2016 WWAO Rapid Needs Assessment

Review Draft
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WWAO – NASA's Western Water Applications Office

A local western office helping to inform water decisions with NASA data

What is the WWAO?

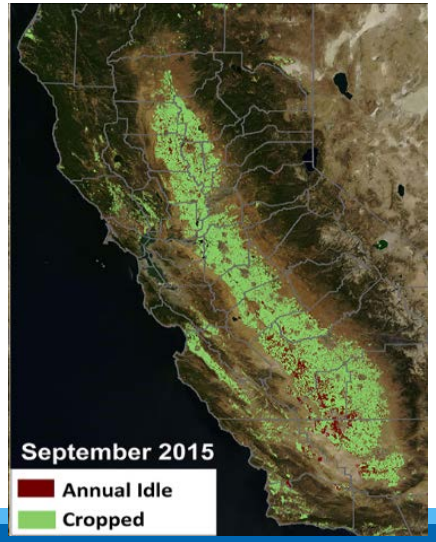
A new initiative from NASA's Earth Science Division, Applied Sciences Program to support Western US water management put NASA data to work in making decisions.

What Does the WWAO Do?

- Connect stakeholders with NASA scientists, NASA technology, tools, and data.
- Develop custom solutions through applications projects.
- Assist application transition into operational state.

How is the WWAO Unique?

- World-class, unbiased science
- NASA's wealth of remote sensing data and expertise.
- Decades of investment in science and technology.
- Provide long-term support to our end users.



Glossary of Acronyms

- ADWR — Arizona Department of Water Resources
- CBRFC — Colorado Basin River Forecast Center
- CDWR — California Department of Water Resources
- ET — Evapotranspiration
- GRACE — Gravity Recovery and Climate Experiment
- JPL — Jet Propulsion Laboratory
- MWD — Metropolitan Water District
- NASA — National Aeronautics and Space Administration
- NIDIS — National Integrated Drought Information System
- NOAA-NWS — National Oceanographic and Atmospheric Administration – National Weather Service
- RFC — River Forecast Center
- RNA — Rapid Needs Assessment
- SNOTEL — Snowpack Telemetry
- S2S — Sub-seasonal to Seasonal
- SWE — Snow Water Equivalent
- USACE — United States Army Corps of Engineers
- USBR — United States Bureau of Reclamation
- USDA-NRCS — United States Department of Agriculture – Natural Resources Conservation Service
- USGS — United States Geological Survey
- WSWC — Western States Water Council
- WWAO — Western Water Applications Office

Goal of the Rapid Needs Assessment

Summarize the science and management needs for western water resources in which NASA observations and research can play a role.

Objectives

- Assemble a preliminary catalog of needs which can be shared with interested NASA and non-NASA scientists and engineers.
- Establish the basis from which short-term projects for prioritized areas will be developed by WWAO.
- Provide guidance for development of strategies WWAO can use to address high-impact long-term needs.

Basis of the Assessment

- The Rapid Needs Assessment (RNA) is based on published needs assessments, journal articles, white papers, congressional briefs and reports, and workshop reports.
- A key input of the RNA was a 2014 informal survey of state representatives from AK, AZ, CA, CO, MT, NM, NV, TX, WY.

Timeliness of Needs

- Classification of needs into near-, medium-, and long-term is subjective, taking into account level of difficulty, technical maturity, time investment required, potential impact, and stakeholder interest.
  - Near: ~1-2 years, Medium: ~3-5 years, Long: ~5-10years

Western States Survey

- In 2014, a survey of western US water managers was conducted as a follow-up to a Remote Sensing Workshop held at JPL in coordination with the Western States Water Council.
- Representatives of nine western state water agencies provided their top three water management needs where NASA capabilities can play a role. Top needs were:
  1. Improved estimates of field-scale evapotranspiration;
  2. Improved quantification and understanding of snowpack and evolving conditions during the snow season;
     - Note: important for both mountain states (supply) and plains states (flood)
  3. Improved sub-seasonal to seasonal precipitation;
  4. Groundwater monitoring, including:
     - Subsidence trends;
     - Improving the resolution of GRACE estimates of groundwater storage.
- Other needs identified were for soil moisture data, water infrastructure (e.g., levees, aqueducts), and water quality.

Western Water Management and Community

Who Manages Water in the West?

Water resources in the western US are managed by a number of Federal and non-Federal entities [6].

Primary Federal entities:

- U. S. Bureau of Reclamation, Army Corps of Engineers, NOAA-NWS, USGS, USDA-NRCS;

Primary non-Federal entities:

- States agencies, groundwater conservation districts, irrigation districts, utilities, municipalities, tribal interests.

Challenges

- Increasing pressure on finite supply of water.
- Complexity of water management and decision-making.
- Aging monitoring networks.
- Existing networks, methods and tools not designed to consider climate stressors.

Opportunity

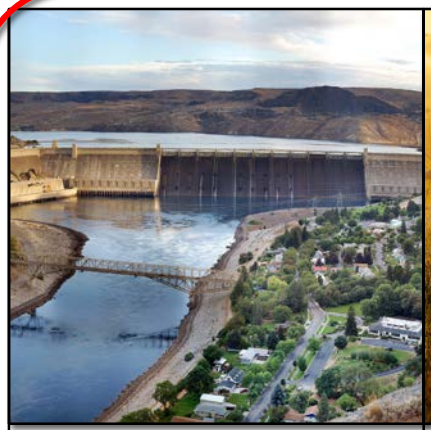
- Apply NASA capabilities to complement and enhance existing networks, methods, tools.

We Organize into Needs per Topical Area and consider Cross-cutting Needs

Topics for discussion today

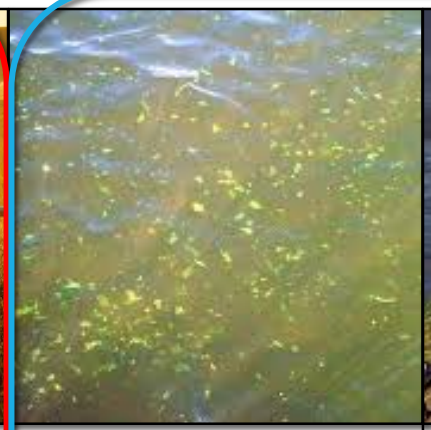
Water Management Topical Areas

Future discussions



Water Supply and Availability

Consumptive Use



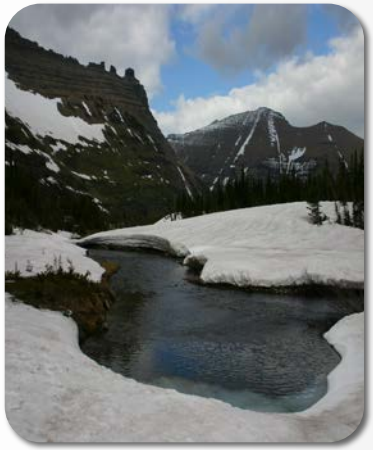
Water Quality

Water Infrastructure

Cross-cutting

- Technical and sociological challenges
  - Making use of emerging and contemporary information sources.
  - “Connecting the Dots” – Integration with traditional data sources and decision making processes.
- Climate change and Extremes

Needs Organized Within Topical Areas



Water Supply and Availability

- Snow pack quantification
- Groundwater monitoring
- Sub-seasonal to seasonal precipitation forecast

Consumptive Water Use

- Evapotranspiration

Background

- Most water systems in the West rely on mountain snowfall that melts each spring, sending runoff to impoundments that store water for year-round use for agriculture and people. [1]
- In systems that rely heavily on snow-fed water supplies, changes to snow depth and snowmelt rates can impact the timing and quantity of runoff, ultimately impacting the availability, access to and use of water in those regions. [2][3][4]
- Estimates of snowpack are derived from a network of point measurements, e.g., SNOTEL, Snow Course, SnoLite, and other NRCS Hydromet sites. [5]
- Point measurements are used to drive models that estimate runoff from snowmelt that are then used to make allocation decisions and forecasts for supply, hydropower, drought mitigation, and flood potential. [6][7]

Challenges and Gaps

- Snow elevation is changing and traditional measurements are often non-existent at high elevations. [2] [3][8]
- Snow depth and volume can have a lot of spatial variability within a basin which is not always captured by in situ sensors as they may not be representative of the region. [7][9]
- Environmental conditions that can impact timing of snow melt, e.g., dust or pine beetle, may not measured by existing systems. [5][7][10]
- Information on the variability of snow water equivalent (SWE) is lacking because traditional ground-based measurements and algorithms can have uncertainties with respect to the spatial distribution of snow and its evolution. [9][11]
- Existing models may not be set up for gridded data or need calibration/validation as new data sources become available, e.g., remote sensing. [5]

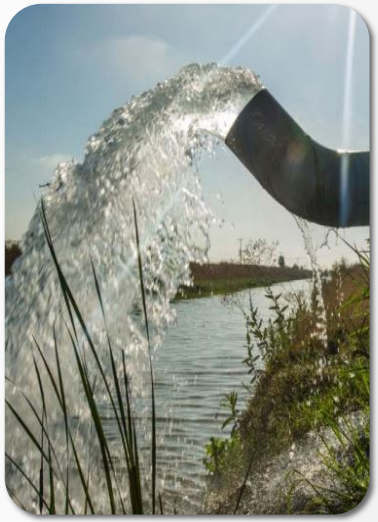
Snowpack Quantification Needs

Management Need	Information Need	Stakeholder(s)	Time Frame	Source
Improved understanding of how the snowpack is evolving in western US mountain basins during the snow season to anticipate and plan for runoff anomalies.	Spatially consistent measurements at basin scale as monthly maps for the snow year of: surface albedo, snow depth, snow cover extent, snow water equivalent.	Western States: AZ, AK, CA, CO, NV, WY , Utilities (MWD), NOAA, USDA- NRCS, Cooperators, NIDIS	Basin scale: Near-term West-wide: Long-term	[7][13]
Support flood control through assessment of springtime flood risk in the Great Plains states by broad-scale monitoring of snowpack.	Spatially consistent monthly maps during the spring of: snow depth, snow cover extent, snow water equivalent.	Plains States, Utilities, Municipalities	Near-term	[12][13]
Incorporate information about dust on snow either into existing CBRFC forecasts or displayed separately, with an indication of how the current year compares to past years and the average for dust.	Weekly anomaly maps of snow albedo for the Colorado River Basin. Weekly maps of albedo estimates for the Colorado River Basin.	CBRFC, Colorado Dust on Snow Program (http://www.codos.org/#codos)	Near-term	[5][7][13]
Development of interactive snow analysis products to characterize basin-distributed snow- covered area and SWE.	Interactive mapping tool that integrates remote sensing observations and traditional measurements.	Western States: CO, UT, WY	Medium-term	[7]
Predict potential impacts to western water supply due to changes in the timing and magnitude of snowmelt in mountainous regions	Update existing operational modeling systems to assimilate gridded snow data including calibration. Evaluation/validation of model output with assimilation of new science data products.	Forecast modelers NOAA RFCs, USDA - NRCS Information users USBR, USACE, Western States: AX, AK, CA, CO, NV, WY, Utilities, Municipalities	Long-term	[7][13]

Background

- Groundwater is the primary source of public water supply for about 130 million Americans, including about 97 percent of the rural population. [14]
- Groundwater sustains and replenishes rivers and streams during the hottest and driest parts of the year, providing critical flow to aquatic ecosystems. [15]
- U.S. Geological Survey's Groundwater Resources Program supports large- scale multidisciplinary studies of groundwater availability across the United States including more than 20,000 observation wells in cooperation with other entities. [16]
- Remote sensing observations have been used in large-scale groundwater mapping and monitoring and are especially effective when used with ancillary data analysis. [17][18][19][20]
- Long-term groundwater-level and subsidence monitoring and modeling are critical to understanding the dynamics of historical and continued groundwater use resulting in groundwater-level and groundwater-storage declines, and associated subsidence. [21]

Challenges and Gaps

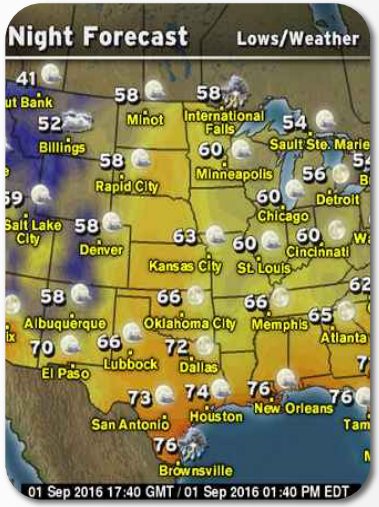


- As locations for additional reservoirs become limited and availability of water from the Nation's streams becomes increasingly scarce, withdrawals from groundwater are likely to increase. [15][22]
- With increased climate variability and uncertainty, reliance on groundwater for agriculture and municipal use is expected to increase in the western U. S. [23]
- "Ground-water pumping can result in reduced river flows, lower lake levels, and reduced discharges to wetlands and springs, causing concerns about drinking- water supplies, riparian areas, and critical aquatic habitats." [15]
- Increased dependency on groundwater may result in land subsidence and permanent reductions in aquifer storage capacity. [23] [24][27]
- Remote sensing has promise for hydro-geologic applications, but has limitations that have prevented it from becoming the quantitative tool that it has for other areas. [24]

Monitoring Groundwater Needs

Management Need	Information Need	Stakeholder(s)	Time Frame	Source
Improved understanding of groundwater fluctuations and water-level trends.	Regional maps of storage change, vegetation.	USGS, CDWR	Regional mapping: Near-term Integrated modeling: long-term	[18][20][24]
Monitor the effectiveness of Managed Aquifer Recharge and Identification of potential sites for Managed Aquifer Recharge.	Monitor and map surface deformation related to recharge and changes over focused sites. Integration of in situ, satellite observations into a modeling environment, e.g., MODFLOW.	USGS, CDWR, ADWR	Regional mapping: near-term Integrated modeling: long-term	[19][21]
Track changes in land subsidence(e.g., magnitude and distribution) to assess the long-term sustainability of groundwater as a source of water.	Time series of subsidence trends at regional scales.	USGS, CDWR, ADWR	Near-term	[13][21][25][26]
Assess the effects of groundwater development (pumping) on surface flows.	Regional maps of the spatial distribution of groundwater discharge, storage changes over large areas, or measurement of surface water heads in large water bodies.	USGS, CDWR	Medium-term	[19][20]

Background



- Water resources management is bounded by how extremes – floods and droughts – are defined and characterized, along with methods and standards for reducing risks. [4][28]
- Seasonal precipitation forecasts are needed to improve water supply reliability for downstream uses, such as, managing extremes (e.g. floods and droughts), making emergency preparedness decisions, and for maintaining ecological benefits. [29][30]
- Sub-seasonal precipitation forecasts are a necessary tool for flood management, more efficient resource and reservoir management and for making water allocation decisions. [31]
- #1 Stakeholder request of NOAA: What is the forecast for the upcoming winter's precipitation? [33]

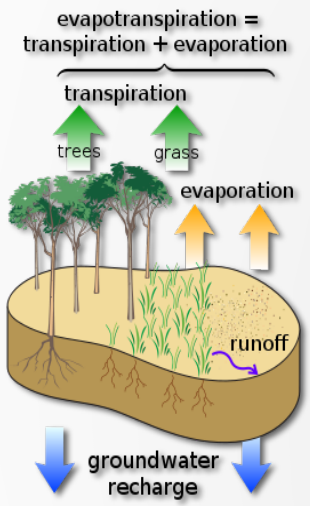
Challenges and Gaps

- The scientific capability for forecasting beyond the ten day time horizon, and at the sub-seasonal to seasonal timescales important for water management is not skillful enough to support water management decision-making. [32]
- Currently available S2S products do not always fit easily into institutional decision-making frameworks, and managers need forecasts of variables and at resolutions that are more directly relevant to their contexts. [32]
- Where reservoir management requires year-round balancing of flood control with other purposes, changes in the magnitude, severity and intensity of extreme runoff require changes in operating rules to better manage flood risks while maximizing storage. [3]

Forecasting Sub-seasonal to Seasonal Precipitation Needs

Management Need	Information Need	Stakeholder(s)	Time Frame	Source
Assess the viability of Forecast Informed Reservoir Operations by determining if increased skill in forecasts can be used to improve water supply, maintain or improve flood risk reduction and achieve ecosystem benefits	Long-term (~20 years) records of hindcasts based on present-day forecast capability to assess skill and uncertainties of forecasts at S2S lead times (e.g. 2 week to 6 months).	USACE, USBR	Near-term	[28]
Regional scale observations of extreme precipitation.	Including snow versus rainfall and that characterize topographic variations/forcing.	NOAA	Medium-term	[31]
More reliable precipitation forecasts to inform water supply and flood control operations at reservoirs where atmospheric river events frequently and predictably occur.	Improved understanding of sources of S2S predictability and how these lend themselves to forecasts of opportunity. Improved model representations of sources of S2S predictability (e.g. MJO, ENSO, snow, soil moisture).	USACE, USBR	Long-term	[30]
Increase the skill S2S precipitation forecasting for western water management.	Improved global and regional observations related to sources of S2S variability (e.g. global circulation to regional snow pack) – see NAS 2016 report and improved global prediction models.	NOAA, WSWC, State Water Agencies: CA, others	Long-term	[28]

Background



- Evapotranspiration (ET) is an important component of hydrological systems that regulates or influences runoff, soil water storage, groundwater recharge, surface water availability, biodiversity, and the global climate system. [41]
- Accurate information on consumptive water use helps water managers in planning, distribution, and management of water resources, particularly in an arid region like the southwestern U. S. [34][37]
- Remote sensing based ET estimates (from Landsat and others) are used for(a) irrigation management and crop water demand assessment, (b) plant growth, carbon and nutrient cycling and production modeling in dry land agriculture and forestry, (c) catchment hydrology, and (d) larger scale meteorology and climatology applications. [35][38]

Challenges and Gaps

- Remote sensing has great potential, but is underutilized by practicing water managers, more work is needed to develop operational ET remote sensing programs for developing and distributing ET maps for crop irrigation scheduling as well as other vegetation water use. [36][41]
- The ability to measure, estimate, and model ET, particularly at the watershed scale, is still limited. [41]
- Development of novel approaches for modeling ET and improvement of the existing approaches are needed for more accurate and robust multi-scale prediction of ET including for extreme climates, particularly droughts. [41]

Evapotranspiration Monitoring Needs

Management Need	Information Need	Stakeholder(s)	Time Frame	Source
Mapping irrigated lands as well as crop type and fallowed land.	Spatially consistent annual maps of crop classifications, crop specific ET at field scale and fallowed land.	Western State Agencies	Near-term	[35]
Improved estimates of field-scale evapotranspiration (ET) to quantify consumptive water use, especially for irrigated agriculture to improve irrigation scheduling, and for estimating the volume of interstate water transfers, for example, in the Colorado River basin.	Spatially consistent basin-wide monthly and annual maps of the distribution patterns of actual ET at ~30m resolution.	USBR-Water SMART Program, Western States incl: AK, AZ, CA, CO, MT, NM, TX, and WY	Near-term	[3][13][34][35][41]
Accurate estimates of riparian zone ET are needed to properly and soundly apportion river water for human and environmental needs	Annual maps of ET from riparian vegetation for monitoring water use.	USBR	Near-term	[40]

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Background Information - Critical Observations vs Western Water Needs: From Survey of Western States

	GEO Priority Water Variables*										Other Priorities Identified in SG's Top 3 Survey					
State	Precip-itation	Soil Moisture	ET	Runoff / Streamflow	Aquifer volume and change	Ground-water recharge / discharge	Land cover / vegetation type	Water Quality	Lake/Reservoir Levels (bathymetry, changes in lake volume, etc)	Snow: Cover/ Depth/ Type; SWE	Water Consumptive Use	Precip-itation Fore-casting	Flood and Drought Fore-casting	Water Infra-structure	Other	Totals by State
AZ			X	X	X	X				X				X	Subsidence	7
AK	X	X	X	X	X	X			X	X	X		X	X	Permafrost	12
CA	X		X	X	X	X				X	X	X		X		9
CO	X		X	X	X	X				X	X	X	X			9
ID						X										1
KS																0
MT			X													1
ND																0
NE																0
NM			X													1
NV	X	X		X						X					Dust on snow, mountain beetle, etc	5
OK																0
OR																0
SD																0
TX	X	X	X			X		X					X			6
UT															Sediment management, Fire	1
WA																0
WY			X	X			X			X						4
	5	3	8	6	4	6	1	1	1	6	3	2	3	3		

Additional GEO priority water variables not mapped: Soil temperature, evaporation (lakes/wetlands), river discharge to the ocean, glacier/ice sheets, elevation/topography