
- **Biodiversity and ecosystem sustainability**
- **Disaster resilience**
- **Food security and sustainable agriculture**
- **Climate change adaptation/mitigation**
- **Clean energy and renewable energy**
- **Water quality**
- **Health and water/vector borne diseases**
- **Severe weather and floods**
- **Droughts and heat waves**
- **Urban water management**
- **Water stress and water use efficiency**
- **Transboundary WEF policy**

Essential Water Variables (EWVs) for WEF Nexus Themes Y = Yes P = Partial X = Used/Needed by GEO-SBAs are in CAPS	Remote Sensing (Satellite and airborne)	In-Situ Observation Networks	WEF-WATER Resources Management (UN-SDG-6)	*WEF-BIODIVERSITY* & ECOSYSTEM Sustainability (UN-SDG-15)	WEF-DISASTER Resilience (UN-SDG - All)	WEF-Food Security/Sustainable AGRICULTURE (UN-SDG-15)	WEF-CLIMATE Change (UN SDG-13)	WEF-Clean ENERGY (UN-SDG-7)	WEF-Water Quality (UN-SDG-6)	WEF-HEALTH & Vector/Vector Borne Diseases (UN-SDG-3)	WEF-Severe WEATHER & Floods (UN-SDG-6, 13, 15)	WEF-Droughts/Heat Waves (UN-SDSG-6, 13)	WEF-Urban Water Management (UN-SDG-6, 11, 15)	WEF-Water Stress (UN-SDG- 6, 13, 15)	WEF-Water Use Efficiency (UN-SDG-6, 13, 15)	WEF-Transboundary Water Policy (UN-SDG- 6, 17)
Precipitation	Y	Y	X	X	X	X	X	X	X	X	X	X	X	X	X	
Evaporation, Evapotranspiration, Evaporative Stress	P	Y	X	X		X	X			X	X	X	X	X	X	
Snow/Ice Cover (including depth, freeze/ thaw margins)	Y	Y	X	X	X		X	X		X	X	X	X	X	X	X
Soil Moisture/Temp	Y	Y	X	X	X	X	X			X	X	X		X	X	
Groundwater	P	Y	X	X	X	X	X		X		X	X	X	X	X	X
Runoff/Streamflow/River Discharge	P	Y	X	X	X	X	X	X	X		X	X	X	X	X	X
Lakes/ Reservoir Levels; Water storage	Y	Y	X	X	X	X	X	X	X		X	X	X	X	X	X
Surface water extent; surface water elevation	Y	P	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glacier/Ice Sheet Balance	P	P	X	X			X				X		X			X

pplemental EWVs: Obs. quired to support primary VVs Yes (Available) Partial Used/Needed By O-SBAs are in CAPS ninayar, Huffman, tierrez, Lawford, 2021)	Remote Sensing (Satellite and airborne)	In-Situ Observation Networks	WATER Resources Management (UN-SDG-6)	BIODIVERSITY & ECOSYSTEM Sustainability (UN-SDG-15)	DISASTER Resilience (UN-SDG - All)	Food Security/Sustainable AGRICULTURE (UN-SDG-15)	CLIMATE Change (UN SDG-13)	Clean ENERGY (UN-SDG-7)	WATER Quality (UN-SDG-6)	HEALTH & Vector Borne Diseases (UN-SDG-3)	Severer WEATHER & Floods (UN-SDG-6, 13, 15)	Droughts/Heat Waves (UN-SDSG-6, 13)	Urban Water Management (UN-SDG-6, 11, 15)	Water Stress (UN-SDG- 6, 13, 15)	Water Use Efficiency (UN-SDG-6, 13, 15	Transboundary Water Policy (UN-SDG- 6, 17)
face Meteorology	Y	Y	X	X	X	X	X	X		X	X	X	X	X	X	
face & Atmospheric Radiation	Y	Y	X	X		X	X	X		X		X		X	X	
ter Vapor & Clouds	Y	Y	X		X	X		X		X		X				
mafrost	P	Y	X	X	X		X									X
d cover, Vegetation & Land	Y	Y	X	X	X	X			X	X	X	X	X	X	X	X
vation/topography, hymetry & geological tification	Y	Y	X	X	X	X	X		X	X	X	X	X	X	X	X
face altimetry	Y	Y	X	X	X		X				X		X	X		
hymetry	P	P	X					X			X		X	X		
face radiation	Y	Y	X	X		X	X	X	X	X		X	X	X	X	
osols	Y	Y			X		X	X		X						
nospheric radiation	Y	Y	X	X	X	X	X	X		X		X		X	X	

Different uses/users of EWV data require very different space/time sampling and latency.
[Example for Soil Moisture specifications at 3 levels: Goal/Breakthrough/Threshold from WMO-OSCAR

Supplemental Water Variables. (WMO-OSCAR, 2021: https://space.oscar.wmo.int	Horizontal Resolution	Time Resolution	Vertical Resolution Height/Depth	Accuracy/Units--Uncertainty	Latency
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	--/--/--

Conclusions/ Recommendations

Conclusions:

- EWVs need to address water cycle research and a broad range of end-user applications, especially the Water-Energy Food Nexus.
- 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 of WEF resoirces.

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 required by WEF are recognized and adopted by international and national programs.

Recommendation:

- The AGU-2021 is invited to review, revise and endorse EWVs required by WEF for the consideration of GEOGLOWS and GEO (Group on Earth Observations)
- Suggest next steps for the elaboration of more specific EWV observational requirements relevant to the WEF Nexus, including observing instruments and networks, data analytics and end user products for decision support systems.

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