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MASS CHANGE MISSION APPLICATIONS – ASSESSING USER NEEDS FOR THE NEXT NASA MASS CHANGE DESIGNATED OBSERVABLE (MCDO) MISSION

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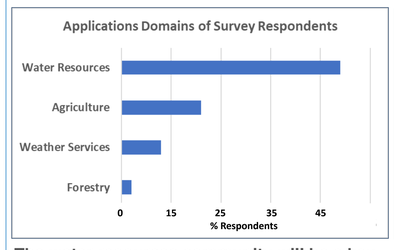
ABSTRACT

As part of the *2017-2027 Decadal Survey for Earth Science and Applications from Space* (Decadal Survey), NASA has identified a Mass Change Designated Observable (MCDO) Study Team to evaluate science and applications needs and satellite mission architectures for future mass change missions (i.e., successors to the GRACE and GRACE Follow On missions). The primary science objective of an MCDO mission is the continued measurement of changes in the Earth's gravity field over time. A major focus of the Decadal Survey is Applications of the data resulting from the recommended mission(s).

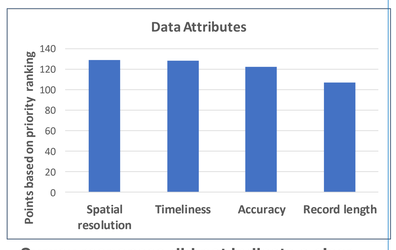
Applications areas relevant to the satellite gravimetry missions include drought monitoring, groundwater depletion, and thermal expansion of the ocean, which contributes to sea level rise. In order to effectively address the applications requirements of future gravity mission data users and to develop actionable objectives for mission design, the Mass Change Mission Applications survey was developed. Information on user needs, current uses, and capabilities derived from the survey will provide insights with respect to data latency, spatial scales, data formats, and technical capabilities of the users. The survey focused on identifying and incorporating the needs of a broad range of existing and potential user communities in order to incorporate these needs into mission design and architecture studies under development. The primary purpose of the survey is to prioritize user needs in order to inform mission design/architecture and data processing decisions. The information gathered can be used to inform mission architecture design, evaluate tradeoffs, and ensure that the data products are optimized for a broad user community. The survey is comprised of two sections 1) General questions about requirements for their applications, and 2) Data use and demographic information to help characterize aspects of the user community. The survey is in the form of a Google document (accessible at https://tinyurl.com/MassChangeSurvey). The survey has been distributed to known and expected satellite gravimetry data users, and to scientists and decision-makers who may have an interest in applied uses of future mission data and information products.

DECADAL SURVEY DESIGNATED OBSERVABLES (DO)

The Earth Science Decadal Survey prioritized five Designated Observables (DOs) for cost-capped, medium- and large-size Earth observing missions to be launched by NASA in the next decade: Aerosols (A), Clouds, Convection and Precipitation (CCP), Surface Deformation and Change (SDC), Surface Biology and Geology (SBG), and Mass Change (MC). Four study teams (A and CCP were combined) are now defining observational target capabilities and evaluating potential mission instruments and architectures. NASA's Earth Science Directorate (ESD) is open to considering observing systems that address these science priorities in partnership with other space agencies and entities.



The water resources community will be a key focus of outreach for future Mass Change mission data products. Along with agriculture and weather services, we expect these groups to comprise a significant applied science user group.



Survey responses did not indicate a clear preference between spatial or temporal resolution requirements, or accuracy. Record length is a slightly less critical attribute.

Reference:
Bernknopf, R., Brookshire, D., Kuwayama, Y., Macauley, M., Rodell, M., Thompson, A., Vail, P., Zaitchik, B., (2018). The Value of Remotely Sensed Information: The Case of a GRACE Enhanced Drought Severity Index, AMS Weather, Climate and Society, v10, pp. 187-203, DOI: 10.1175/WCAS-D-16-0044.1

MASS CHANGE APPLICATIONS OVERVIEW

The Mass Change Designated Observable (MCDO) Study Team has identified a **Mass Change Applications Team (MCAT)** to provide input into the MCDO Science and Applications Traceability Matrix (SATM). The MCAT will also continue communication with end-users and value-added providers through mission/system development and implementation. The Decadal Survey identified science and applications priorities (see Table 3.2 at www.nap.edu/read/24938/chapter/6), which includes the 'High Priority' objective, H-4c; "Improve drought monitoring to forecast short-term impacts more accurately and to assess potential mitigations." Applications of future remote sensing missions is, in this context, specifically identified as an objective of the Decadal Survey.

The **needs of applications communities** for a future gravity mission are being assessed and used to inform mission design and data processing decisions through the SATM and a value framework, including:

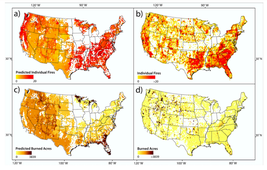
- Leveraging well-developed current and past work and sources for MC applications needs information
- The Mass Change Applications Survey (https://tinyurl.com/MassChangeSurvey)
- Direct user engagement (i.e., Workshops & Community Meetings)
- Development of a Community Assessment Report (CAR)

The GRACE and GRACE-FO Projects have supported numerous practical and operational applications, including;

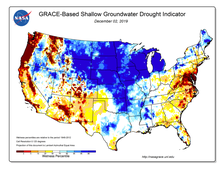
- **Water supply assessments**
- **Drought monitoring and forecasting**
- **Flood vulnerability**
- **Fire risk**
- **Agricultural planning and yield forecasting**
- **Consequences of sea level rise**

SATELLITE GRAVIMETRY APPLICATIONS EXAMPLES

- **GRACE-Based Flood Potential Index, JT Reager and J. Famiglietti** JPL/CalTech (see; tinyurl.com/GRACE-FPI)
- **Sensitivity of US wildfire occurrence to preseason soil moisture , D. Jensen and JT Reager** JPL/CalTech (see; tinyurl.com/GRACE-Wildfire)
- **The Value of Remotely Sensed Information: The Case of a GRACE Enhanced Drought Severity Index, R. Bernknopf and D. Brookshire** (UNM), **Y. Kuwayama and M. Macauley** (RFF), **M.Rodell (GSFC),** A.Thompson and P. Vail **(RFF),** B. Zaitchik **(JHU)** (see; tinyurl.com/GRACE-DSI)



Fire predictive maps for (*a*) individual and (*c*) burned areas (May 2012–Apr 2013), compared to (*b*) actual fire distribution and (*d*) actual burned area for that year for validation, (Jensen, et al, 2018)



Shallow groundwater drought indicator based on GRACE TWS, integrated with other observations using numerical modeling of land, surface water, energy. (nasagrace.unl.edu)

MASS CHANGE APPLICATIONS CONSIDERATIONS

Most practical applications require higher-level products (e.g., changes in individual water storage components as opposed to bulk mass changes) as well has higher spatial and temporal resolutions than can currently be delivered by GRACE-FO (see graphics below). This necessity highlights the importance of advanced data processing techniques and data assimilation. Gravimetric data is not a standard product used in water/natural resource management. As a result, the mission must address how this data will be integrated into water/natural resource management tools (e.g. higher level products). Examples include;

Improved Spatial Resolution (highest priority of end-users at this time)

- e.g. Most heavily populated regions are along coastlines, but GRACE and GRACE-FO TWS uncertainty is larger near coasts.

Improved Temporal Resolution

- e.g. Most water management information (e.g. soil moisture for crop forecasts) needed during critical decision periods are addressing changes within 1 week to 1 day periods.
  - ➢ Note--that Latency & Temporal Resolution needs are intertwined

Improved Accuracy

- Value is highly variable:
  - ➢ Important for some applications (e.g., seasonal snowpack), not for others (e.g., drought monitoring – relative wetness)

Value of specific resolution and accuracy improvements are difficult to specify without further study

- ➢ OSSE is a potential approach

Continuity and length of data record

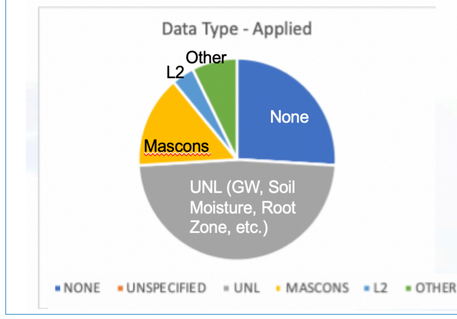
- Considered very important by end-users

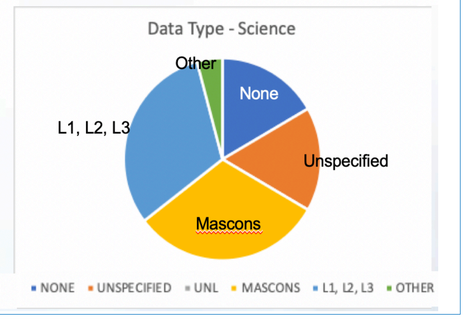
FOR MORE INFORMATION:

MCDO; science.nasa.gov/earth-science/decadal-mc
MCAT Survey; tinyurl.com/MassChangeSurvey
GRACE/GRACE-FO Applications; gracefo.jpl.nasa.gov/applications

MASS CHANGE APPLICATIONS SURVEY FINDINGS – 75 Responses

Data Type Requirements -- Applied vs. Science

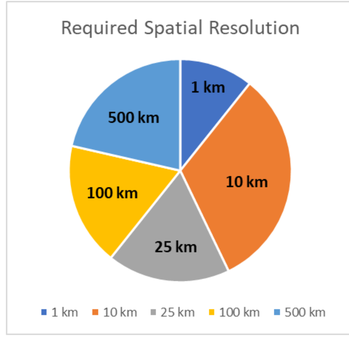


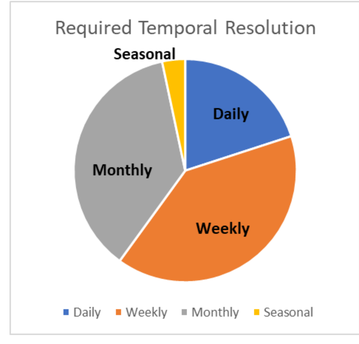


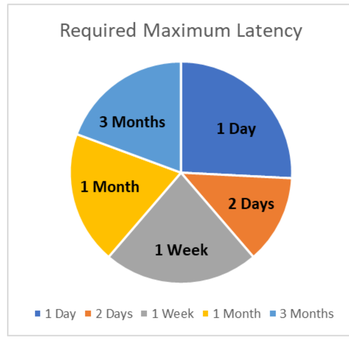
The Mass Change Applications Team (MCAT) solicited feedback from known users of data and information products from the Gravity Recovery And Climate Experiment (GRACE) and the GRACE Follow On (GRACE-FO) satellite missions. This survey was designed to provide inputs not specified in the DS with regards to user desires for Mass Change (MC) observations such as **spatial and temporal resolution, accuracy, and latency**. In addition, user demographics were derived in order to better understand who the users are and what their objectives are for data use. --- The importance of continuity in the MC record and the need to understand and evaluate emerging gravimetric technologies also drove the need to survey the community. Quantifying the hydrology community's desires and priorities with respect to the four primary data characteristics listed above, and translating those into performance targets, is fundamental to the completion of the SATM, and the eventual mission design.

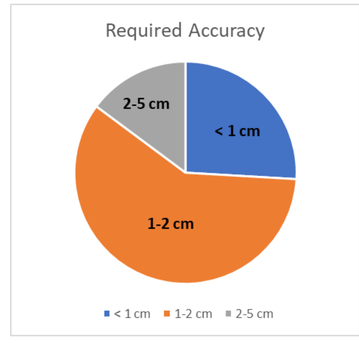
Half of the respondents indicate that spatial resolution of 25 km or less would be desirable. Over half indicated that one week latency and weekly or lower temporal resolution would be sufficient for their applications. Accuracy requirements of 2 cm or less are desired by most existing and potential data users.

The GRACE and GRACE-FO missions are a collaboration between NASA, the Center for Space Research at the University of Texas, NASA's Jet Propulsion Laboratory, the German Space Agency (DLR), and Germany's National Research Center for Geosciences (GFZ).









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