

Introduction: Our solar system contains many examples of what may be called extreme environments. These can be examples of high temperature and pressure environments in places like the deep atmospheres of the gas giants or on the surface of Venus. The permanently shadowed regions of the moon are examples of extreme cold conditions, a more common phenomena in space. Other extreme environments may be driven by high radiation conditions, or perhaps reactive atmospheric chemistry, which happens to be another feature of Venus. The extreme environments in the solar system pose interesting challenges to missions and technologists as they plan approaches to exploring and understanding our solar system.

This poster and associated lightning talk will feature a NASA facility primarily designed to help study and prepare to explore some of the extreme environments in our solar system. The facility, the Glenn Extreme Environment Rig (GEER), is located at NASA Glenn Research Center and has been conducting science experiments, supporting technology development efforts, and helping missions prepare for successful operations in challenging environments, especially hot and reactive atmospheres. Over the years several experiments and tests have been conducted in GEER. While many have been aimed at simulating the high-temperature and pressure extremes of Venus as well as reproducing conditions of its reactive atmosphere (e.g.[1]), other applications are possible and have been conducted as well, including supporting the Juno mission in interpreting microwave radiometer data.

Recent Accomplishments: The facility functions were impacted by COVID but since returning to onsite presence, the GEER team has brought the facility back to its normal operation schedule. Below are highlights of significant accomplishments in the last year:

1. Juno mission support: First test program post pandemic to enable science driven exploration of water vapor impacts at various Jupiter related conditions on microwave sensing.
2. Weathering test of Rocks and Minerals: Test in which GEER demonstrated a newly added capability of being able to support over 350 passive sample exposures in one test run.
3. HOTTech-1 test: First test run for the HOTTech Program, kicking off a series of multiple technology maturation tests in hot and reactive environments relevant to the Venus surface.

GEER Operation: The goal for facility operations is high quality and efficient investigations in a cost-effective manner. One part of this is to provide sufficient and accurate calibration and test characteristic information of the GEER facility allowing for timely adaption to the evolving academic and industrial needs. Furthermore, over time GEER customers' expectations for test design have been more complex which is not surprising as technologies maturing to higher TRLs (Technology Readiness Levels) will require more effort and capability. To meet future customers' demands and expectations, the GEER team plans to introduce the soft launch of updated GEER testing processes in FY24. There are two phases in this updated GEER testing processes. In the Phase I: Test Planning, it is critical to fill out the GEER Customer Test Requirements Document (TRD), which will be available through the GEER website [2]. Most GEER customers may expect to spend 4 to 8 weeks finalizing the scope of work, cost estimate and test agreement with the GEER team before proceeding to the Phase II: Testing. In the Phase II, test execution depends primarily on the duration at conditions desired by the customer, the complexity of the test setup and the required startup and shut down sequences for safety and data integrity.

Conclusions: GEER at NASA's GRC has been simulating extreme atmospheric conditions to enable scientific understanding of atmospheric and surface interactions, technology development, and material compatibility for future spacecraft missions. Post COVID-19 pandemic, the GEER team has successfully supported NASA's HOTTech Program, Juno Spacecraft Mission, and other scientific experiments. The GEER facility is a key Planetary Science Community asset, and the GEER team is looking forward to making more contributions to the success of the community and supporting upcoming space exploration missions.

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References: [1]R. P. Harvey et al., (2014) Venus in a Bottle: High Fidelity Simulations of Venus Surface Conditions with NASA's Glenn Extreme Environments Rig (GEER), *GSA Annual Meeting No.136-5*. [2] GEER website: <https://www1.grc.nasa.gov/space/geer/>