GRACE Mission: Status and Prospects

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2013 GRACE SCIENCE TEAM MEETING

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GRACE Mission Summary

GRACE Science Status

Time variable gravity measurements enable multidisciplinary studies in Hydrology, Oceanography, Glaciology and Solid Earth Sciences

- RL05 Gravity Model Release
- GEWEX Workshop on GRACE and Hydrology

Mission Events:

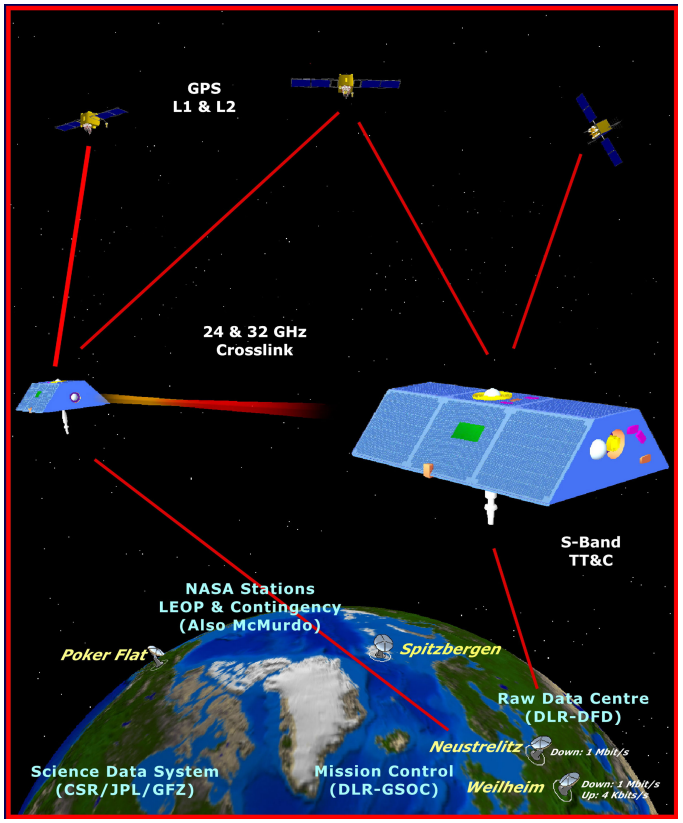
- Completed Biannual 2013 ESD NASA Senior Review
  - Science rating High (4.7/5)
  - Mission Extended to 2018
  - Technical Risk (High)
- Climate Mission Role raises concern for mission extension

Mission Life

- Adequate satellite resources for continued mission
- Ageing components and single string components are concerns
- Battery Life is primary focus
- Lack of Thermal Control requires attention
- Outstanding Mission Operations Support

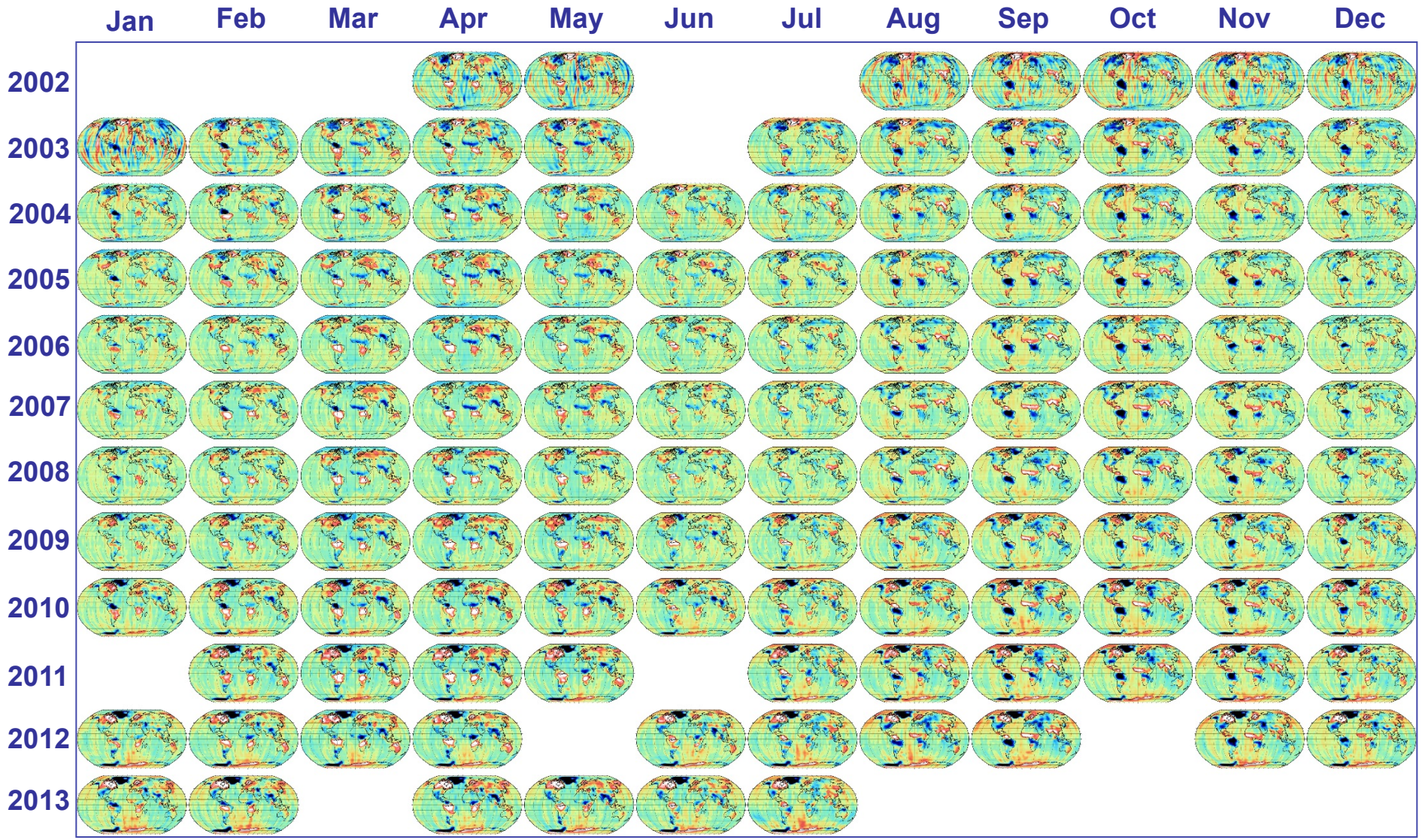
Measurement Continuity Prospects

- NASA GRACE FO is in implementation
- Ongoing efforts to maximize GRACE lifetime
  - Approaches for Bridging possible gap
- Battery Management to maximize mission life
- Mission Continuity to GRACE FO Interval
  - Approaches for Bridging possible gap
- Activities to improve the Science Yield



Operations Concept: All instruments on, all the time

Over 11.5 Years in Orbit – 125 Global Gravity Solutions



RL05 Solution Overview

Status of the RL05 Data Release

Solutions from January 2003 – July 2013 have been released

The Level-2 processing for data in 2002 is ongoing

Some Observations

Factor of two improvement in solution accuracy, overall

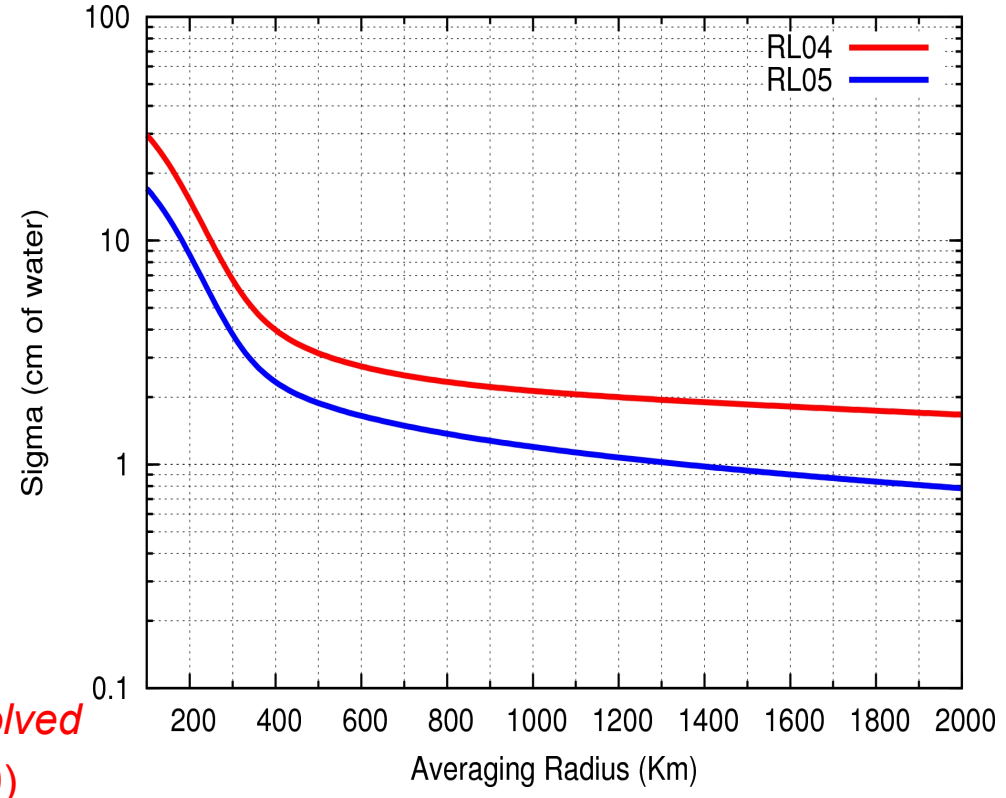
For spatial scales < 500 km, increasing noise observed after 2010

Vast majority of users should see no difference in the products for t > 01 2011

Issues

Slope differences between solutions resolved

Differences in Model Resolution(60 vs 90)



CSR RL05

GGM 05 C Status

Plan

- Compute GGM05S from 135 RL 05 Monthly Solutions
  - Degree and Order 180
- Compute Mean Gravity Model From GOCE Mission data
  - Degree and Order 250
- Combine Information Array from DTU10S Geoid
  - Degree and Order 360, initially

Combine information arrays to obtain GGM 05C

- Obtain solution
- Validate solution
- Calibrate the Covariance Matrix

Issues

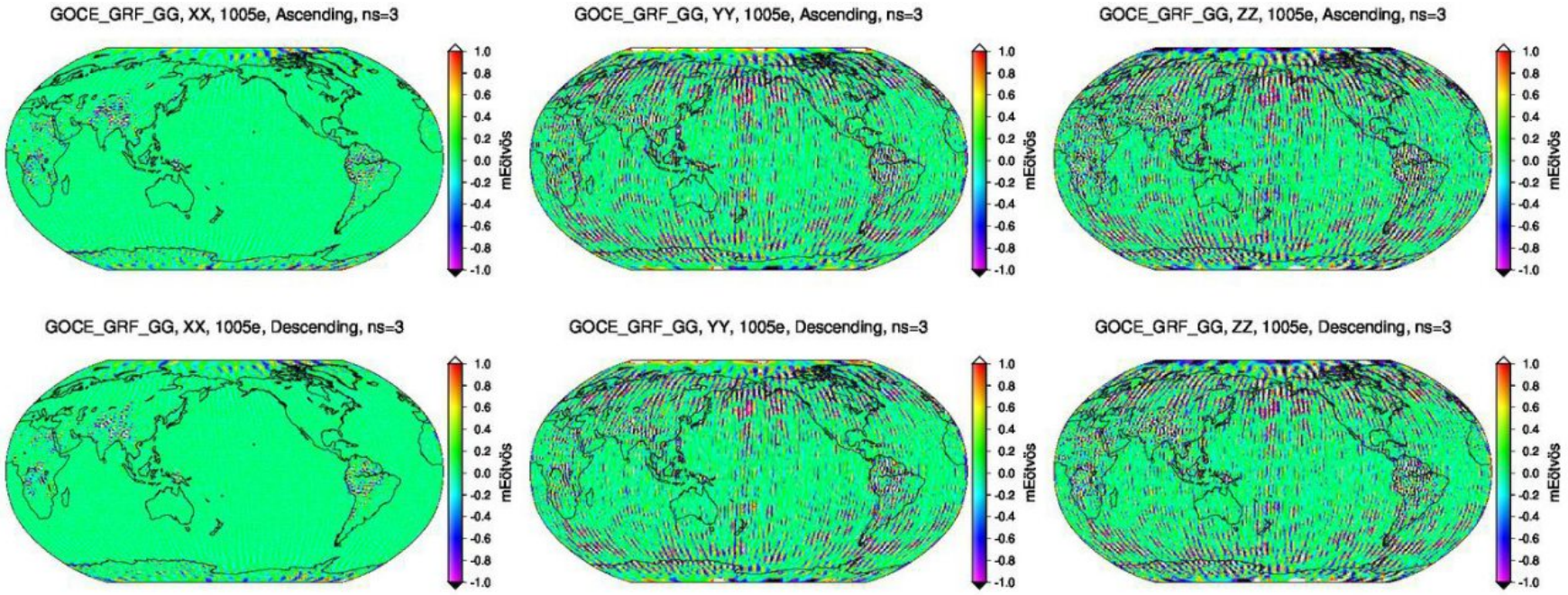
- Relative weighting of solutions to account for different information content

GOCE ANALYSIS: Progress and Plans

- Processing progress:
  - Pre-processing, examination of residuals, and data screening has been completed for Nov ’09 to Jan ’13
  - Models validated, band-pass filtering strategy adopted (10-50 mHz)
  - ‘Polar gap’ to be addressed by filling with GGM05S (GRACE: 2003-2013)
  - Preliminary gravity fields from first 61-days of continuous data
    - GOCE-only and GRACE/GOCE solutions with optimally weighted XX, YY and ZZ complete to 220x220
- Processing plans for next two months:
  - Accumulate 250x250 GOCE information matrices (XX, YY, ZZ and XZ)
    - Results indicate XZ is useful
    - Contribution of each component TBD when entire mission is processed
  - Produce 250x250 GOCE+GRACE satellite-only solution and 360x360 solution combined with DTU10 surface gravity anomalies
  - Primary issues remaining are the fine-tuning of the relative weighting of GOCE, GRACE and surface data and the exact method of using GGM05S to fill ‘polar gap’

GOCE ASSESSMENT (residuals)

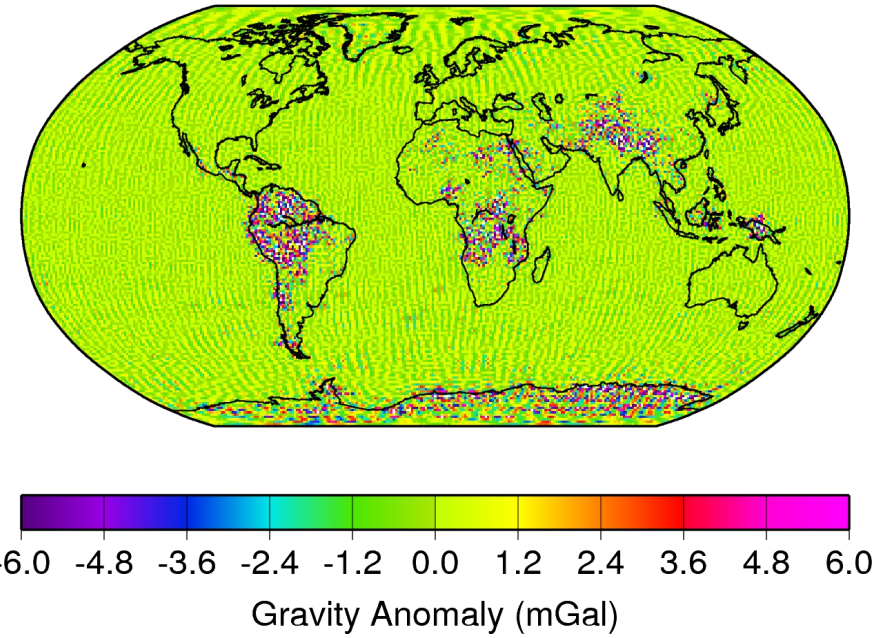
Maps shows GOCE data residual relative to GIF48 where terrestrial gravity was poor/unavailable; and shows the striations from GRACE



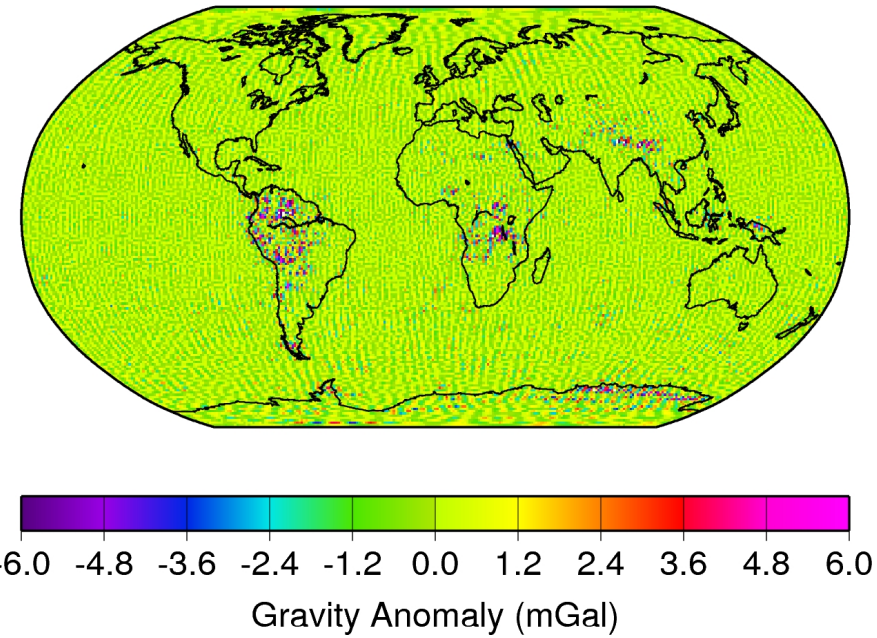
Low residuals in XX direction (first column) show analogy between the GOCE gravity gradients and GRACE data in the along-track directions.

GOCE ASSESSMENT (solution)

GIF48 – GOCO03S



test07 – GOCO03S



Mapped only up to deg/ord 180
GIF48 = GRACE + surface gravity (apriori mean field)
Test07 = GRACE + GOCE (61 days) + surface gravity

Results indicate that including 61 days of GOCE data has reduced effect of weak surface gravity data and moved solution closer to GOCO03S

GOCE ASSESSMENT (ocean circulation)

Compute correlation between ocean circulation (zonal and meridional currents) implied by MSS-Geoid and long-term average; test limited to degree/order 180

Gravity solution	Zonal	Meridional
GRACE only (GGM05S)	0.910	0.481
GRACE+DTU10 (GIF48)	0.922	0.575
GOCE only *	0.937	0.605
GRACE+GOCE	0.937	0.606
TUM-GOCE02S	0.935	0.605

* 'Kaula-constraint' applied in preliminary solution but will not be used for final results

Conclusions:

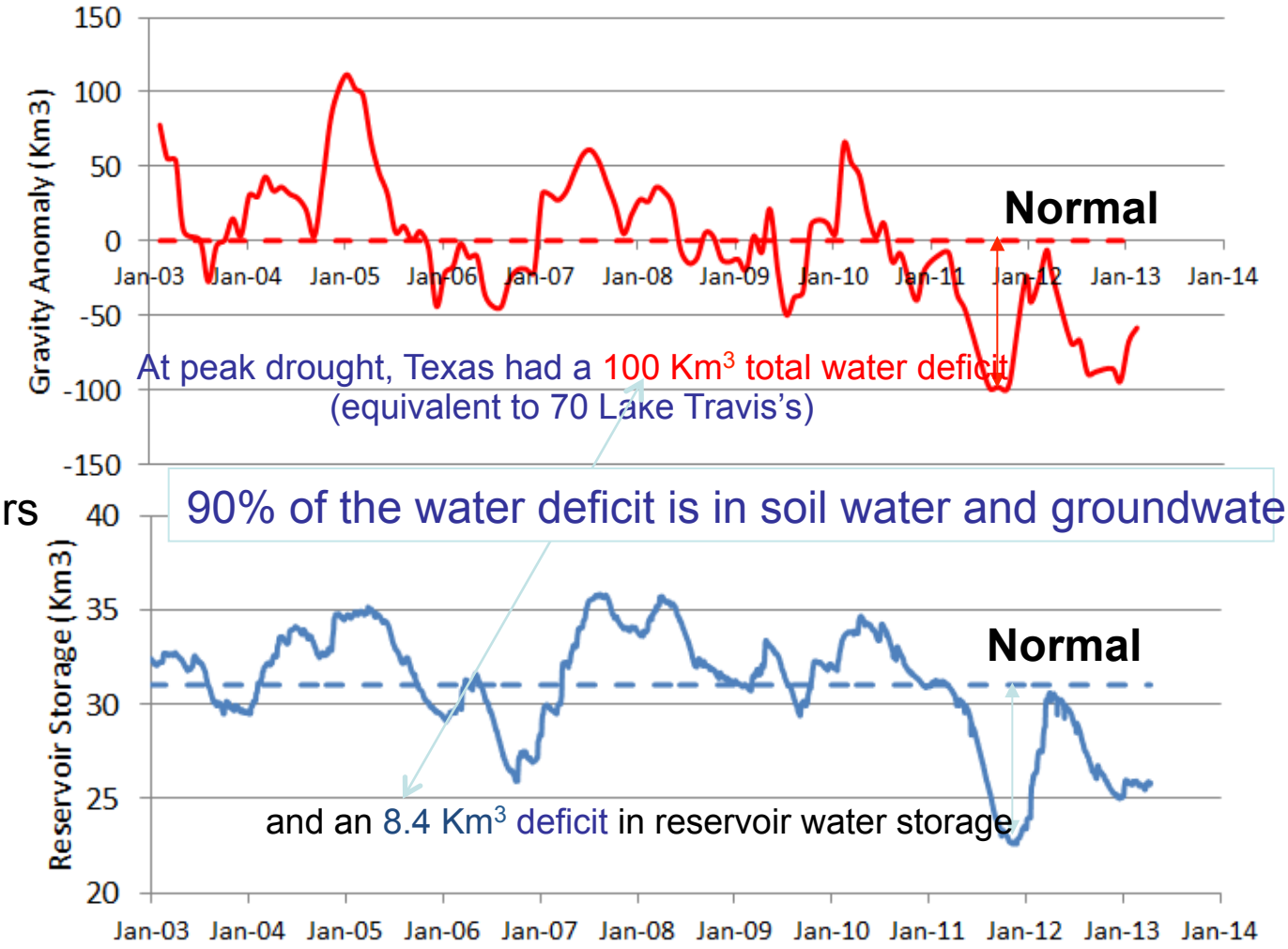
- Appropriately filtered, the GOCE data is remarkably good and is able to determine a very significant part of the mean gravity field
- Handling 'polar gap' is perhaps most challenging part, but effective strategies are available

GRACE and Texas Reservoir Water Storage

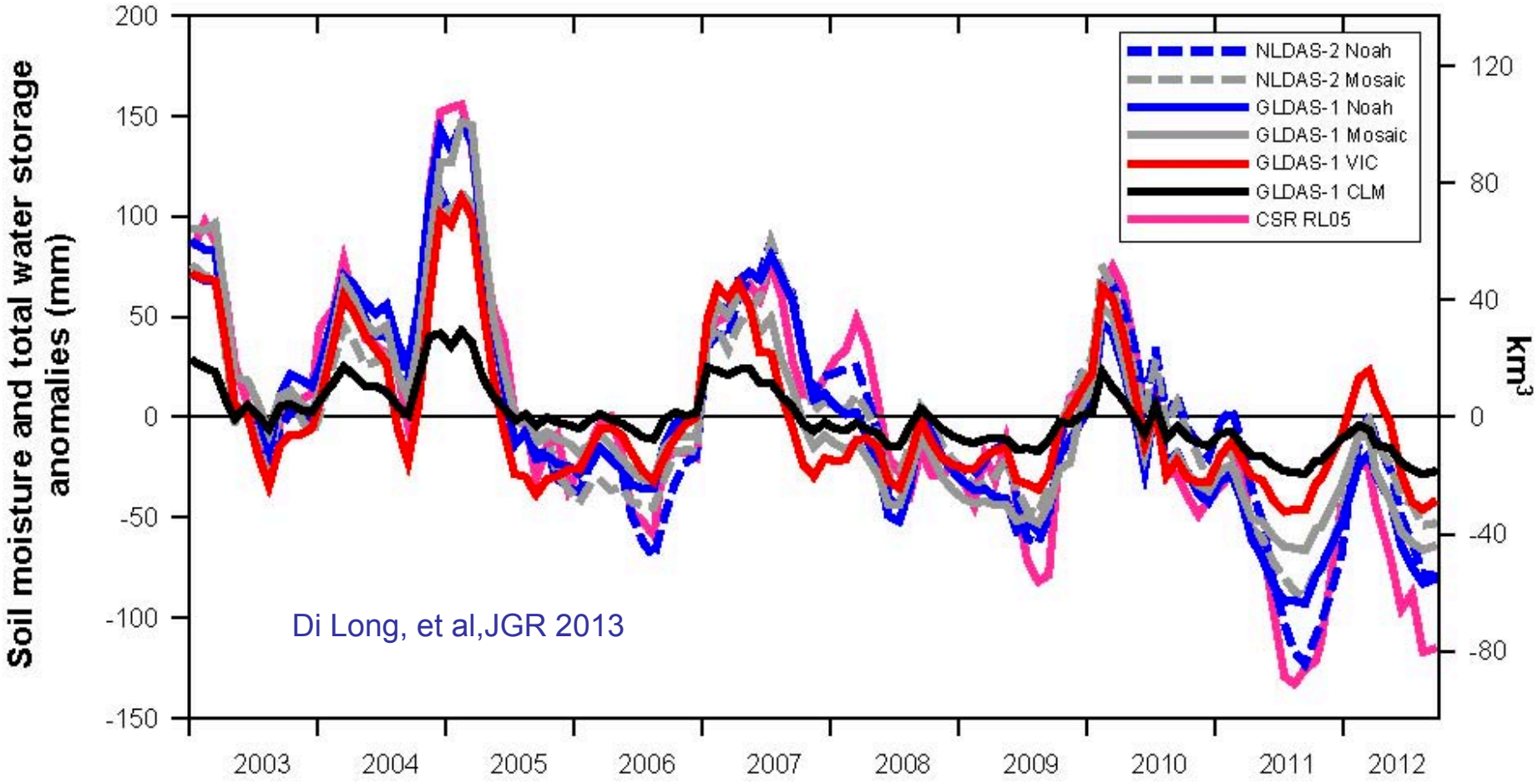
Surface water reservoir storage is closely correlated with the GRACE data

Grace Satellites

Surface Water Reservoirs

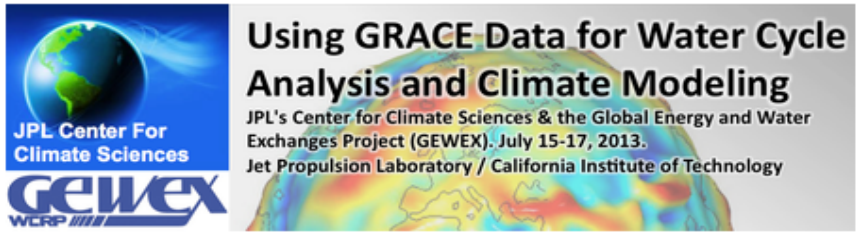


TEXAS STATE TOTAL WATER STORAGE ANOMALIES



Using GRACE Data for Water Cycle Analysis and Climate Modeling

JPL's Center for Climate Sciences & Global Energy and Water Exchanges Project (GEWEX)
Monday, July 15, 2013 at 8:30 AM - Wednesday, July 17, 2013 at 3:00 PM (PDT)
Pasadena, CA



Organizers: Felix Landerer & Carmen Boening (JPL)

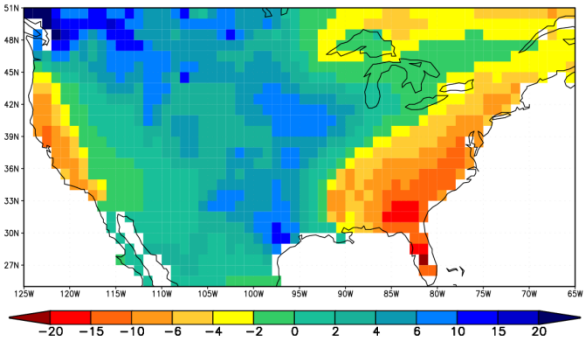
About the Workshop: 60+ intl. Scientists (hydrology, oceanography, climate modeling & geodesy)

Goals / Topics -> Outcomes / Recommendations:

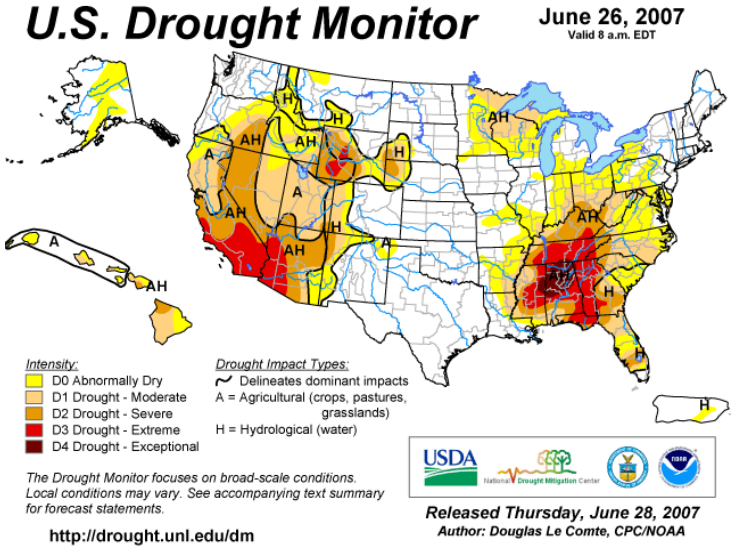
- Advance understanding of the ***terrestrial water budget components, global and regional water cycle, ocean circulation and sea level change*** with decade-long GRACE data record:
  - GRACE essential for closure of regional water budgets;
  - Land-ocean balance and sea level budget reveals regional impacts of climate modes (ENSO);
- Improve & evaluate ***hydrology, ocean, ice & coupled climate models*** by using GRACE data (e.g., via data assimilation, parameter estimation):
  - With GRACE, significant improvements in hydrology and land surface models (e.g., terrestrial water cycle timing & amplitudes, surface water and groundwater, permafrost);
  - Climate models have significant land water biases, highlighting the need for ***model parameter improvements*** based on satellite data; ***CMIP6 should provide GRACE-compatible model output (total water storage);***
  - First ocean assimilation very promising (e.g., separation of steric/non-steric components);
- ***Recommendations to optimize GRACE data***; deal with potential data gap from GRACE to GRACE Follow-On:
  - ***Timely updates to Level-3 data products*** very helpful for end-users (e.g., drought monitoring & flood forecasting); need better ***uncertainty estimates***; mature ***GRACE-mascon solutions***;
  - Other geodetic & ancillary measurements can at least partially fill a data gap (coarser resolution)

GRACE Data Assimilation for Drought Monitoring

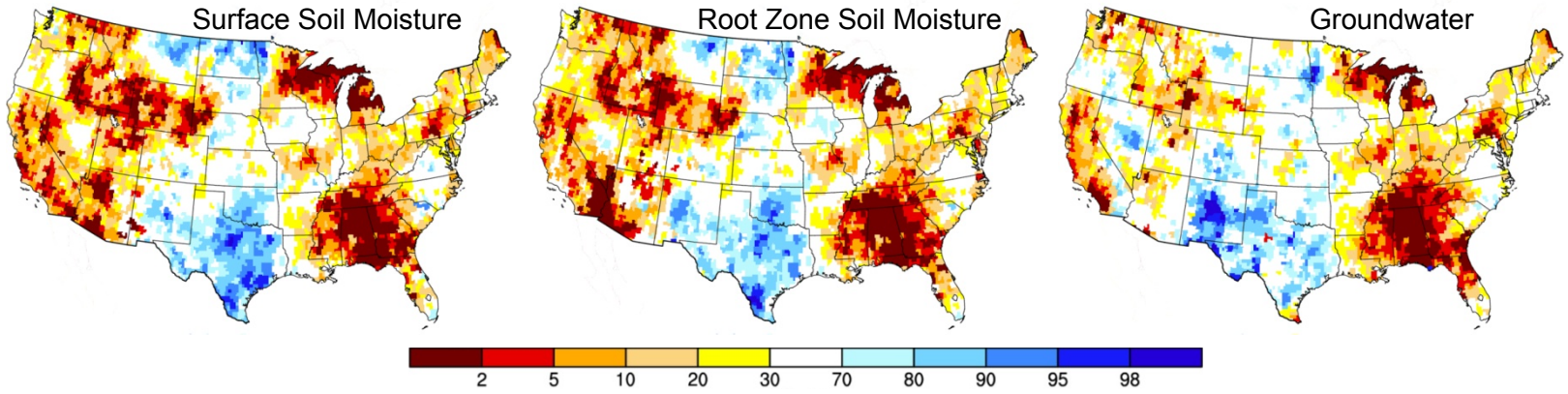
GRACE terrestrial water storage anomalies (cm equivalent height of water) for June 2007.



New process integrates data from GRACE and other satellites to produce timely information on wetness conditions at all levels in the soil column, including groundwater. For current maps and more info, see http://www.drought.unl.edu/MonitoringTools.aspx



U.S. Drought Monitor product for 26 July 2011.



Drought indicators from GRACE data assimilation (wetness percentiles relative to the period 1948-present) for 26 June 2007.

Slide from M. Rodell, 2012

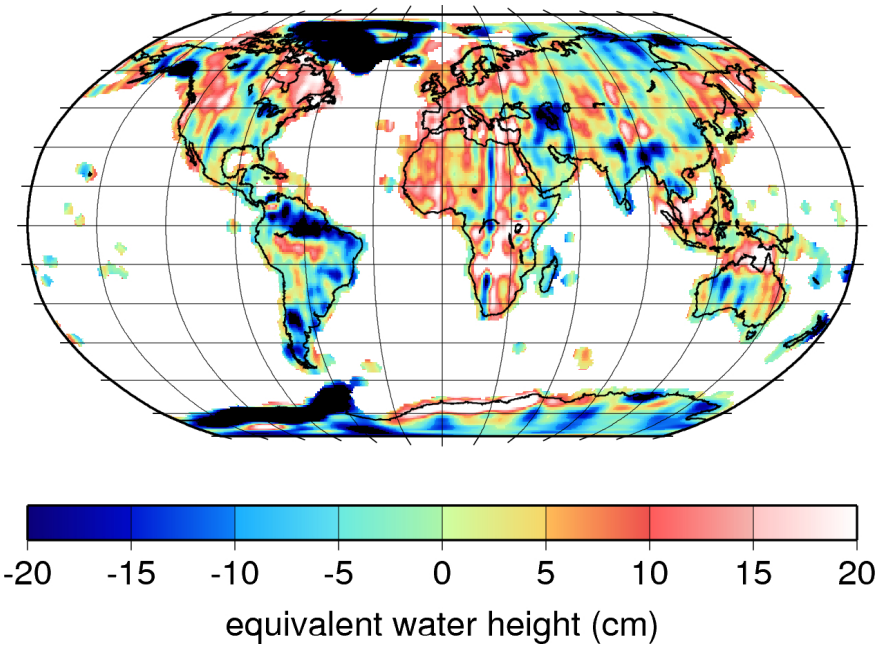
Quick look fields/grid

- Completely automated process
  - 21 day window, weighted more towards the center of the solution and tapering towards the ends
  - Window slides by one-day every day
  - Automatic data editing is implemented based on daily regularized solutions

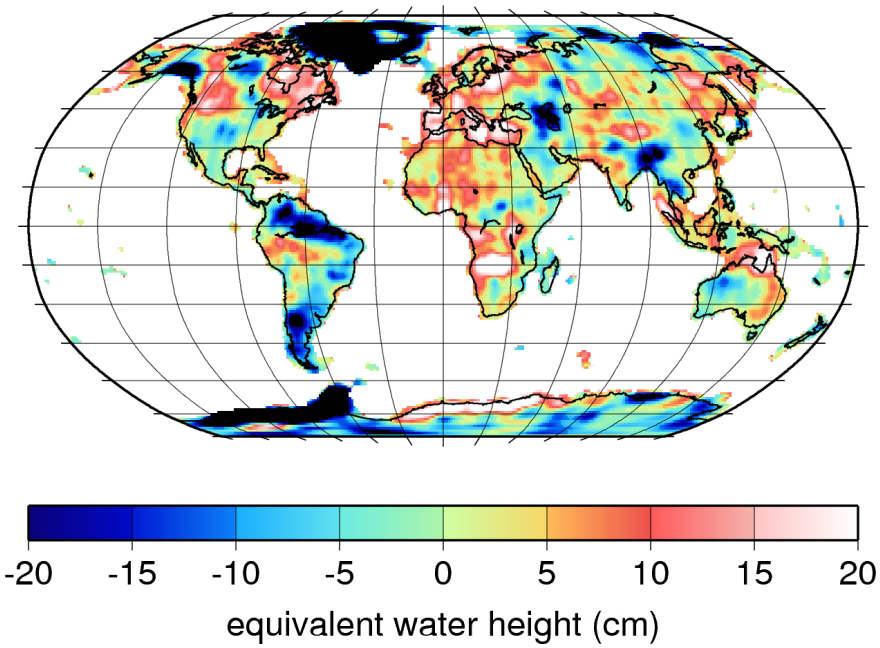
- Regularized grids provided as ascii files everyday, in the format and signal definition of Tellus (JPL)
  - Long term GRACE mean (2004 – 2009) is removed
  - C20: seasonal model based on SLR analysis (Ries)
  - Degree 1 terms: seasonal geo-center model (Ries 2011)
  - GIA is removed (Paulson et al, 2007)

Ries, J., Seasonal Geocenter Motion from Space Geodesy and Models, Third GGOS Unified Analysis Workshop, Zurich, Switzerland, 16-17 September 2011.

Before automatic editing



After automatic editing



Summary

GRACE has been in orbit for more than 11.5 years and 125* monthly gravity model solutions have been released.

GRACE measurements have improved the understanding of the climate system's secular, seasonal and inter-annual signals (Recognized as a Climate Mission)

Operational User Community is growing

Scientific advances are expected from improved spatial-temporal resolution obtained with RL-05 gravity models

GRACE instruments performing nominally,
End of mission likely due to battery problems

Project focused on extending the mission to overlap with GRACE-FO

Next GRACE Science Team Meeting

Potsdam, Germany– October 2014