National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

A Golden Era for Hydrology from Space

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Strategic Focus Area: A Golden Era for Hydrology from Space **| Strategic Initiative Leader:** Susan E Owen

Objectives: *The overarching goal of this initiative is to strengthen JPL's capabilities for scientific discovery in hydrology and water resources in the upcoming era of satellite remote sensing.*

Background: Science questions addressed include a) how much water do we have?, b) how is water availability spatially and temporally changing?, c) are existing measurements sufficient or should new space missions be designed for terrestrial hydrology?, and d) how is the water cycle influencing and interacting with the solid earth system, and energy and carbon cycles?

Approach and Results: a) <u>Water, Energy, Carbon Cycle Interaction</u>: This activity involves a multi-mission exploration of variability between water, energy and carbon cycles using hydrology missions (GRACE, GRACE/FO, GPCP), energy missions (CERES), and vegetation information (MODIS) for major river basins. Results indicate decreased ratio of precipitation to evapotranspiration, and greater sensible heat flux during the severe droughts of 2012, 2013 and 2022. Led by E. Tajfar (postdoc), M. Pascolini-Campbell, M. Hakuba.

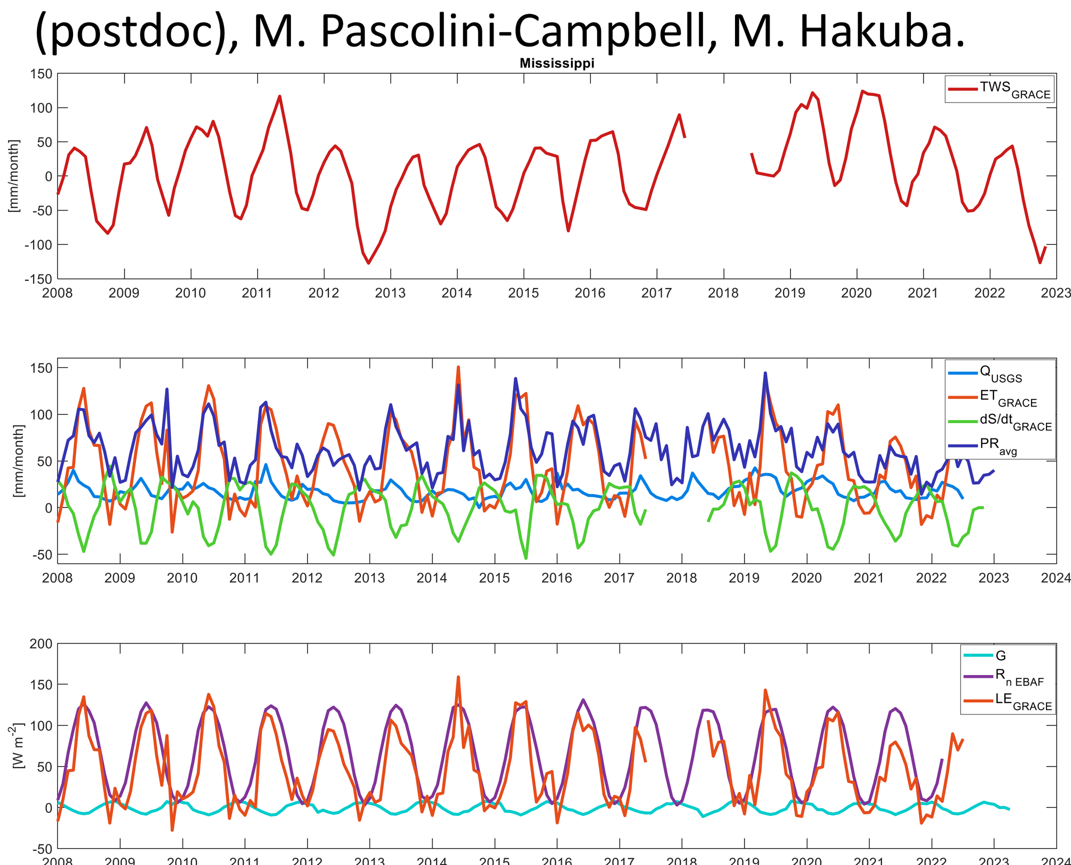

Figure 1. Basin-averaged water and energy components at the Mississippi River Basin *using GRACE/GRACE-FO, CERES and satellite-based precipitation data sets.*

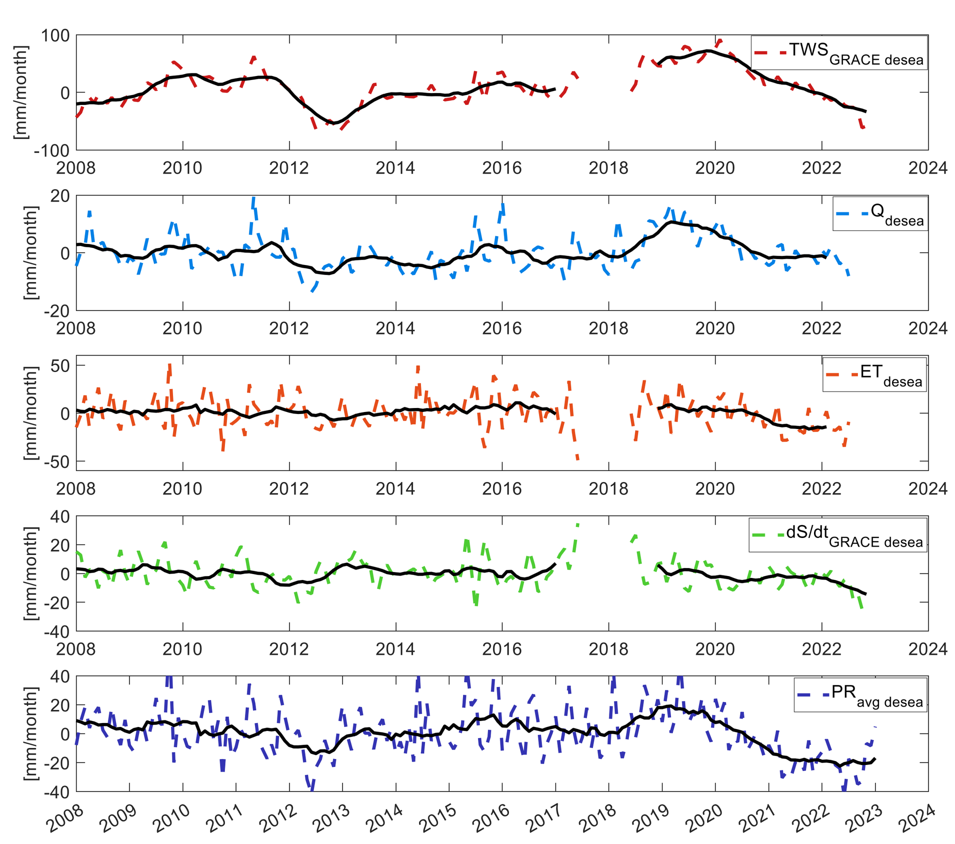

Figure 2. Water and energy fluxes interannual variability highlighting key drought years in 2012, 2013 and 2019.

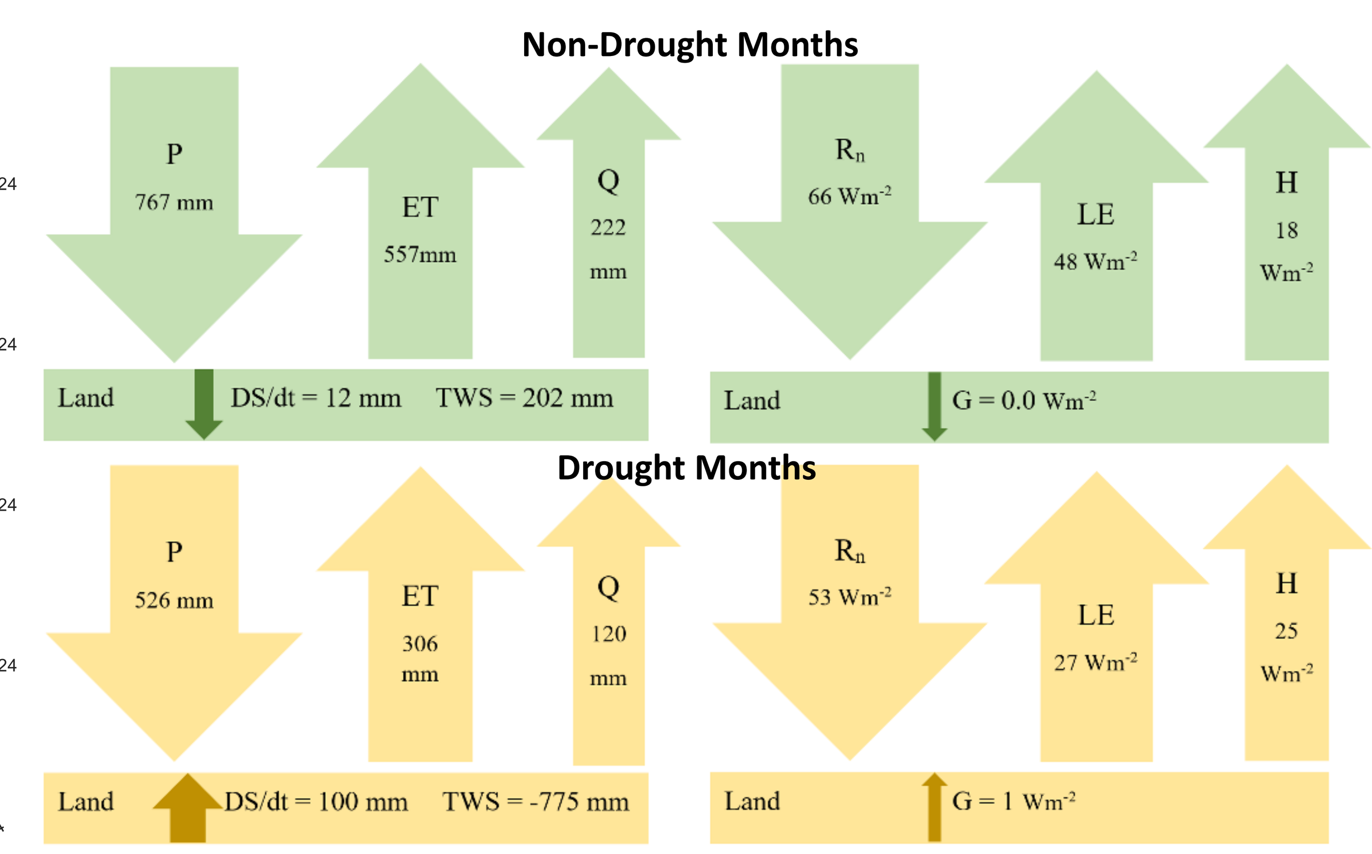

Figure 3. Partitioning of water and energy fluxes using a multi-sensor approach (GRACE, GRACE-FO, CERES, GPM) to characterize drought/non-drought conditions.

b) <u>**Hydrology mission requirements for extreme events**</u>**.** This study identifies the intrinsic spatial and temporal scales of hydrology extremes (as measured by precipitation, runoff , soil moisture). It will be useful in design of upcoming hydrology mission requirements to ensure hydrologic extremes are captured. Led by M. Pascolini-Campbell.

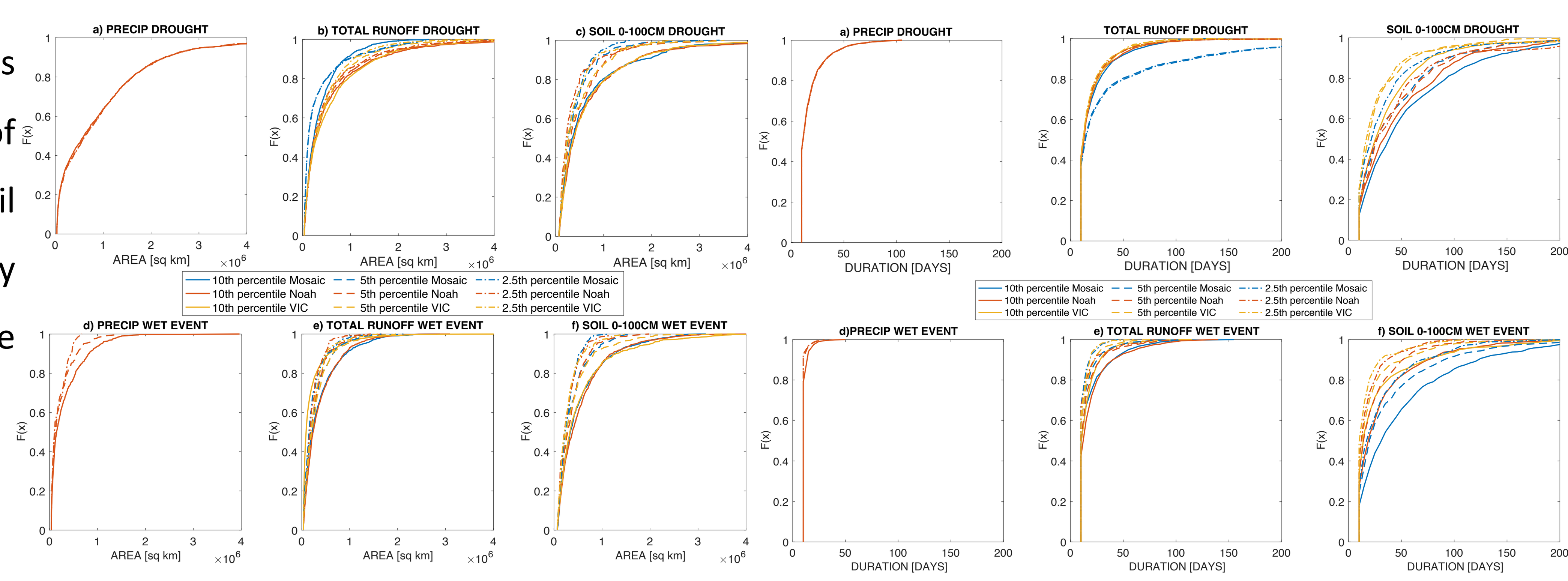

Figure 4. Cumulative distribution function for the drought / wet extreme event area (sq km) (left panels) and duration (days) (right panels). More than two-thirds of extreme precipitation events occur on timescales of 15 days or less, which suggests current missions (i.e. GRACE, SWOT) may miss a significant portion of events. 10th percentile wet extremes on average are 300'000 sq km for precipitation and runoff anomalies, but larger (560'000 sq km) for soil moisture extremes.

Significance/ Importance to JPL

This work will pave the way for future studies possible with the Earth System Observatory (ESO) including the upcoming Mass Change, Surface Biology and Geology missions, as well as Libera. This work also addresses Decadal survey key science questions, by investigating how water and energy fluxes are changing. Other activities address the time scales of hydrologic extreme events, needed for designing mission requirements.

Publications:

- David, C. H., & Frasson, R. P. D. M. (2023). Blame the river not the rain. *Nature Geoscience*, *16*(4), 282-283.
- Frasson, R. et al. (2023). Estimating the relative impact of measurement, parameter, and flow law errors on discharge from the Surface Water and Ocean Topography mission. *J. Hydromet.*, *24*(3), 425-443.
- Munasinghe, D. et al., A multi-sensor approach for increased measurements of floods and their societal impacts from space, *Under Review Comm. Earth and Environment.*
- Pascolini-Campbell, M. (2022). Soil and plants lose more water under drought. *NCC*, *12*(11), 969-970.
- Pascolini-Campbell, M., Reager, J.T., Intrinsic Spatial Scales of Droughts and Floods using NLDAS-2 modeling output, *Under review J. Hydromet.*
- Tajfar, E. et al. Characterizing water/energy/carbon cycle changes during droughts for the Mississippi River Basin, Manuscript in prep.

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