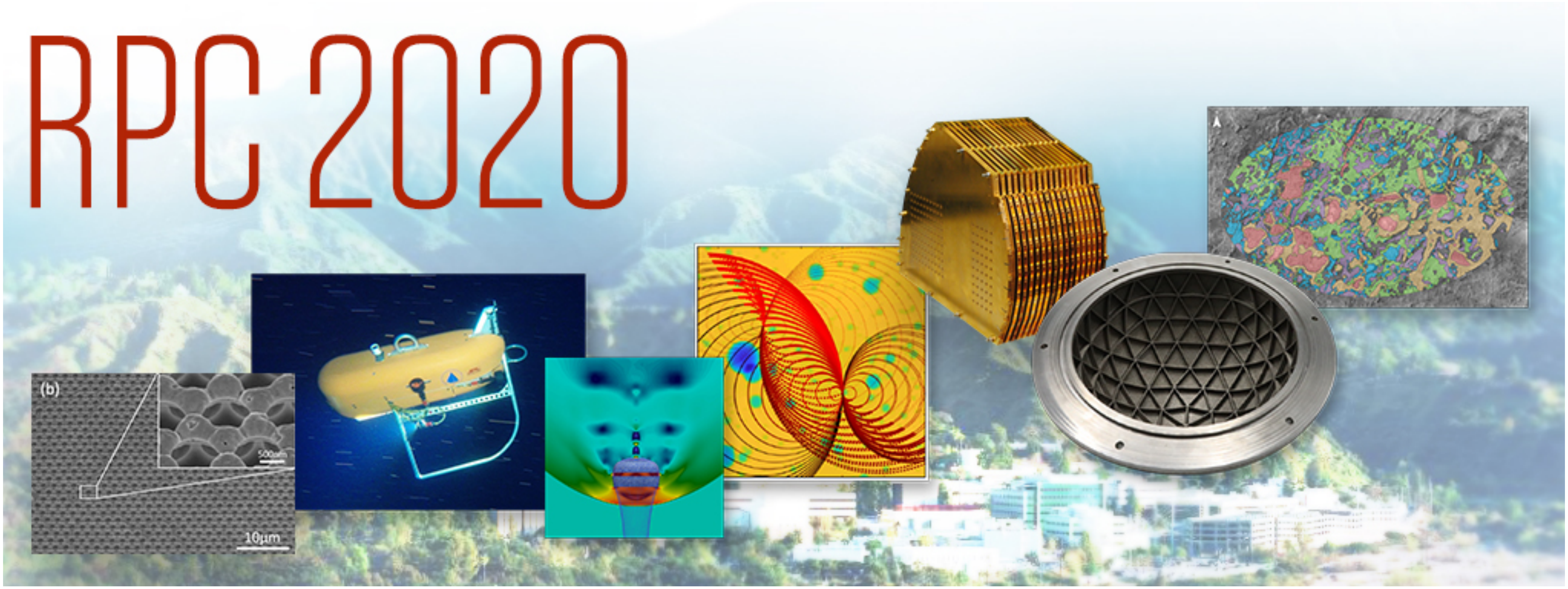

Virtual Research Presentation Conference

New science capability in GRACE-like gravity missions with onboard gradiometers

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Program: SURP
Assigned Presentation #RPC-035

Jet Propulsion Laboratory
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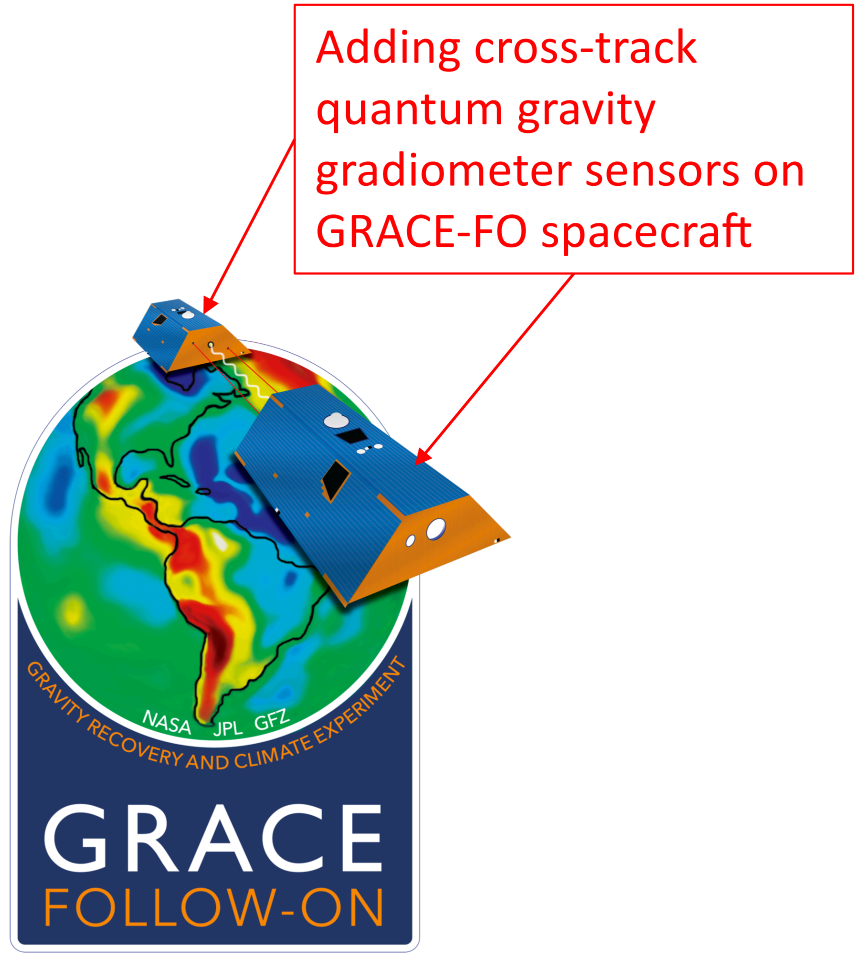
Tutorial Introduction

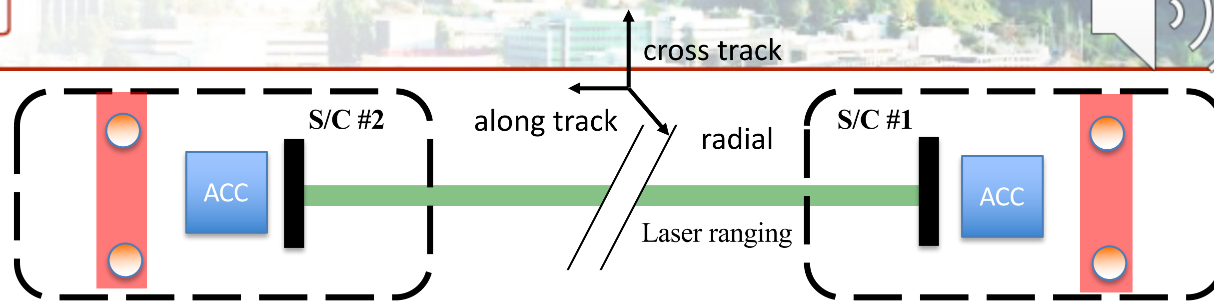
- Global mapping of Earth gravity field provides valuable information on climate change studies.
- GRACE and GRACE-Follow On missions have successfully demonstrated the power of high resolution global gravity maps.
- We proposed to explore a measurement architecture that can further improve Mass Change observations beyond GRACE-FO. We focused on a hybrid configuration of laser ranging interferometer (GRACE-FO) together with onboard quantum gravity gradiometer (QGG).



Problem Description

- Context (Why this problem and why now)
  - Mass Change is one of the Designated Observables identified in the 2018 Decadal Survey
  - Quantum gravity gradiometer is a promising future technology that is currently under evaluation by the Mass Change Study Team
  - We proposed the LRI+QGG hybrid architecture and believed that it has unique advantages.
- SOA (Comparison or advancement over current state-of-the-art)
  - Laser Ranging Interferometer (LRI) architecture used in GRACE-FO is well understood.
  - QGG architectures, either single-spacecraft of the proposed hybrid configuration, had not been compared with LRI in the same simulation platform.
  - Leveraging UT-Austin's expertise on gravity recovery simulation, we aimed for comprehensive trade studies on various QGG architectures.
- Relevance to NASA and JPL (Impact on current or future programs)
  - NASA has assembled the Mass Change Study Team to evaluate options for missions after GRACE-FO.
  - JPL constructed and managed GRACE and GRACE-FO missions, also pioneered and is leading in space QGG technology development. This study will continue the leadership of JPL in Earth gravity observations.

Methodology



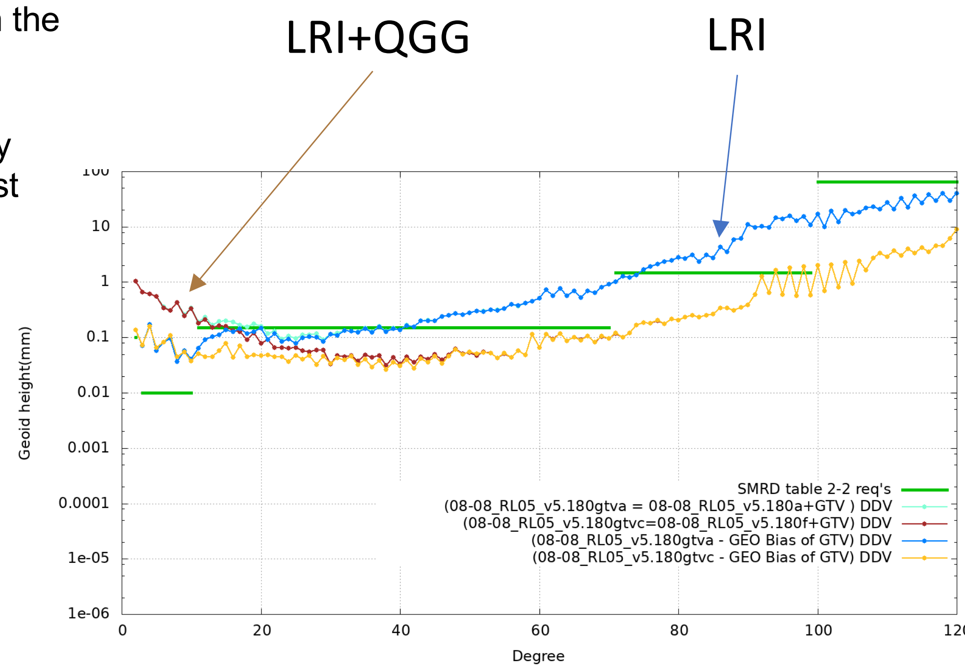
- The hybrid architecture consists of LRI (as in GRACE-FO) and a cross-track QGG on each spacecraft to provide gravity gradient measurements.
- QGG uses cold atoms for measuring gravity gradient, featuring high sensitivity and long term stability.
- The UT-Austin team developed code based on proven software package for previous missions to incorporate new data type provided by QGG.
- High-fidelity numerical simulations were used to synthesize observation errors with the same statistical characteristics as might be expected in data from a flight instrument. The observation, or the signal, itself was synthesized by (in sequence) adopting a measurement concept, selecting an appropriate mission design, adopting a suite of gravity and dynamic environment models that was representative of the mission design, and synthesizing simulated observations unique to the mission concept. The measurement noise was added to the simulated observations. The simulated observations were then used in the gravity field retrieval software. The retrieved gravity field was compared with the "true" gravity field model, and the statistics of the difference of the two were regarded as representative of the achievable science quality. The simulations were extended, as needed, to other architectures for comparative purposes and to obtain greater understanding.

Results

a) Accomplishments
- Compared different architectures on equal footing
- Established a point-design for the hybrid architecture, which shows significant improvement over LRI and requires feasible technical assumptions.
- Established that aliasing effect would be better managed in the hybrid architecture then LRI or QGG alone.

b) Significance
- Validated that appropriate use of QGG can help with gravity field modeling in the exactly the domains where the greatest gains are to be made with the next generation of gravity mapping missions.
- The enterprise further strengthens JPL and UT Austin collaboration.

c) Next steps
- Trade study and QGG performance requirements
- Aliasing mitigation
- Connections of science applications to feasible accuracy



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