Water Cycle Missions for the Next Decade

A Workshop to Gather Wisdom and determine how to prepare for the next generation of water cycle missions in support of the second Earth Science Decadal Survey

April 29-30, 2013; Baltimore-Washington International (BWI) Airport; Embassy Suites

Workshop Overview

Building on the first Earth Science Decadal Survey, NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space, the objective of this workshop was to gather wisdom and determine how to prepare for the next generation of water cycle missions in support of the second Earth Science Decadal Survey.

Following a short plenary, we discussed the intersection between science questions, technology readiness, application benefits and satellite design optimization in a series of breakout group discussions designed to form the seeds of a set of water cycle mission formulation groups.

The workshop formulated next-generation water cycle mission working groups and white papers, designed to identify capacity gaps and inform NASA.

Water Cycle Missions for the Next Decade

Workshop Charge

Water Cycle: The global water cycle describes the circulation of water as vital and dynamic substance in its liquid, solid, and vapor phases as it moves through the atmosphere, oceans and land. Life in its many forms exists because of water, and modern civilization depends on learning how to live within the constraints imposed by the availability of water.

Gaps: There are important gaps in knowledge of where water is stored, where it is going, and how fast it is moving.

Vision: Global measurements from space open a vision for the advancement of water science and applications. This vision includes advances in understanding, data, and information that will improve the ability to manage water and to provide the water-related infrastructure that is needed to provide for human needs and to protect and enhance the natural environment and associated biological systems.

Water Cycle Missions for the Next Decade

Workshop Charge

2007 Decadal Survey: Identified 17 new missions (3 water cycle)

Envisioned a future in which surface, subsurface, and atmospheric water will be tracked continuously in time and space over the entire globe and at resolutions useful for timely inclusion into models for prediction and decision support related to use of water for agriculture, human health, energy generation, and hazard mitigation.

What will we do in the next decade? ~2020-2030

The intended outcome of this workshop was to identify the vision for the next decade of water cycle satellite observations, and to develop a roadmap and action plan for developing the foundation for these missions.

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Goals and Outcomes

Workshop objectives:

- Identify key water cycle science questions and application needs.
- Provide basic information regarding existing, proven and emerging technology available for next-generation water cycle missions;
- Identify science and user needs for next-generation water cycle satellite missions, and the required development of science and applications needed to use this technology;
- Provide an opportunity for applications and users of water cycle satellite systems to identify potential applications; and
- Provide a roadmap and working groups for developing the next-generation water cycle satellite mission science, technology and applications.

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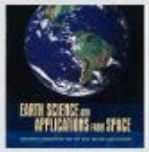
Background Reading



2007 DECADAL SURVEY

Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, National Research Council, 2007.

2012 MIDTERM ASSESSMENT

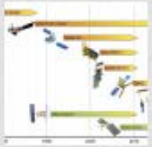
Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey, National Research Council, 2012.

2012 CHAPMAN CONFERENCE

AGU Chapman Conference on Remote Sensing of the Terrestrial Water Cycle, 2012 REPORT

2013 NATIONAL STRATEGY

National Strategy for Civil Earth Observations, National Science and Technology Council, 2013



2010 MULTI-MISSION STRATEGY

Su, et al., Earth observation Water Cycle Multi-Mission Observation Strategy (WACMOS), Hydrol. Earth Syst. Sci. Discuss., 7, 7899-7956, 2010.

IGWCO THEME

Integrated Global Water Cycle Observations (IGWCO) Theme, Overview Report

GEOSS WATER STRATEGY REPORT

GEOSS Water Strategy Report, Nov 2012 The CEOS Contribution, Dec 2012

GEWEX SCIENCE QUESTIONS

GEWEX "Global Energy and Water Exchanges" Project Science Questions

POST-2002 EARTH OBSERVING MISSIONS

NASA's Plans for Post-2002 Earth Observing Missions, National Academies Press, 1999.

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1-Page Mission Concepts

A primary outcome of the workshop was the development of 1-page "Future Water Cycle Mission Concept Papers". These papers briefly outlined the mission (1) concept,(2) measurement technique, (3) application benefits, and (4) multi-process integration.

Subsurface Temperature Sensing Satellite (STemSS), **Kenneth Jezek and Joel Johnson (2)**
The Aerosol, Clouds, Ecosystem (ACE) Decadal Survey Mission, **Jay Mace (13)**
Precipitation Mission Concept, **Gail Skofronick-Jackson (47)**
L-Band Microwave Remote Sensing and W-Train Concept, **Entekhabi, Yueh, Njoku (17)**
Short Time Scale Processes GNSS-R Mission, **Chris Ruf (9)**
Water Cycle Mission, **Paul Houser (43)**
Next Generation Surface Energy Balance, **Rachel Pinker (8)**
Visible, short-wave and thermal sensing at the field scale, **Ayse Kilic (7)**
Space snail, **John David (0)**
Moderate spatial resolution infrared sounder, **Thomas Pagano (4)**
Global geostationary drought monitoring constellation, **Will Pozzi (5)**

Survey Results: ~30 surveys received with top choice = 3, second = 2, third = 1

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Subsurface Temperature Sensing Satellite (STemSS) (2)

Vars: Measurement of internal ice sheet temperature
Tech: P-S band microwave radiometer., L-Band SAR
Apps: Ice sheets, permafrost, boreal forests, soil moisture, seasonal snow cover.

The Aerosol, Clouds, Ecosystem (ACE) Decadal Survey Mission (13)

Vars: Clouds, Aerosols, and Ocean Ecosystems. Cloud Microphysical properties
Tech: Doppler cloud/precipitation radar, high spectral res lidar, multi-angle polarimeter.
Apps: Continued heritage from A-Train to detect key changes in hydrologocal cycle.

Precipitation and Cloud Process Measurement Mission Concept (47)

Vars: Precipitation and cloud measurements.
Tech: Ku,Ka,W-radar, multi-channel microwave radiometer, Vis/IR radiometer.
Apps: Cloud and precipitation physics process observatory, including frozen precipitation.

L-Band Microwave Remote Sensing and W-Train Concept (17)
Short Time Scale Processes GNSS-R Mission (9)
Water Cycle Mission (43)
Next Generation Surface Energy Balance (8)
Visible, short-wave and thermal sensing at the field scale (7)
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L-Band Microwave Remote Sensing and W-Train Concept (17)

Vars: Current and planned Water mission synergies (GPM,SMAP,SMOS,SWOT,SCLP,GRACE)
Tech: Polarmetric Active/Passive, 1.2-1.4 GHz, Low Earth Orbit.
Apps: Take advantage of near-future synergies between currently-planned water missions.

Short Time Scale Processes GNSS-R Mission (9)

Vars: Ocean surface wind speed, soil moisture, ice sheets, high-temporal resolution.
Tech: Microwave signals of opportunity: GPS, Galileo, and other geo-navigation signals.
Apps: High temporal frequency sampling (hourly) from small-sate constellation.

Water Cycle Mission (43)

Vars: Land-Atmosphere-Ocean water/energy balance (Precip, ET, Soil Moisture, Snow, etc..)
Tech: Hyper-spectral active/passive microwave, 1-200GHz, 1km resolution.
Apps: Simultaneous water cycle obs, allowing improved model and application constraints.

Next Generation Surface Energy Balance (8)
Visible, short-wave and thermal sensing at the field scale (7)
Moderate spatial resolution infrared sounder (4)
Global geostationary drought monitoring constellation (5)

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Next Generation Surface Energy Balance (8)

Vars: Radiative fluxes over land and ocean
Tech: High-resolution multi-channel vis/IR geostationary
Apps: Radiative fluxes are primary drivers of snow melt, albedo feedbacks, glacier dynamics.

Visible, short-wave and thermal sensing at the field scale (7)

Vars: ET and monitoring change in vegetation and water resources
Tech: Landsat Continuity (10-30m VNIR, SWIR, Thermal).
Apps: ET continuity for field-scale water resource management, agriculture water use.

Moderate spatial resolution infrared sounder (4)

Vars: boundary layer water vapor and temperature profile
Tech: Hyper-spectral infrared sounder, global daily coverage, Microwave sounder.
Apps: Climate & weather model improvement, fire, drought, air quality, etc..

Global geostationary drought monitoring constellation (5)

Vars: Global drought monitoring.
Tech: Thermal band global geostationary constellation.
Apps: Evaporative stress index, global drought maps.

Water Cycle Missions for the Next Decade

Insights from Breakout Sessions

Important Considerations:

- Temporal consistency and continuity of critical observations.
- Improve resolution and reduce latency for critical applications.
- Focus on observations that will improve weather/climate predictive capacities
- Involve end users from the start to ensure mission utility, temper unrealistic expectations
- For many applications (water availability) we to move beyond observing a single state to monitoring and modeling the entire system.
- In the next decade weather models will be 1km, observations should be ahead of this.
- GPM has a radar that serves as a reference for other obs: what is our hydrology reference?
- Possible that very different time/space scale applications require very different missions
- Appealing future options: (1) water cycle "core" satellite, (2) W-Train constellation
- Small sensors have fundamental limitations
- Airborne could be used to capture important water cycle events (snow melt).

Water Cycle Missions for the Next Decade

Insights from Breakout Sessions

Recommendations:

- OSSE capability to objectively assess and refine mission design. Define cost function as the ability to address the grand science question. Include other NASA missions, international missions, airborne systems, and ground observational networks in the evaluation.
- Consider citizen scientists (observer networks) in mission planning
- Consider a GEO-microwave mission
- Consider signals of opportunity mission
- Need to devote resources to high-risk, lower cost technology (inflatable antennas)
- Need low latency real-time data for applications.
- Still a need for PBL process observations for understanding/modeling extremes.
- Engage multi-disciplinary user community early; more private sector participation.
- Multi-process water cycle field campaign(s).

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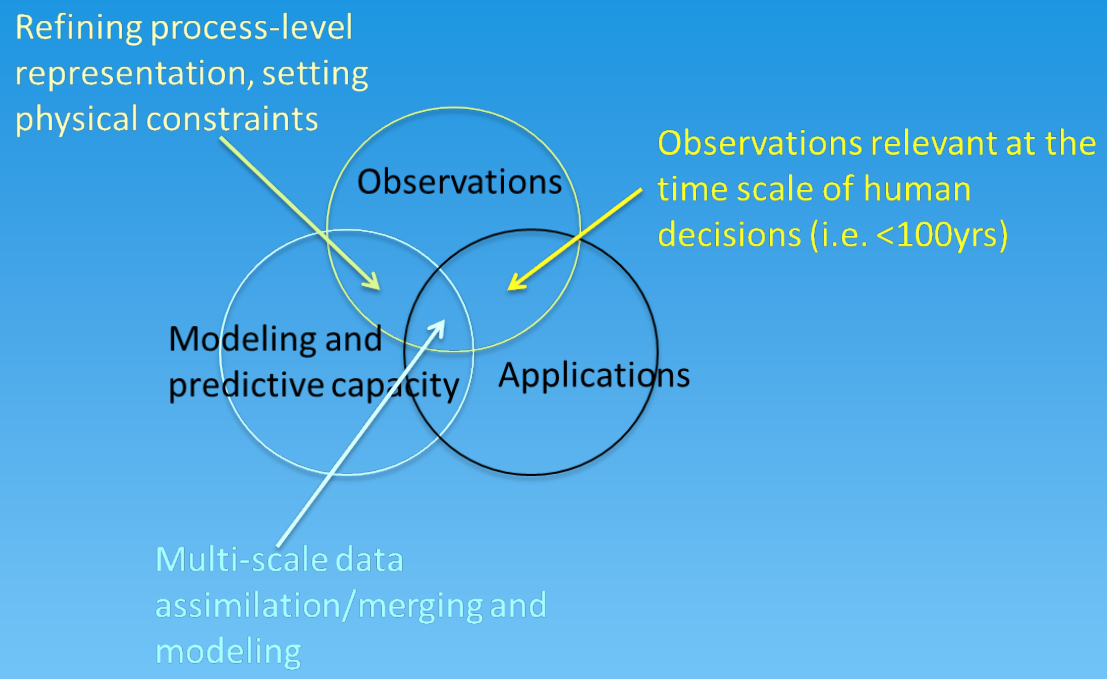
Insights from Breakout Sessions

Q: How can we synergize multi-source (i.e., satellite, airborne, and in-situ), multi-sensor, multi-scale, multi-variable measurements to produce new knowledge and observing, modeling and predictive capabilities?



Unify under a GRAND Science Question:

How can we monitor and predict the terrestrial freshwater cycle?

Decision process and metric:

OSSE capability to objectively assess and refine mission design.

Is the precursor to multi-process observing systems, multi-process field campaigns?

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