



Recent JPL Results from GRACE

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GRACE Mission

Science Goals

High resolution, mean & time variable gravity field mapping for Earth System Science applications.

Mission Systems

Instruments

- Microwave Ranging System (JPL/SSL/APL)
- Accelerometer (ONERA)
- Star Cameras (□DTU)
- GPS Receiver (JPL)

Satellite (JPL/Astrium)

Launcher (DLR/Eurockot)

Operations (DLR/GSOC)

Science (CSR/JPL/GFZ)

Orbit

Launched: March 17, 2002

Initial Altitude: 500 km

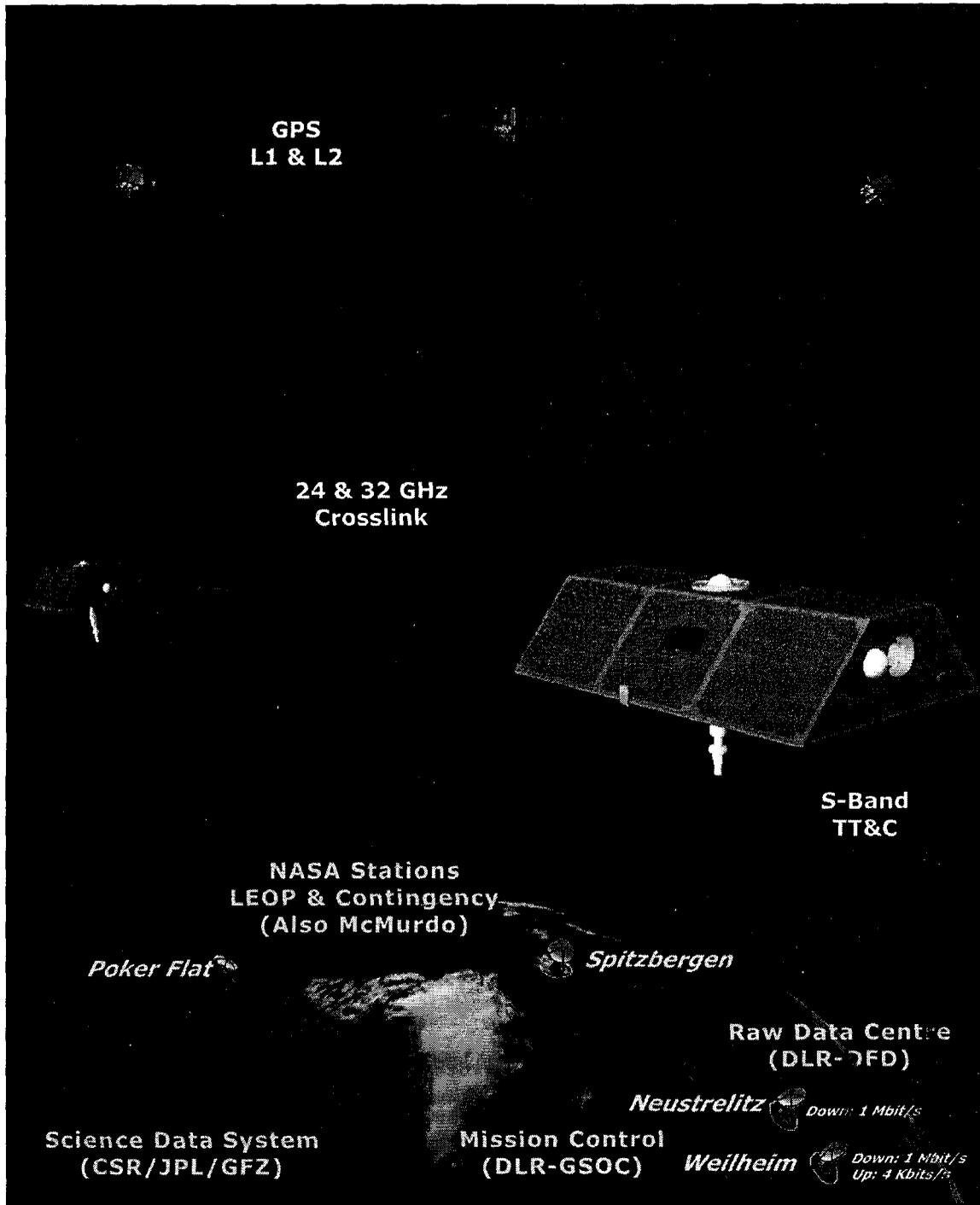
Inclination: 89 deg

Eccentricity: ~0.001

Separation Distance: ~220 km

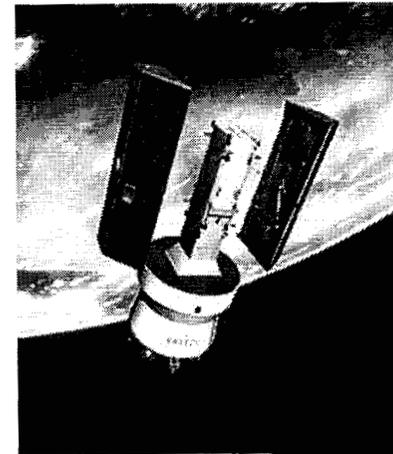
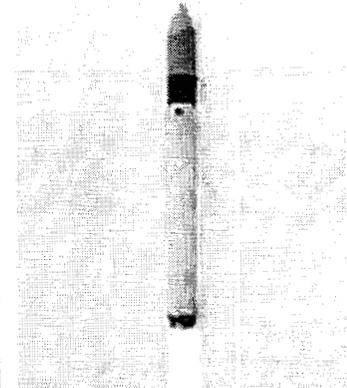
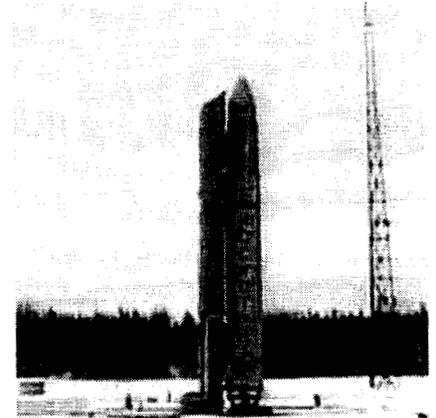
Lifetime: 5 years

Non-Repeat Ground Track, Earth Pointed, 3-Axis Stable



GRACE Project Status

- Spacecraft & System
 - Launched 09:21 UTC, March 17, 2002
 - Reached target orbit
 - Satellites collecting science data
 - Remain in Commissioning Phase
 - Finalizing Flight Procedures and Software
 - K-Band Boresight Calibrations
 - Loss of some redundancy on GRACE-1
- Mission Operations
 - GSOC successfully operating twin satellites in a multi-mission environment
 - Over 99% science data recovered from satellites (science & housekeeping)
- Science Data System(JPL,CSR,GFZ)
 - Initial gravity model improvement underway
 - Time Variable Effects
 - Measurement Evaluation
 - On-going assessment of the flight segment



JPL Grace Level-2 Solution History

- Producing gravity solutions with the *Mirage* software
- Solutions routinely to degree 120, test solution for August to degree 150
- Parameterizations intentionally differ from that of CSR for independent verification
- Limited up to now by computational resources
 - Now running on new 30 processor (Pentium-4 2.2Ghz Xeon) Beowulf
 - 2 days to complete degree 120 solution for 1 month of data

JPL Level-2 Solutions

- Mirage
 - Used range, range rate, and range acceleration for gravity solutions
 - 1 day arcs
- Nuisance parameterization could be improved (eg: no 1/rev kinematic partial for KBR, only dynamic 1/rev acceleration)
- GPS treatment
 - GPS orbits and (transmitter) clocks fixed
 - Solve GPS transmitter clocks
 - Withhold all GPS data
- Use optimal weighting (same as CSR)

JPL Level-2 solutions

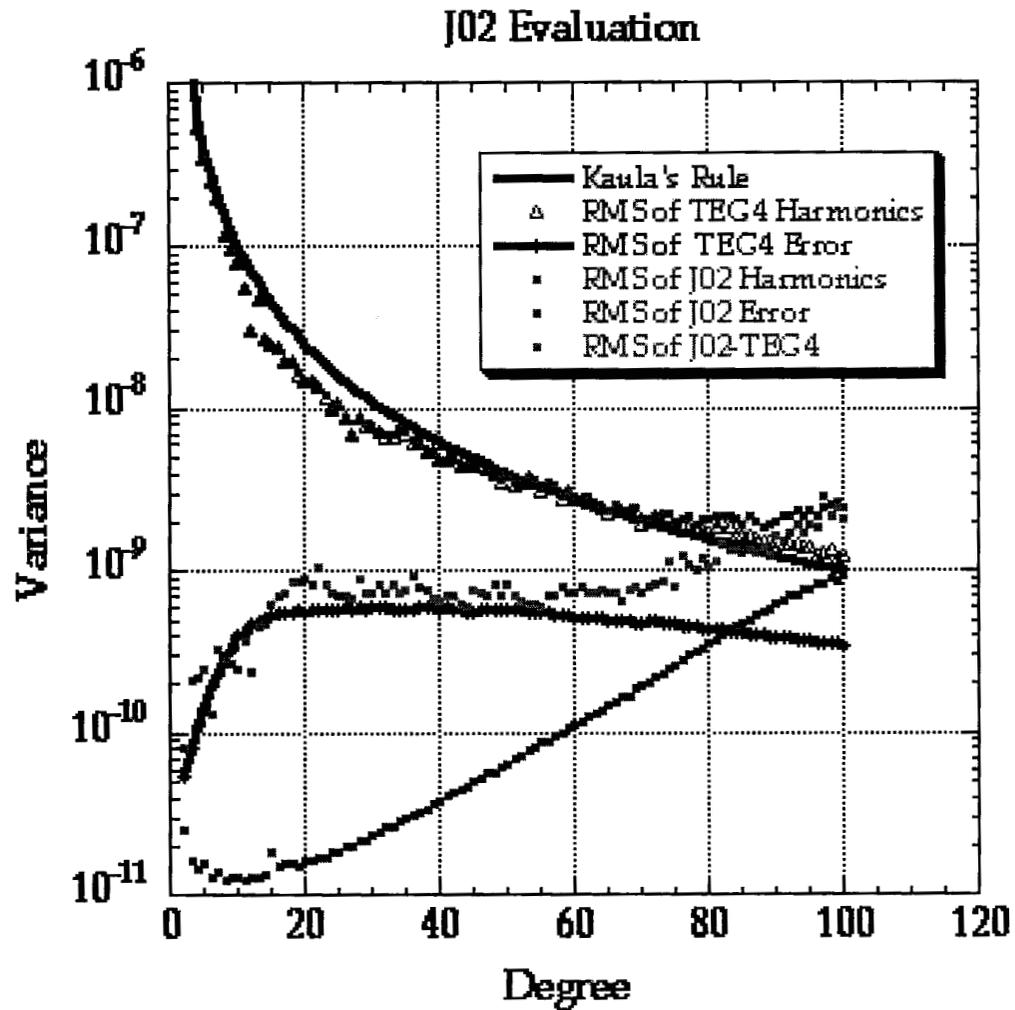
Major solutions

- J01: 14 days in April, degree 100
 - GPS to degree 70, KBR to 100, nominal field TEG4 to degree 100
 - 1/rev in T and N every 1.5 hours, Ct,Cr,Cn every 1.5 hours, 3 axis ACC bias every day
- J02: 14 days in April, degree 100
 - GPS to degree 70, KBR to 100
 - 1/rev in T and N every 12 hours, Ct every 12 hours, 3 axis ACC bias every day
- J03: 28 days in April/May degree 120
 - GPS to degree 70, KBR to 120, TEG4 nominal to degree 120
 - 1/rev in T and N every 12 hours, Ct every 12 hours, 3 axis ACC bias every day
- J04: 26 days in August degree 120
 - GPS to degree 70, KBR to 120, TEG4 nominal field to degree 180
 - Same as above but
- J05: 26 days in August degree 150
 - GPS to degree 70, KBR to 150, TEG4 nominal field to degree 180
 - Same as above

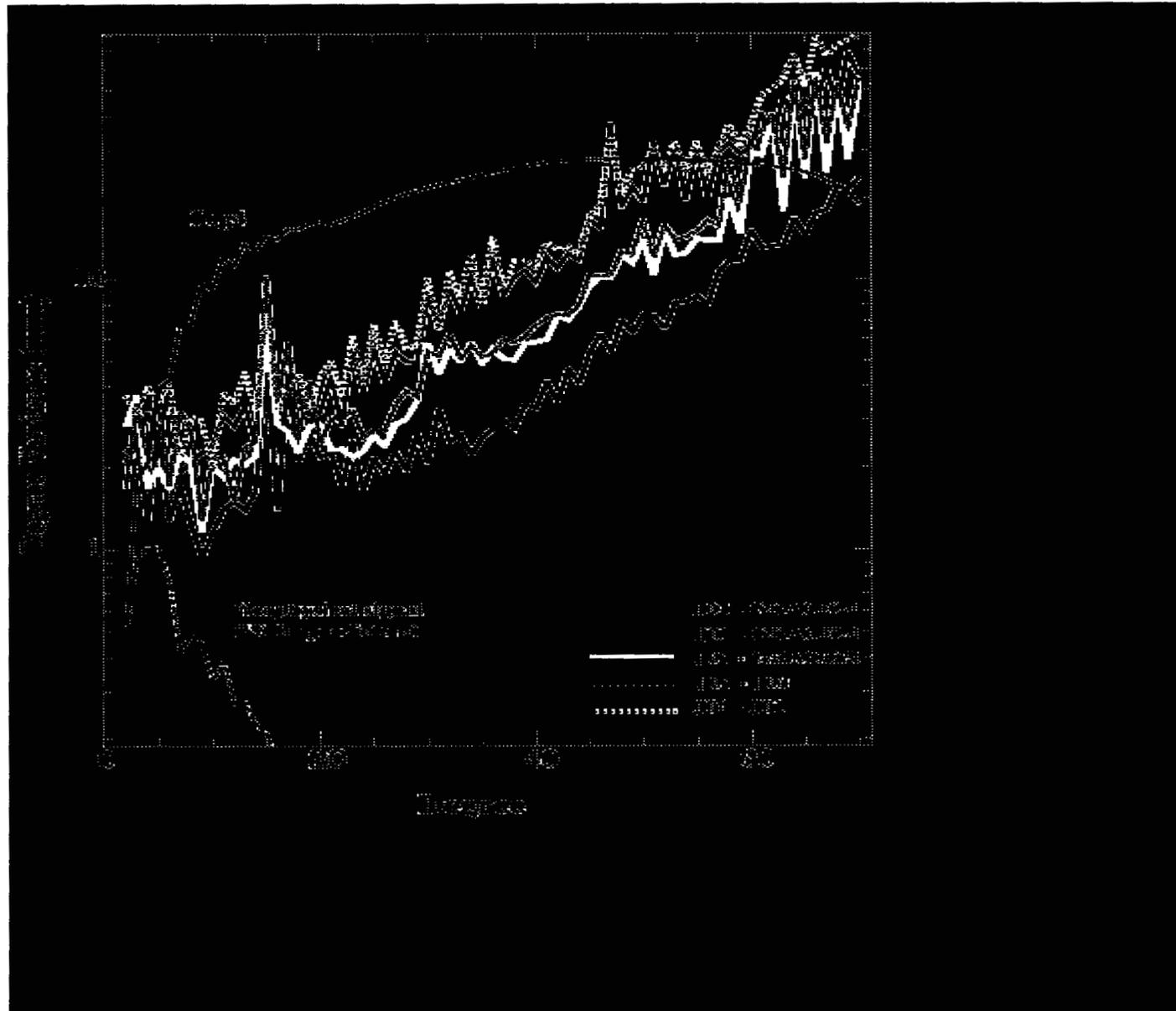
JPL Level-2 Quality Assessment

- For each solution, looked at degree variation of solution wrt to
 - Kaula, TEG4, other GRACE solutions
- For each solution, looked at degree variation of covariance wrt to
 - Kaula, TEG4, other GRACE solutions
- Limited tests on J03 and J04 fits on Jason-1
- Released several fields to CSR for comparison with other GRACE fields
- and to Victor Zlotnicki for assessment of “mean” field
- Sent several fields to CU for analysis of spatial patterns in April/August differences

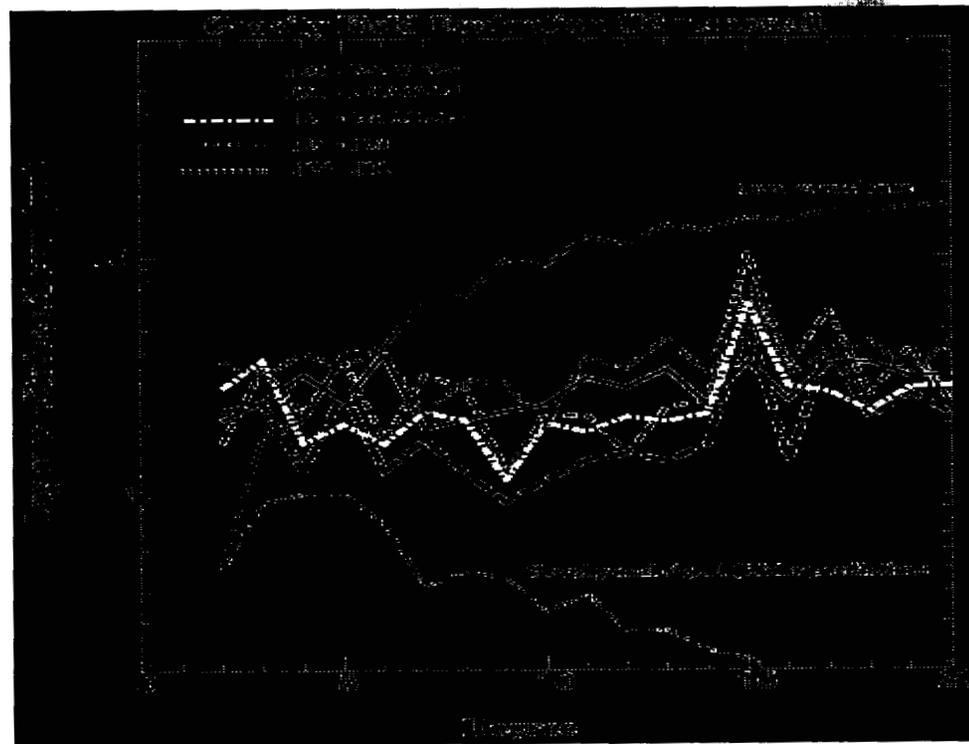
Typical Grace Gravity Field Evaluation



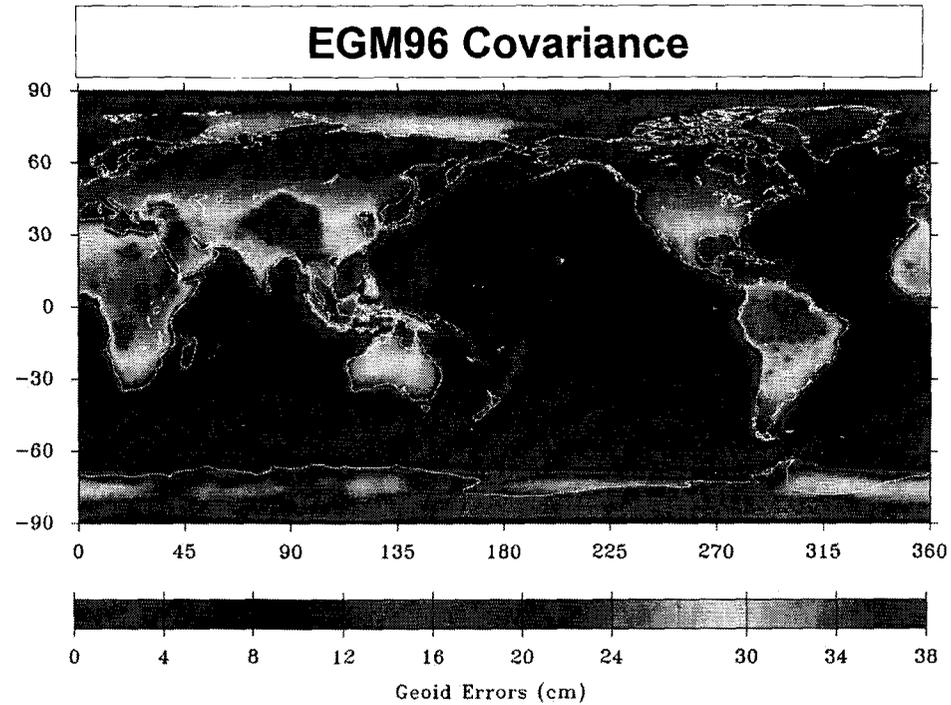
Grace Gravity Field Differences



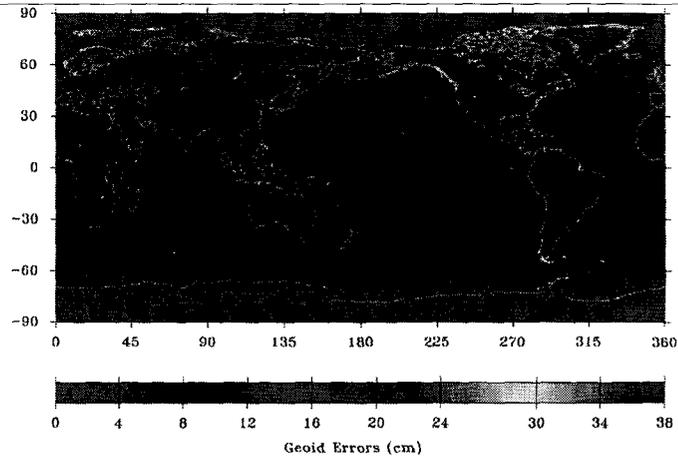
Grace Gravity Field Difference (J2 removed)



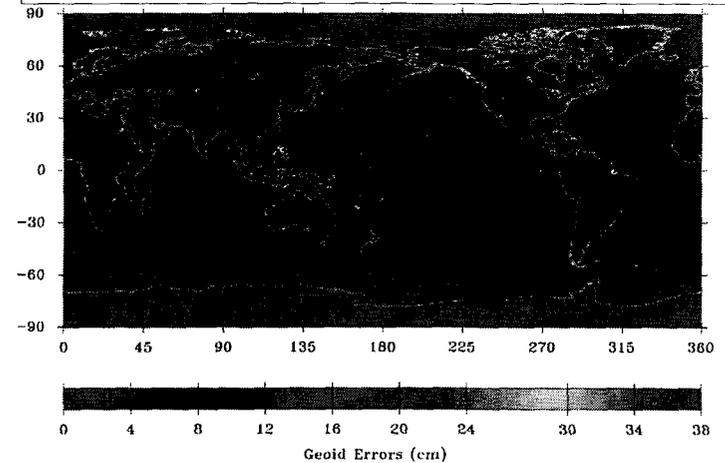
GRACE Geoid Error Distribution



JPL 03 Grace Covariance



UTCSR Grace Covariance



Gravity Field Evaluation

GPS + KBR range-rate derived orbits with 12-hour empirical accelerations (const. in T, 1/r in T & N components)

- Using 120x120 part of the gravity models

	TEG4	G21	J03	J04
	03-MAY-2002 ¹			
GPS phase (m)	0.14	0.14	0.14	0.16
GPS range (m)	0.47	0.46	0.47	0.55
KBR RR (μ/s)	20.1	3.47	1.72	7.94
	15-AUG-2002 ¹			
GPS phase (m)	0.15	0.15	0.15	0.15
GPS range (m)	0.60	0.59	0.59	0.60
KBR RR (μ/s)	19.2	2.84	3.15	1.22

¹ GPS phase ($\sigma = 20$ cm); GPS range ($\sigma = 1$ m); KBR range-rate ($\sigma = 20$ μ/s)

Gravity Field Evaluation

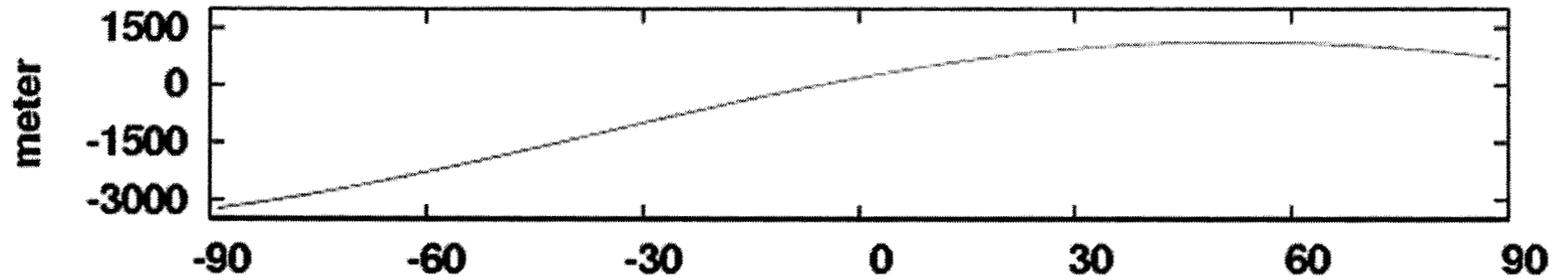
GPS + KBR range-rate derived orbits with 1.5-hour empirical accelerations (const. in T, 1/r in T & N components)

- Using 120x120 part of the gravity models

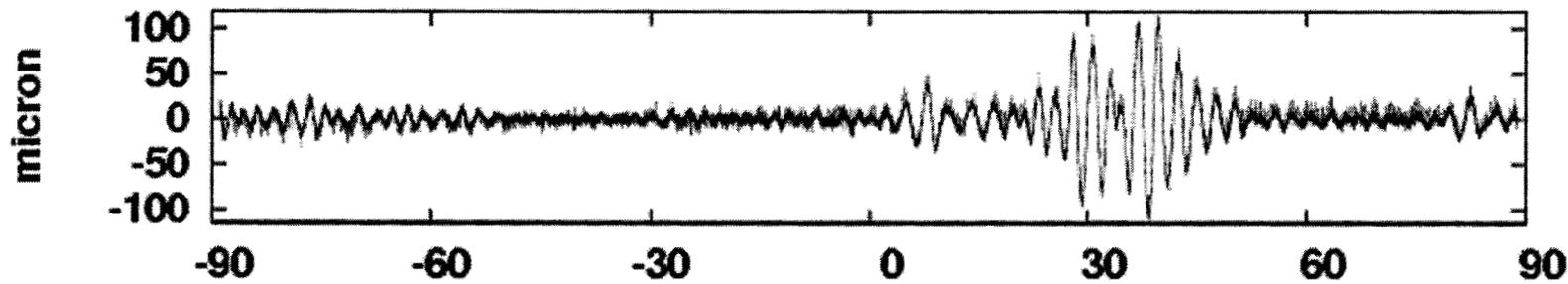
	TEG4	G21	J03	J04
		03-MAY-2002 ¹		
GPS phase (m)	0.14	0.14	0.14	0.14
GPS range (m)	0.42	0.42	0.42	0.42
KBR RR (μ/s)	18.9	0.82	0.75	2.92
		15-AUG-2002 ¹		
GPS phase (m)	0.14	0.15	0.15	0.15
GPS range (m)	0.54	0.54	0.54	0.54
KBR RR (μ/s)	18.6	0.90	0.99	0.90

¹ GPS phase ($\sigma = 20$ cm); GPS range ($\sigma = 1$ m); KBR range-rate ($\sigma = 20$ μ/s)

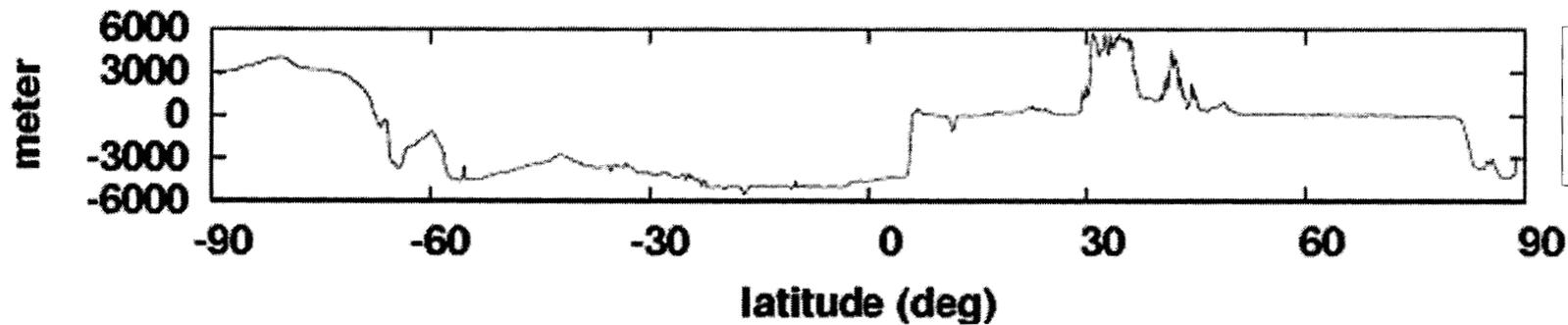
GRACE Satellite-Satellite Range Performance



Full sat-sat
Range - Bias

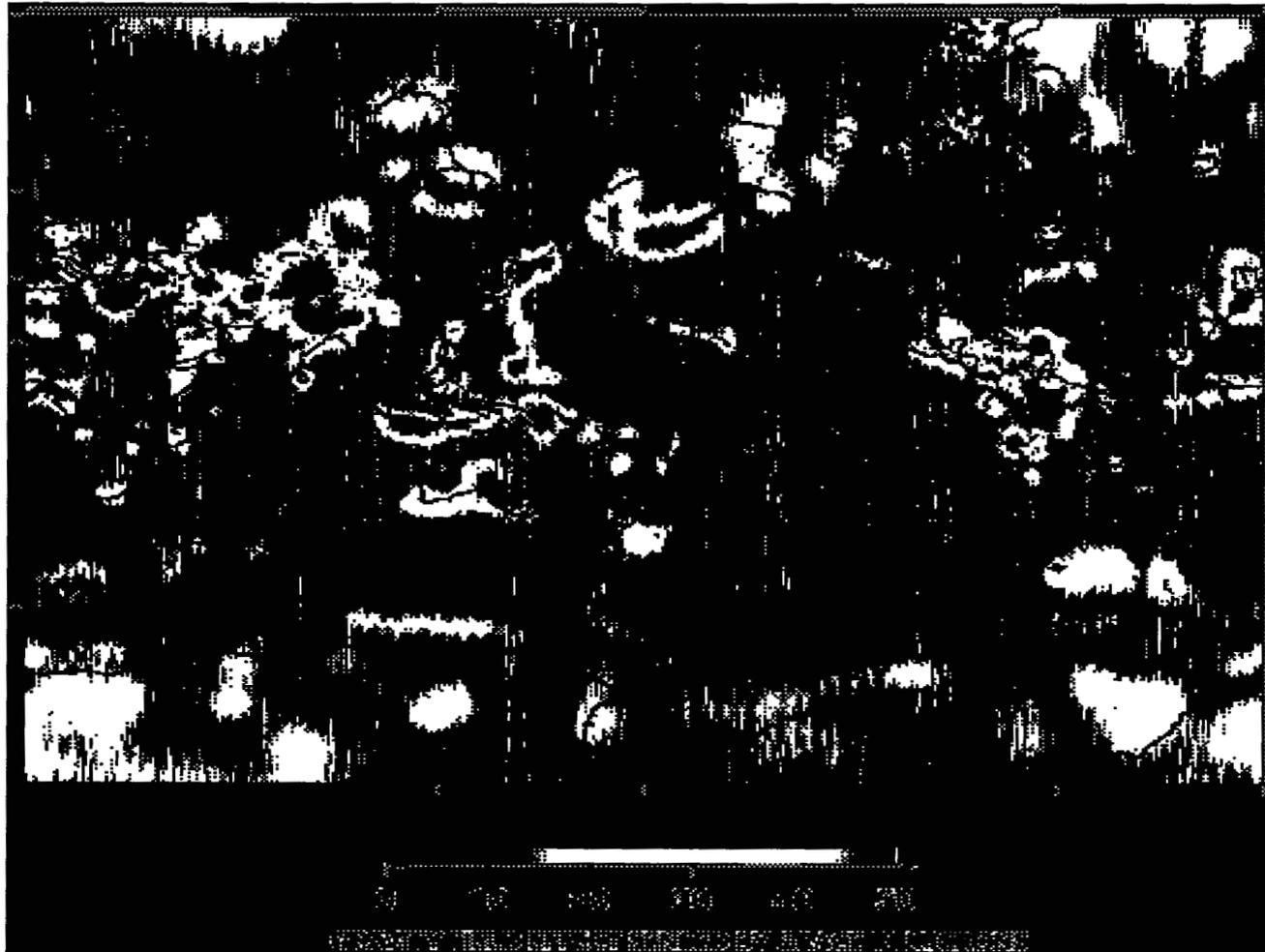


After removing
long period
part



Topography
Along
Groundtrack

Gravity Field Sensed by Grace, 200 day version



Summary

- Grace fields *definitely* are a significant improvement over EGM96/TEG4 class fields
 - ~5-15 times better between degrees 5 and 50
 - Uniform errors geographically
 - Agree well with UTCSR fields
- Would like improved quality, especially at longer wavelengths
- Some evidence that high frequency KBR data meets or exceeds specs
- Work Remaining:
 - Investigate systematic errors in accelerometer (“twangs”)
 - Input misalignment between SCA and ACC