National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

Detection and monitoring of sub-monthly mass change signals with GRACE-FO

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Objective: Develop a processing scheme to process GRACE-FO on-board measurements and derive a higher resolution data product that will reflect sub-monthly mass variations in a global scale.

Background: Typical resolution of gravity field products:

Time domain: Monthly | Space domain: ~330 km

Higher spatial and/or temporal resolution from GRACE-FO?

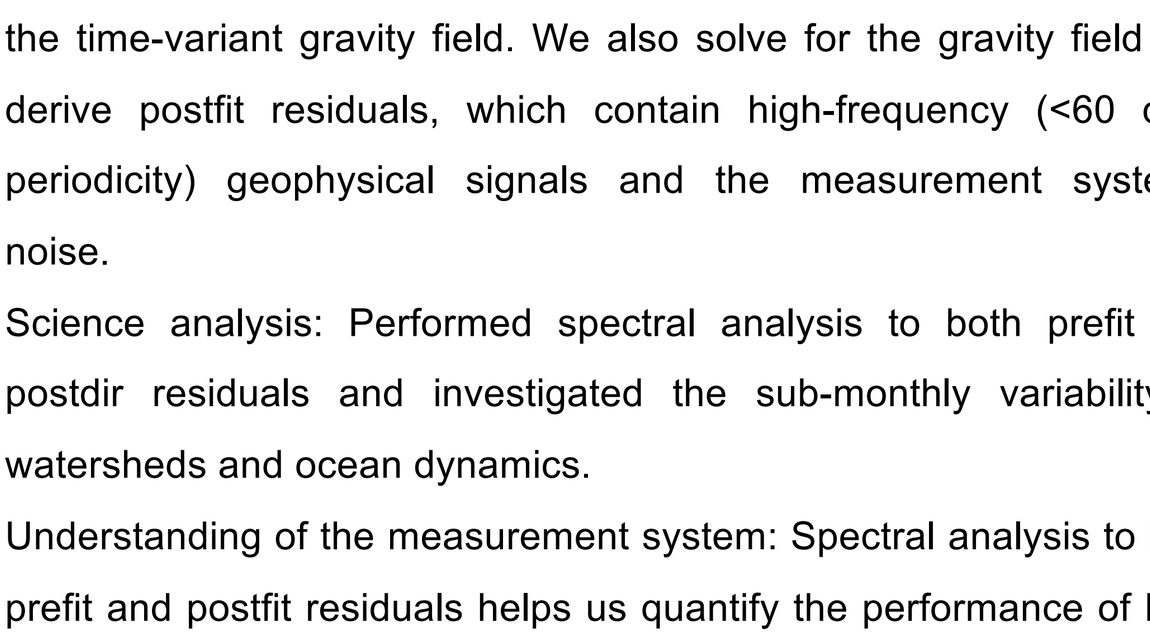
Detection and monitoring of *sub-monthly* mass redistribution signals is an additional layer of surface mass information that is recorded in the GRACE-FO along-track observations. **Motivation:** Our goal is to extract the *hidden signals* from GRACE-FO along track measurements, use them as a novel tool to study mass redistribution processes and derive a template for innovate data products that can be used for research and applications.

Approach:

- We used background forces described in Yuan (2018) and the most modern accelerometer product available (ACH) to estimate the dynamic orbits, from which we subtracted the range rates measured by the LRI.
- The output of this process, is termed as prefit residuals and reflects the time-variant gravity field. We also solve for the gravity field and derive postfit residuals, which contain high-frequency (<60 days periodicity) geophysical signals and the measurement system's noise.
- Science analysis: Performed spectral analysis to both prefit and postdir residuals and investigated the sub-monthly variability of watersheds and ocean dynamics.
- Understanding of the measurement system: Spectral analysis to both prefit and postfit residuals helps us quantify the performance of MWI and LRI as part of the GRACE-FO measurement system.

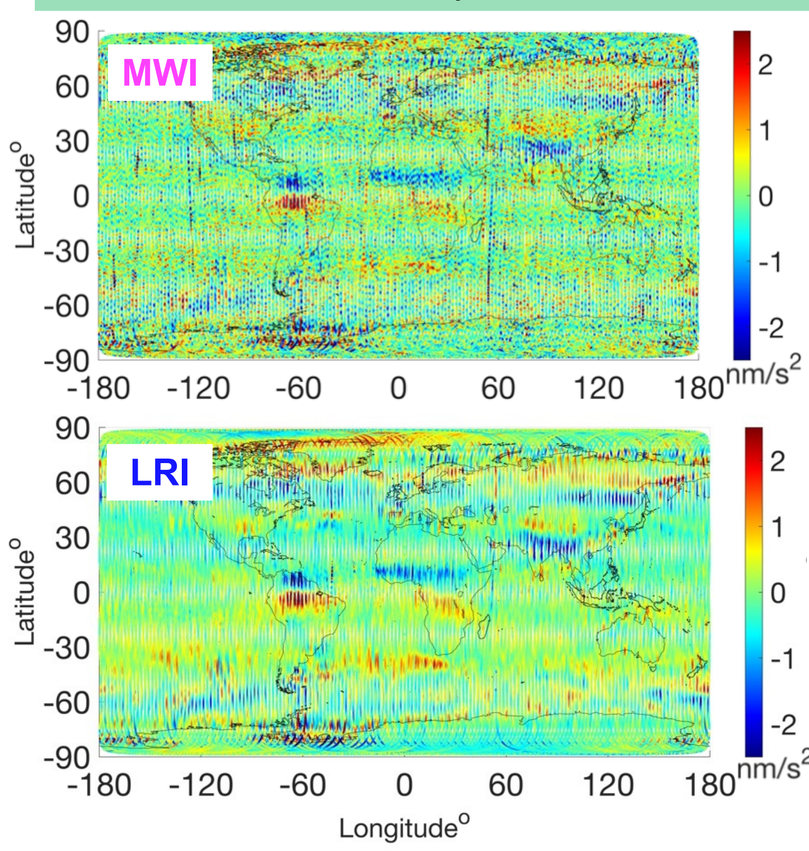
Results:

0. Geophysical signal content in along track products analyzed in different frequencies (on 2022-03)



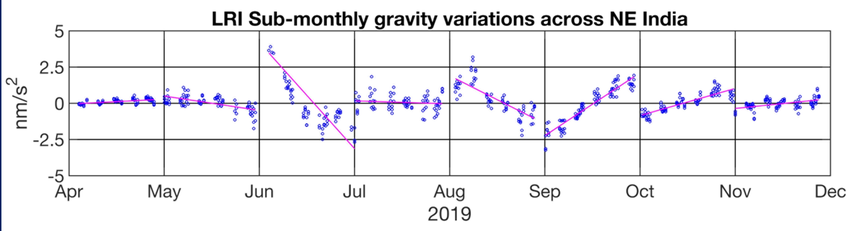
5 mHz =28 CPR=715 km 15 mHz =90 CPR=230 km 21 mHz =120 CPR=165 km

1. Sub-monthly mass change variations and LRI/MWI performance



- MWI/LRI pick up sub-monthly signals consistently down to 340 km.
- LRI can measure signals down to 280 km if the mass change is larger than 2 cm of EWH.

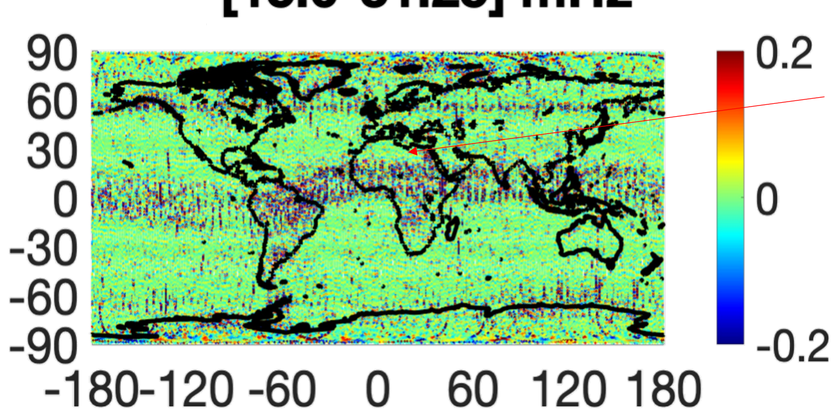
Monitoring of submonthly mass variations:



Detailed look of sub-monthly range accelerations across NE India. Linear trend of sub-monthly variations is shown in pink for each month

2. Feedback on Level 1B and Level 2 products

Prefit Range Accelerations: Use as diagnostics



Mismodelled non-gravitational forces: thruster firings → better ACC modeling !

Significance: Benefit for Mass Change Observable and future JPL's gravity missions:

Study of sub-monthly mass change variations

Validation of science models: (e.g., test the efficiency of existing ice sheet mass balance models to map sub-monthly variations).

Feedback on Level 1B product: Evaluate the performance of the thruster model used in ACH.

Future gravity missions:

- LRI's low instrumentation noise, allows for detection of seasonal and monthly gravity signals at finer spatial scales than MWI (21 mHz as opposed to 15mHz).
- LRI/MWI are consistent in retrieving sub-monthly gravity signals (depending on the magnitude of sub-monthly mass change signals LRI may provide slightly higher frequency).

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