

Implementation of GRACE and GRACE-FO observation covariance estimates at JPL

Matthias Ellmer[1], David Wiese[1], Christopher McCullough[1], Dah-Ning Yuan[1], Eugene Fahnestock[1]

[1]Jet Propulsion Laboratory, California Institute of Technology

©2020 California Institute of Technology. Government sponsorship acknowledged.

Jet Propulsion Laboratory
California Institute of Technology

This document has been reviewed and determined not to contain export controlled technical data.

Background and Introduction

The GRACE and GRACE-FO Science Data System team at JPL plans to incorporate full observation covariance information into the processing of future Level 2 GRACE and GRACE-FO data releases.

The stochastic models describing the covariance information are determined from observational data using an algorithmic framework established within GRACE processing by the Graz group (Kvas et al, 2019; Ellmer, 2018).

We show preliminary results from processing of V04 KBR and LRI data in the range-rate domain, also including GPS Code and phase observations in the form of pseudoranges. We compare these against results obtained using a white noise only approach.

Kvas et al, 2019: ITSG-Grace2018: Overview and Evaluation of a New GRACE-Only Gravity Field Time Series: (https://doi.org/10.1029/2019JB017415)
Ellmer, 2018: Contributions to GRACE Gravity Field Recovery (https://doi.org/10.3217/978-3-85125-646-8)

This document has been reviewed and determined not to contain export controlled technical data.

Processing

GRACE and GRACE-FO data was processed on the basis of preliminary/final V04 L1B data.

When integrating the dynamic orbit from this data, no empirical Low-low SST parameters (Bias, Drift, Oscillation) were estimated.

At this point, the processing splits into two separate branches:

1. Gravity field solutions following the JPL RL06 schema are computed. These include empirical SST parameters. Noise is modeled as white.
2. Gravity field solutions following the proposed JPL RL07 schema are computed. These do not include empirical SST parameters. Noise is modeled as a full covariance matrix determined through variance component estimation.

Both sets of solutions are thus determined from the same dynamic orbit, and with the same data basis. Data editing for the full covariance case removes those points specified by the white noise editing, with no additional screening performed.

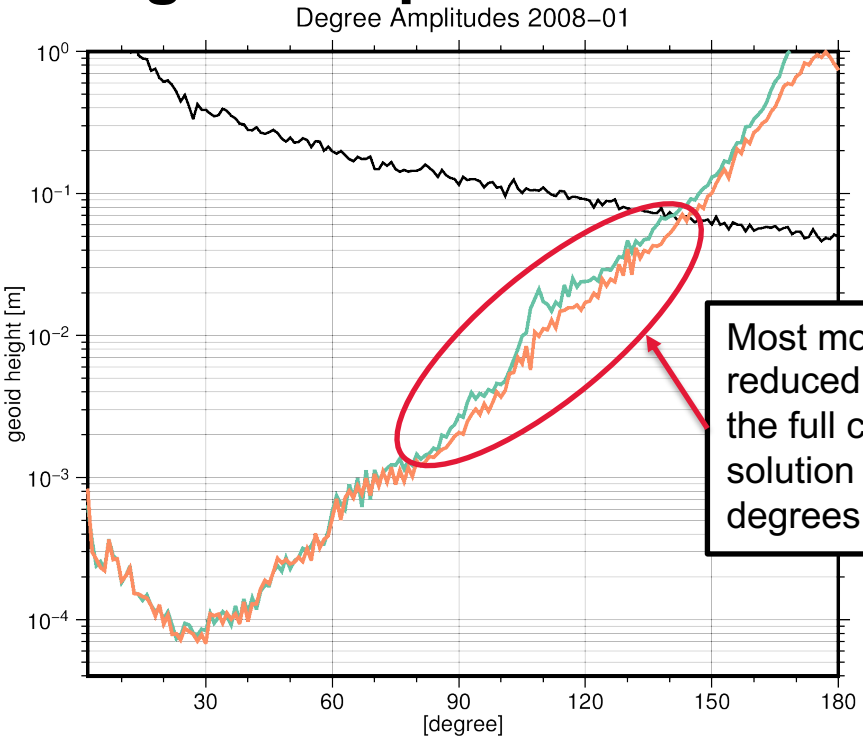
This document has been reviewed and determined not to contain export controlled technical data.

GRACE V04 L1B KBR

White noise and Full Covariance Solutions for 2008

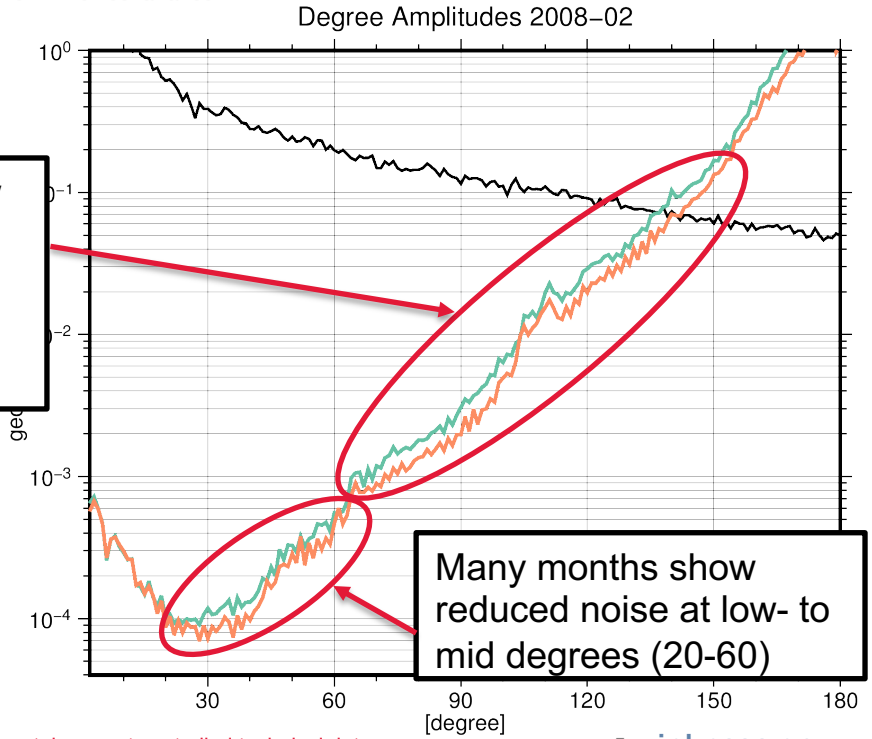
This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes



GOCO06s
JPL–RL07 Prelim. White noise
JPL–RL07 Prelim. Full covariance

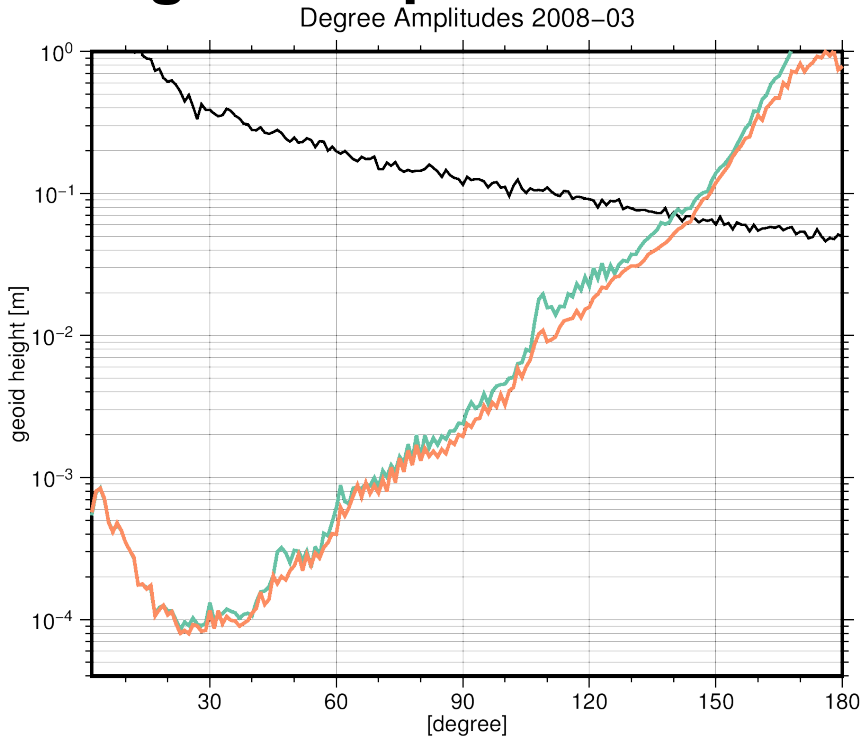
Most months show reduced noise for the full covariance solution at high degrees (>60-90).



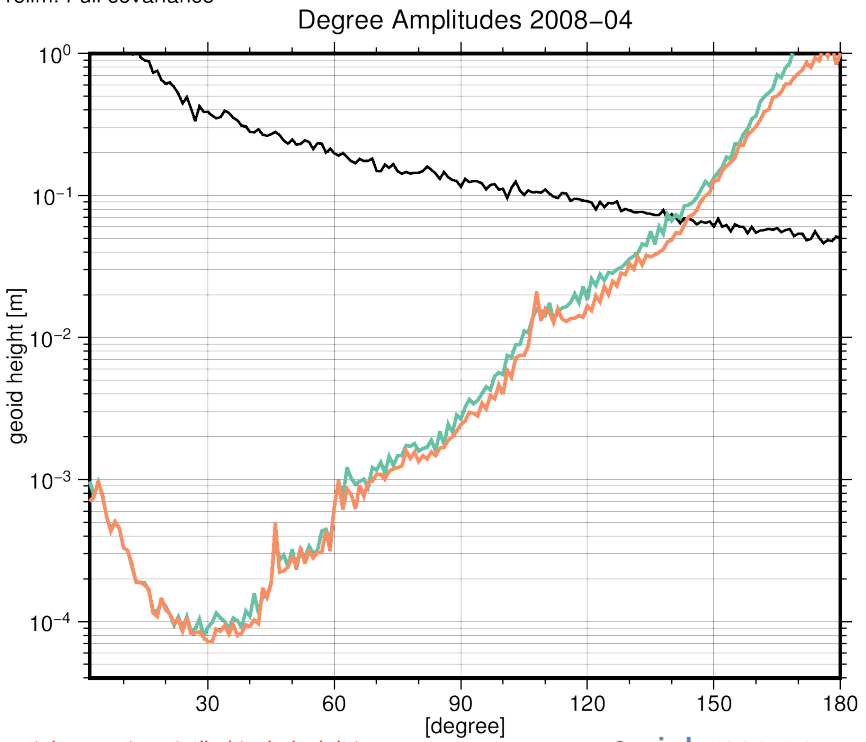
Many months show reduced noise at low- to mid degrees (20-60)

This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes

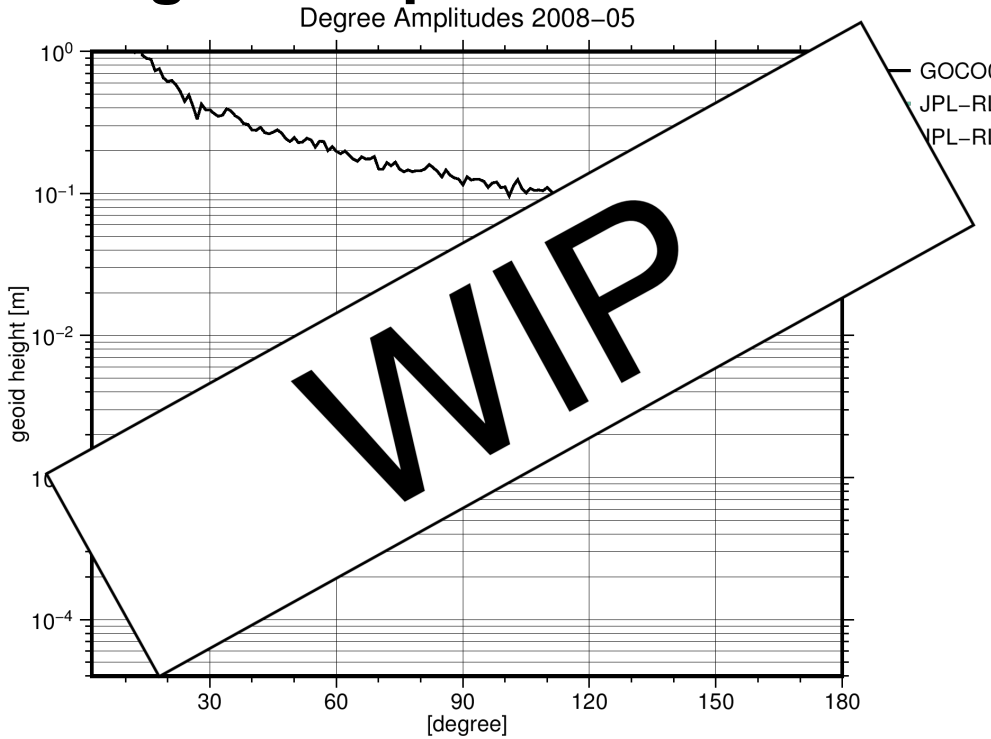


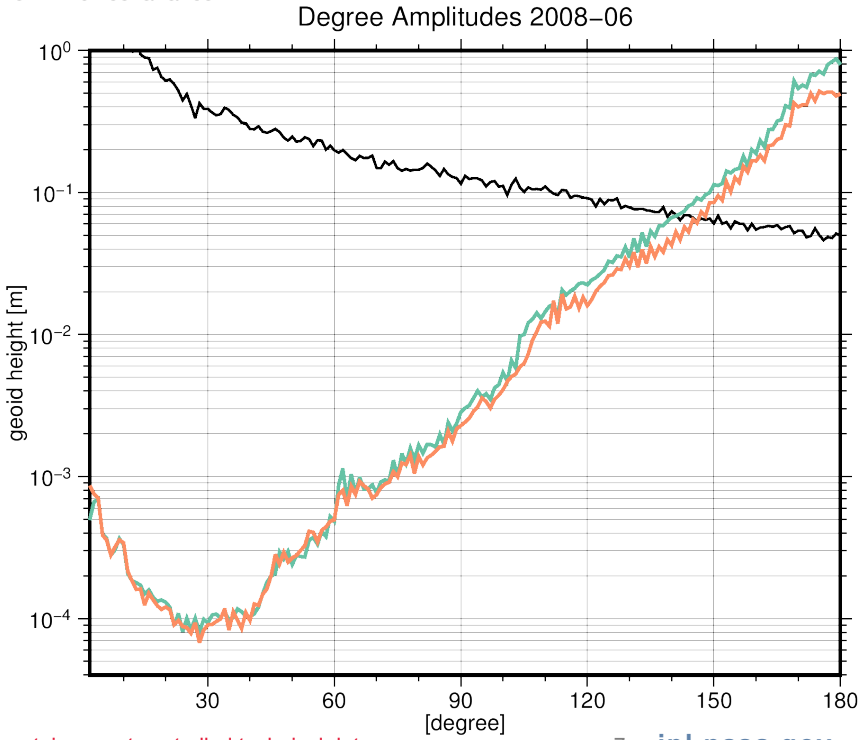
GOCO06s
JPL–RL07 Prelim. White noise
JPL–RL07 Prelim. Full covariance



This document has been reviewed and determined not to contain export controlled technical data.

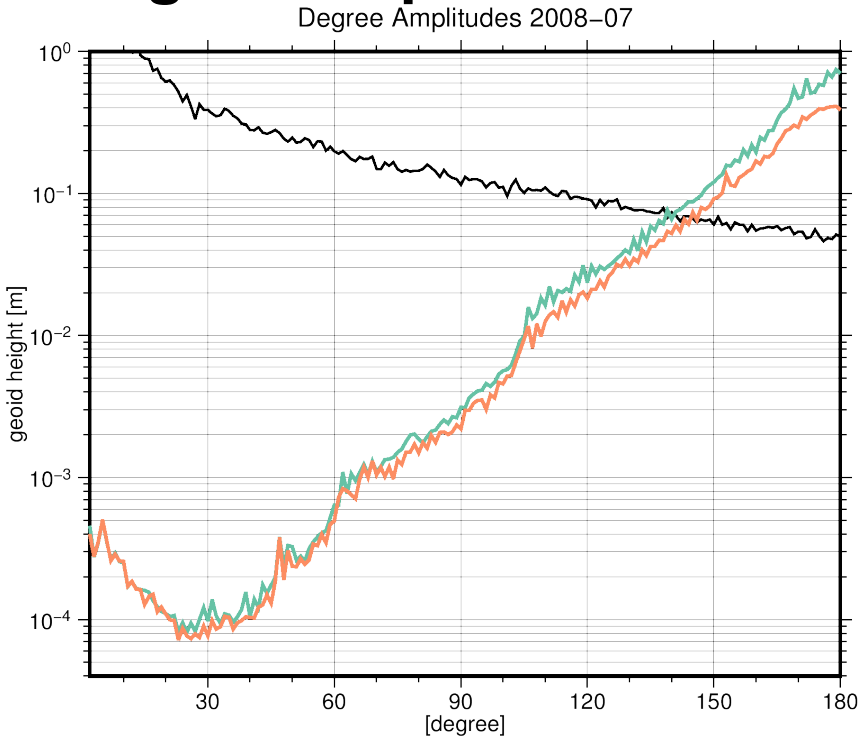
Degree Amplitudes



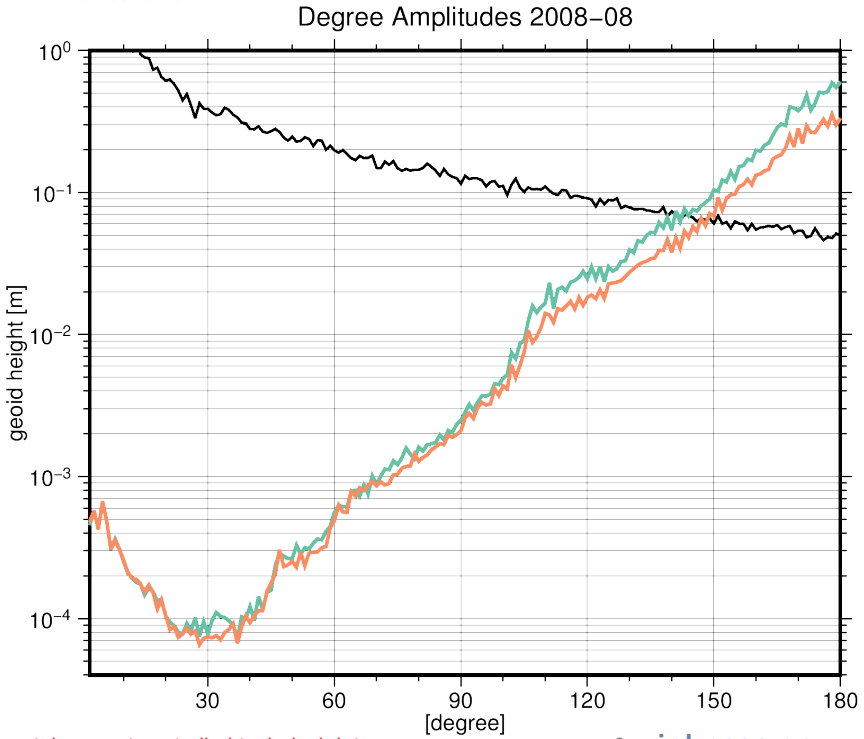


This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes

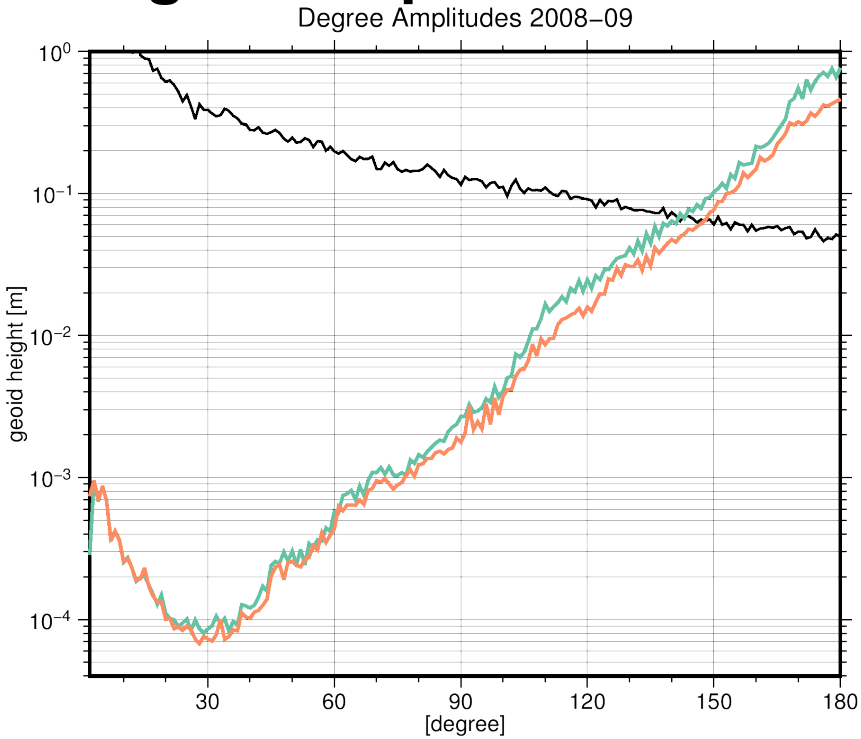


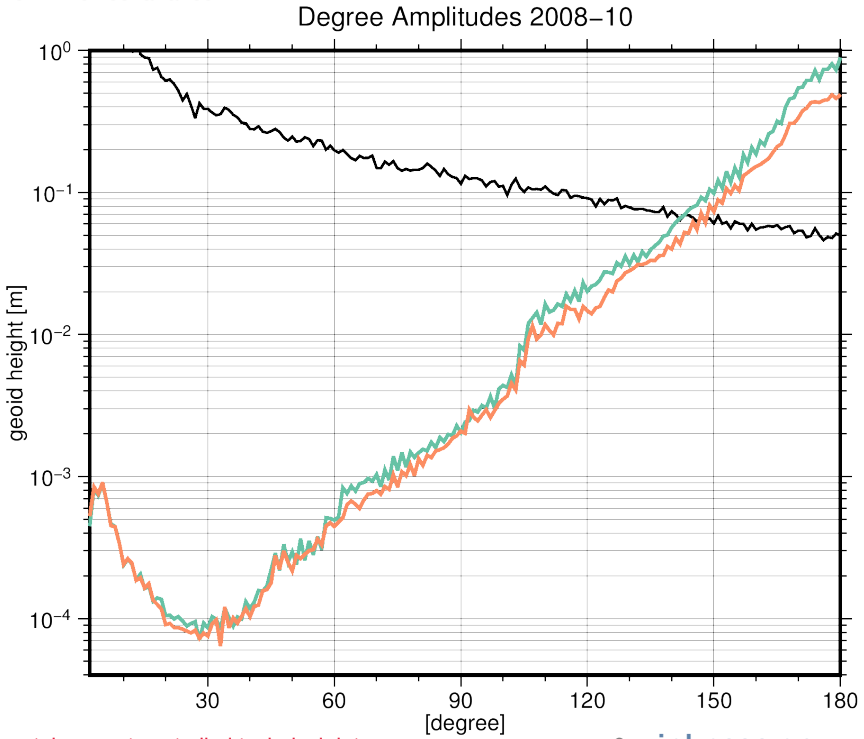
GOCO06s
JPL–RL07 Prelim. White noise
JPL–RL07 Prelim. Full covariance



This document has been reviewed and determined not to contain export controlled technical data.

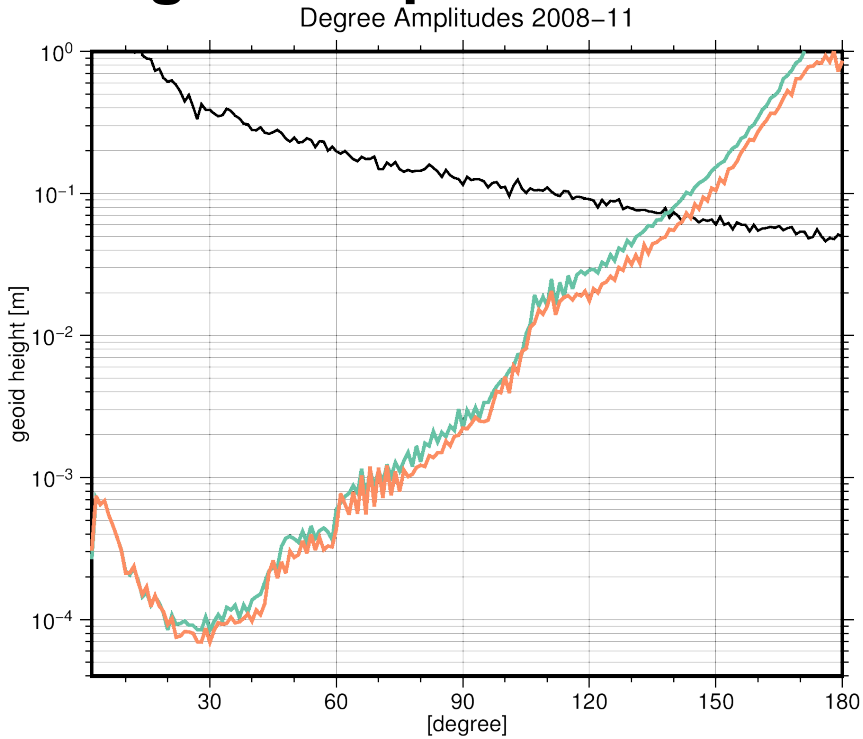
Degree Amplitudes

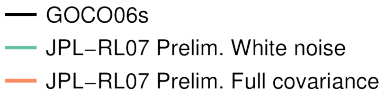


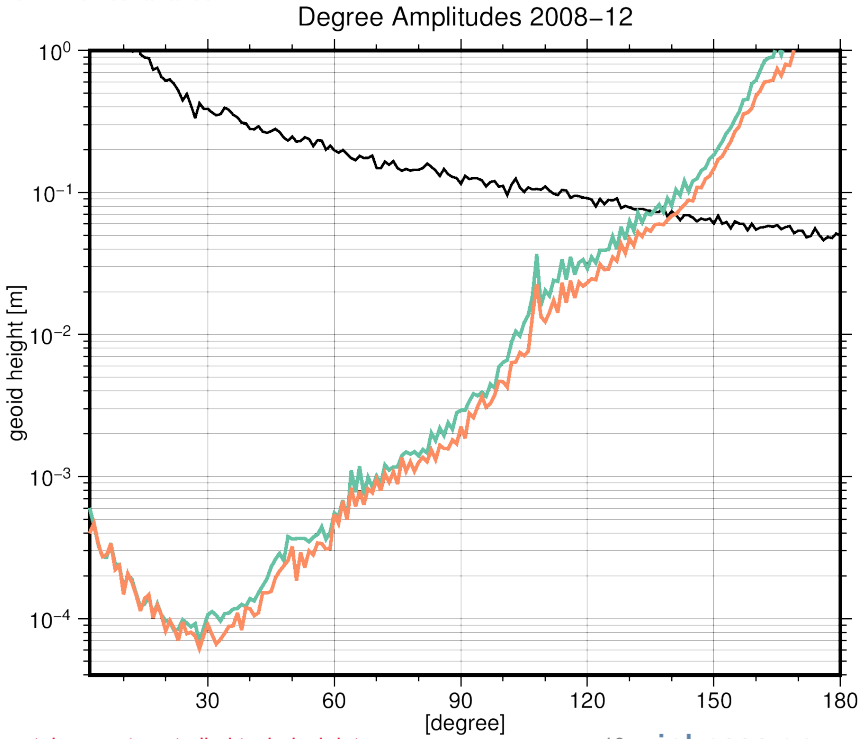


This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes

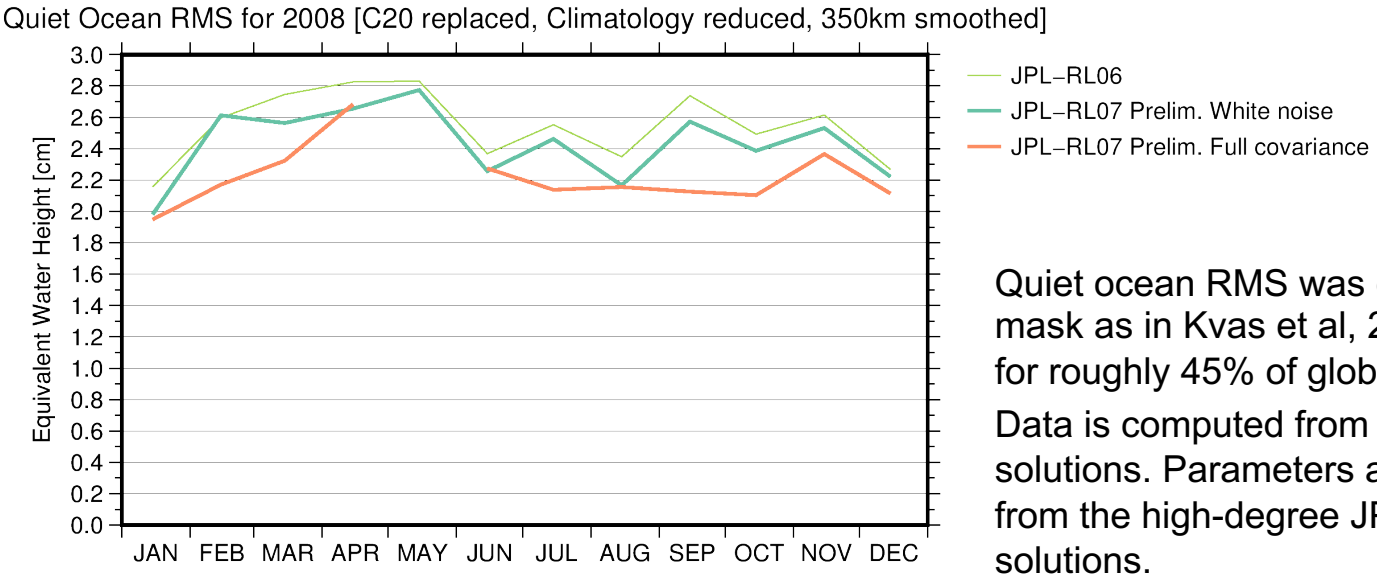






This document has been reviewed and determined not to contain export controlled technical data.

Quiet Ocean RMS



Quiet ocean RMS was computed using the same mask as in Kvas et al, 2019. This includes data for roughly 45% of global ocean areas.

Data is computed from degree/order 96 solutions. Parameters above that were truncated from the high-degree JPL-RL07 preliminary solutions.

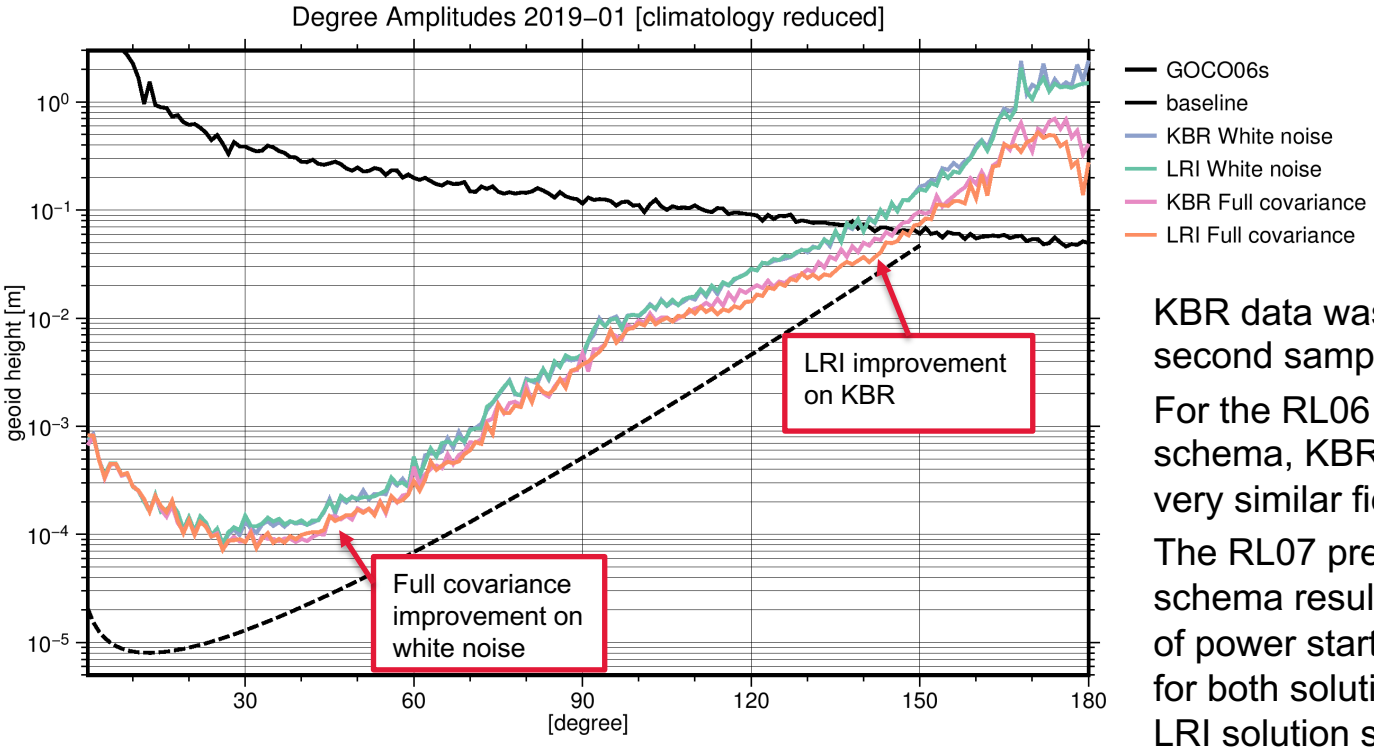
The new full covariance solutions show noise level on par or below that of the white noise solutions.

This document has been reviewed and determined not to contain export controlled technical data.

GRACE-FO KBR and LRI Solutions for January 2019

This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes



KBR data was processed at a 5 second sampling, LRI at 2 seconds.

For the RL06 white noise processing schema, KBR and LRI data result in very similar fields.

The RL07 preliminary full covariance schema results in a marked reduction of power starting at around degree 30 for both solutions. Additionally, the LRI solution shows less power at high degrees from 120 to 180.

This document has been reviewed and determined not to contain export controlled technical data.

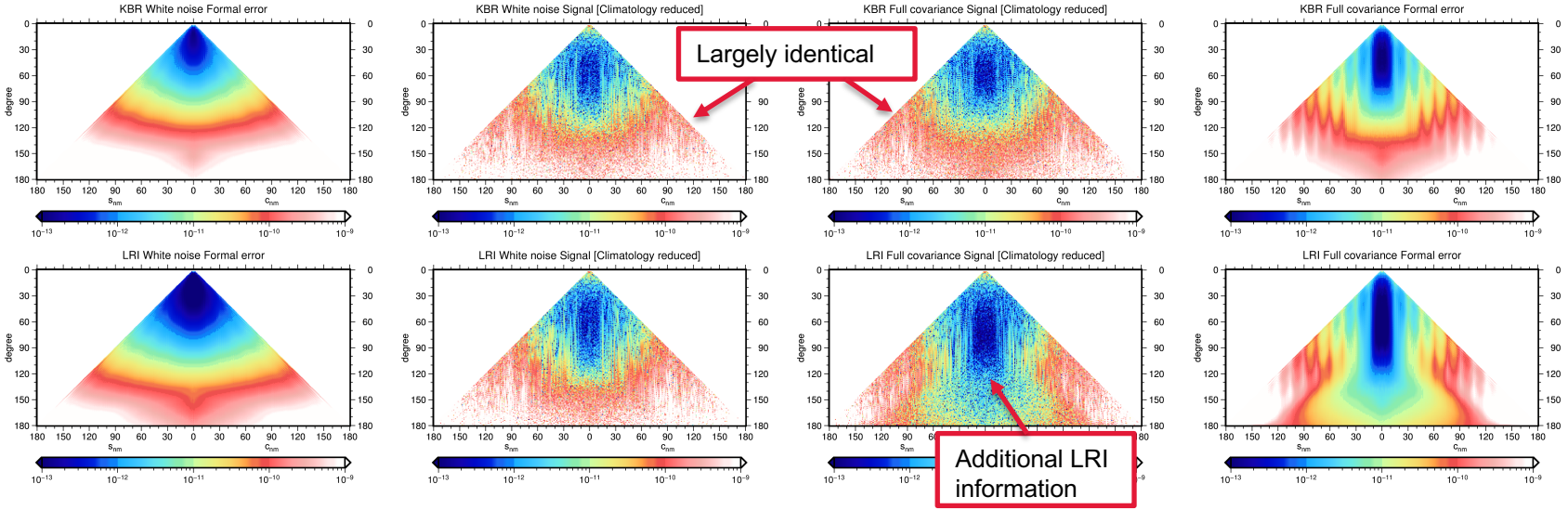
Comparison of full solutions and formal errors

White noise

Full covariance

KBR

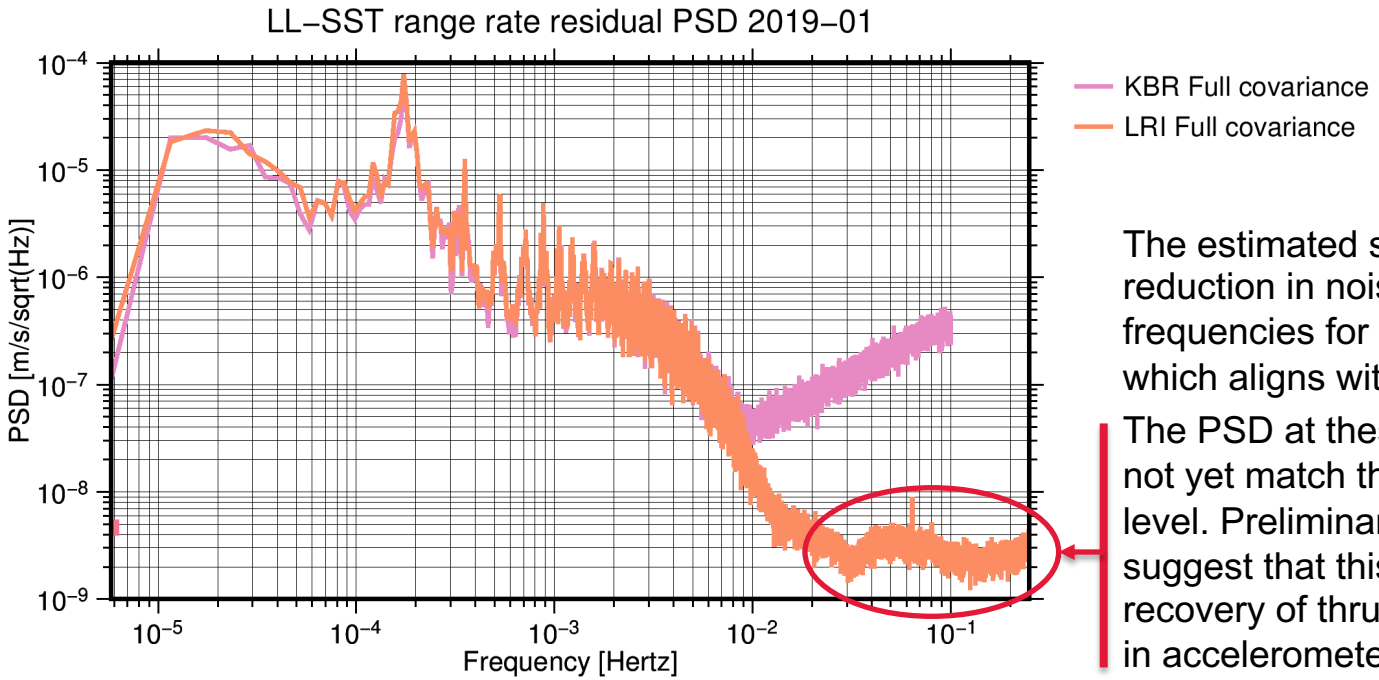
LRI



The full spectrum plot confirms that the white noise KBR and LRI solutions are largely identical. For the KBR solution, employing the full covariance approach leads to small improvements in signal recovery, with the major change being observed in the structure of the formal errors. For LRI data, employing a full covariance estimate brings vastly improved signal recovery in zonal and near-zonal coefficients up to very high degrees.

This document has been reviewed and determined not to contain export controlled technical data.

Low-low SST stochastic model



The estimated spectra show a large reduction in noise levels at high frequencies for LRI observations, which aligns with expectations.

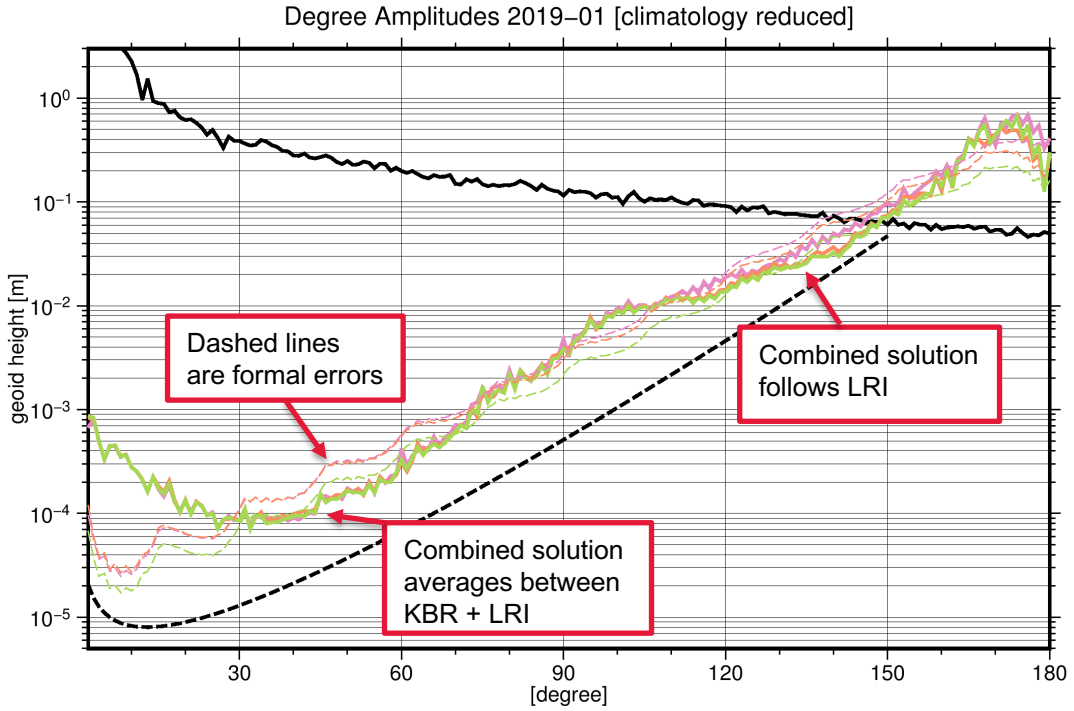
The PSD at these frequencies does not yet match the instrument noise level. Preliminary investigations suggest that this is due to incorrect recovery of thruster firing signatures in accelerometer data.

This document has been reviewed and determined not to contain export controlled technical data.

GRACE-FO KBR and LRI
Combined solutions for January 2019

This document has been reviewed and determined not to contain export controlled technical data.

Degree Amplitudes for combined solution

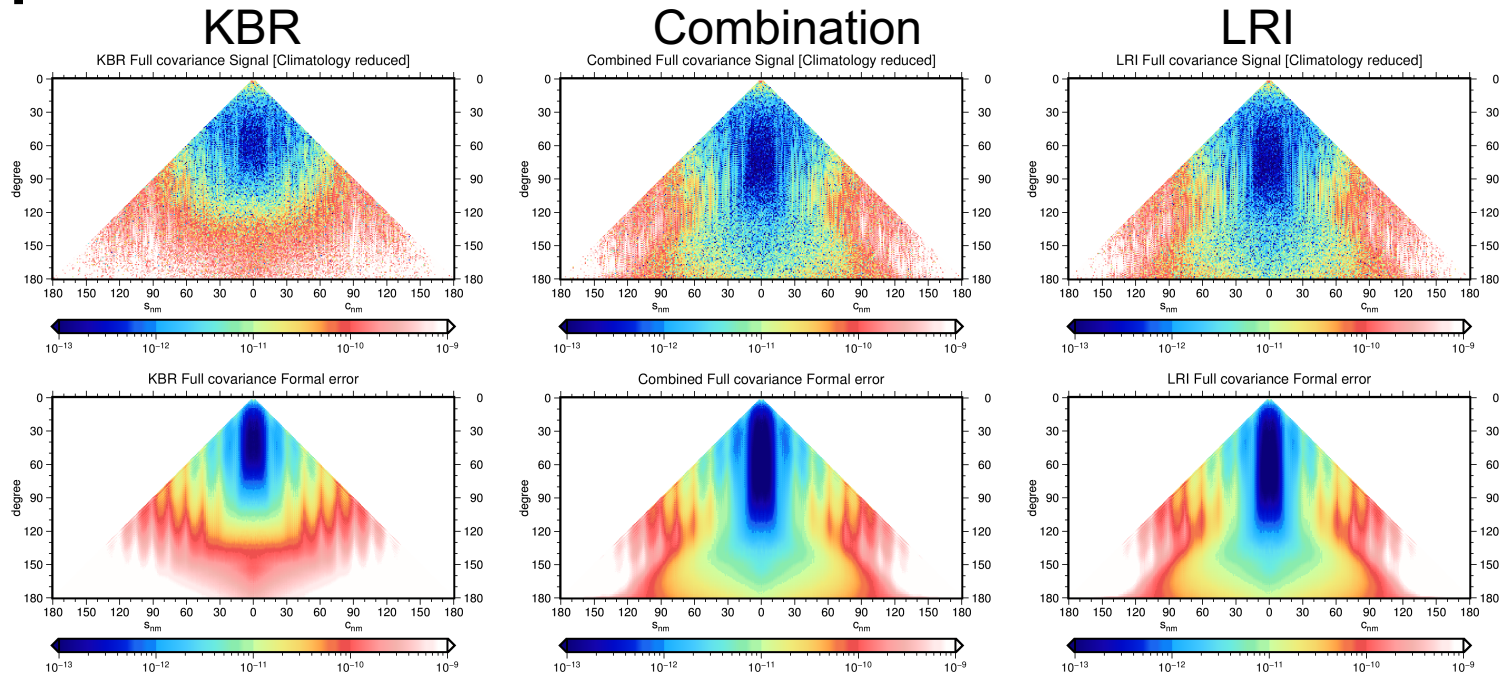


When building a combined solution, using full covariance information, the largest effect is the observed reduction in formal error. This can be wholly attributed to the increased data strength obtained by doubling the number of observations.

Further, the combined solution nicely aligns with the LRI solution in the part of the spectrum where this instrument has improved fidelity, illustrating the advantage of the full covariance approach.

This document has been reviewed and determined not to contain export controlled technical data.

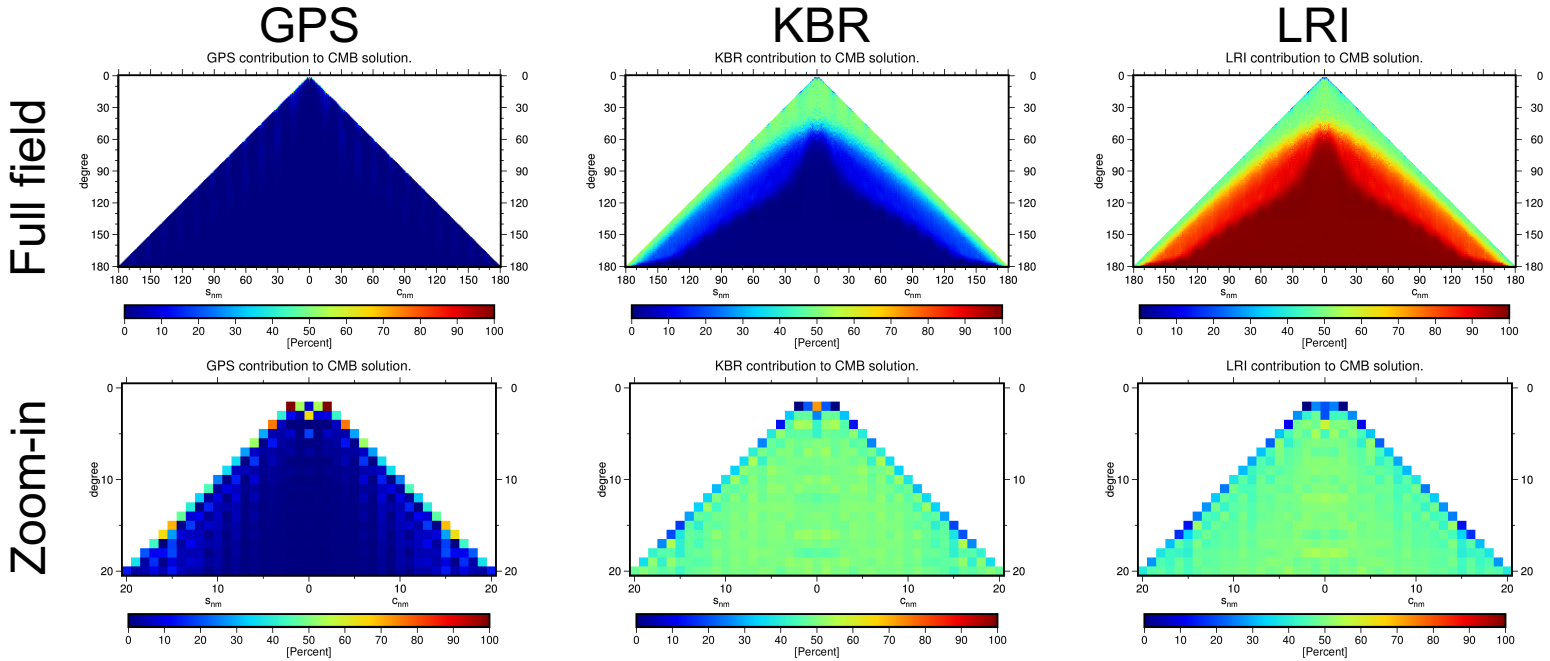
Comparison of solutions and formal errors



The combination solution shows the benefit of LRI observations in the zonal and near-zonal parameters, clearly visible in the spectrum above degree 30. Formal errors are improved, due to the increased data strength of using two observation sets. This is particularly apparent at low degrees, below 30, where signal recovery between KBR and LRI performs similarly, leading to the largest relative improvement.

This document has been reviewed and determined not to contain export controlled technical data.

Contribution of observation groups to combined solution



Analysis of the contributions of all three observation groups shows that LRI data dominates the solution in the near-zonal and tesseral parameters. Information for near-sectorial parameters is derived in roughly equal parts from both KBR and LRI data. GPS data provides the most information at low degrees, more so for sectorial coefficients than others, and some limited information at resonant frequencies at higher degrees.

This document has been reviewed and determined not to contain export controlled technical data.

Summary

- JPL has developed the capability to estimate and apply full noise covariance matrices in its gravity field determination workflow.
- Noise level in solutions is reduced, as shown by quiet ocean RMS time series.
- The full covariance approach allows for exploitation of increased LRI signal content with regard to KBR.
- JPL RL07 data will incorporate these processing improvements.
- JPL is exploring the benefits of combined KBR+LRI solutions.

This document has been reviewed and determined not to contain export controlled technical data.



Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov

This document has been reviewed and determined not to contain export controlled technical data.