Australian Government

Geoscience Australia

Determination of the Temporal Variations of the Earth's Centre of Mass from Multi-Year SLR Data

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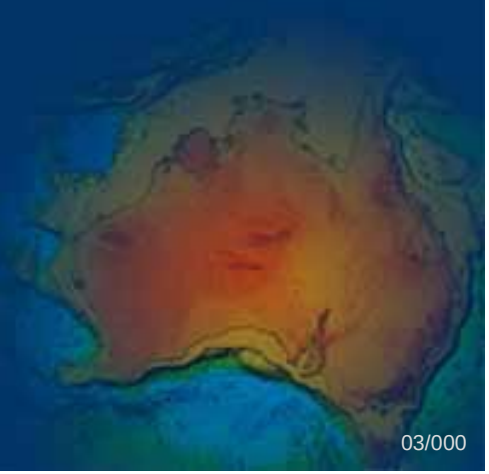

Overview

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- Gravity SH and Geocentre Definition
- SLR Data Processed
- Computation Standard
- Lageos: COM Results
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- Summary from Lageos Results
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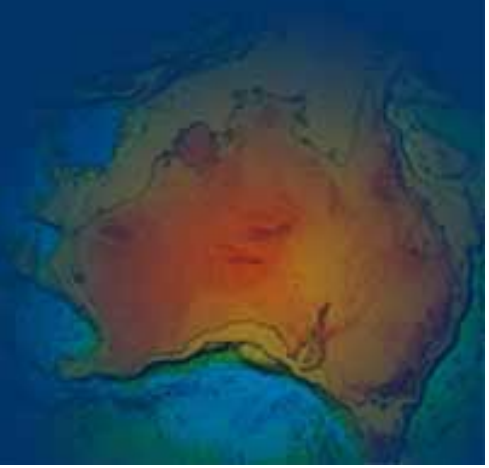
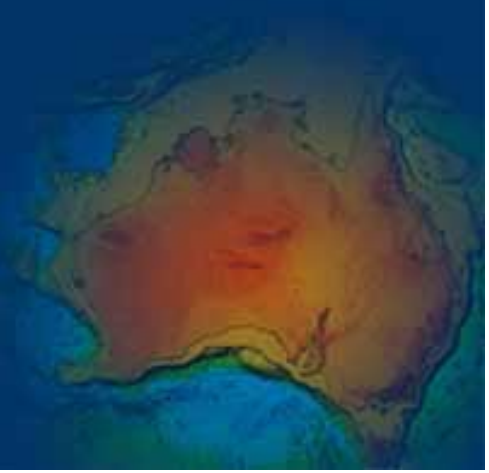


Introduction

- Geodetic parameters used to monitor global change are generally estimates of station coordinates, gravity field coefficients and their time variation
- These are referred to a TRF defined by its origin (geocentre), orientation and scale which is also time varying
- Need to know how the parameters defining the TRF also change with time
- How does the CoM (Geocentre) deviate from the defined origin?

Introduction

- Temporal variation of the CoM and orientation is a measure/symptom of mass transport -- what can be learned from this?
- What are the dynamics that cause the geocentre, orientation and scale to vary?



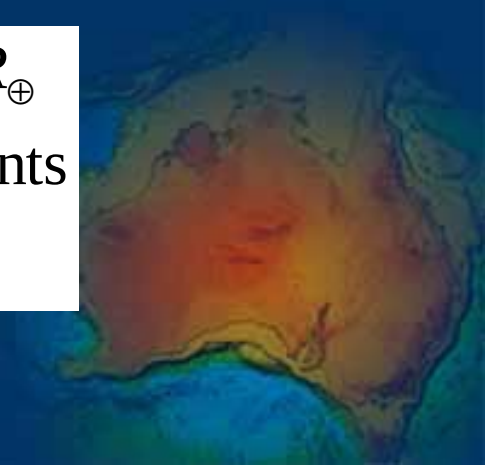
Gravity SH and Geocentre Definition

- MacCullagh's formula established the relationship between the lower degree harmonics of the Earth's gravity field and its physical representation [geocentre (=0), orientation, etc]
- Evaluation of the degree one harmonics give direct access to the Earth's CoM

$$X_{com} = C_{11} R_{\oplus}; \quad Y_{com} = S_{11} R_{\oplus}; \quad Z_{com} = C_{10} R_{\oplus}$$

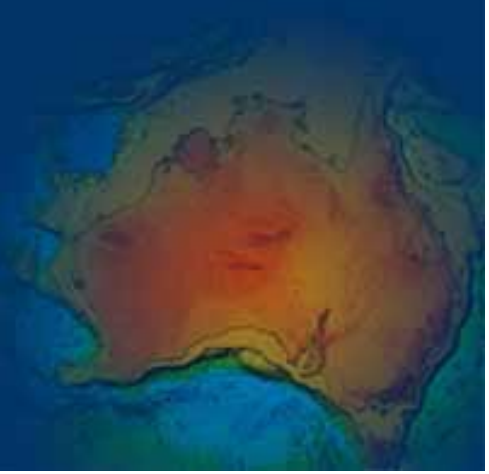
C_{10}, C_{11}, S_{11} are unnormalised SH coefficients

$R_{\oplus}$ = Earth radius



SLR Data Processed

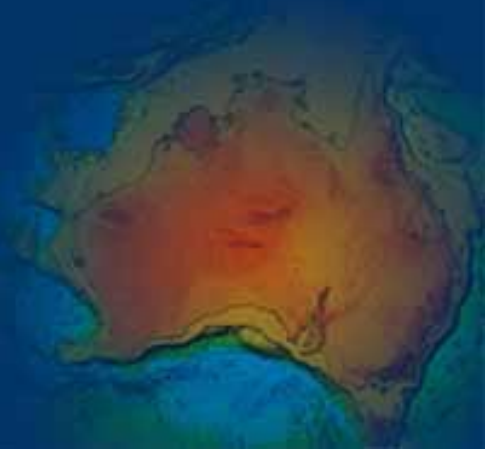
- Lageos-1 and Lageos-2 from January 1993 to end September 2006
- Stella and Starlette from beginning 1996 to end 2005



Computation Standard
Geodyn / Solve

Weekly Arcs

- ITRF2000 + Earth and Ocean tide loading
- GGM01S + Earth and Ocean tides + time varying gravity
- EOP – C04 apriori



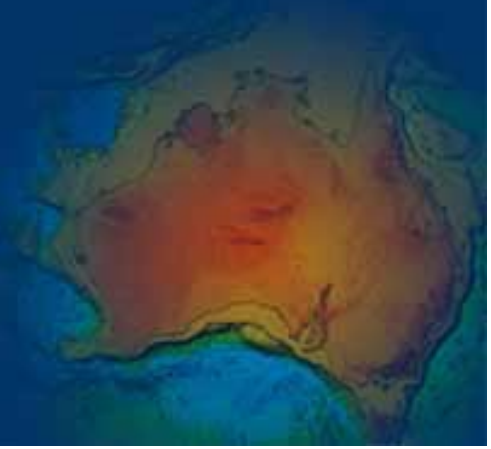
Computation Standard

Estimated Arc Parameters

- State Vector
- SRP – once per arc
- General Acceleration – once per arc – constant (along track) and 1/rev (along & cross track)
- Range bias – some stations (ILRS AWG Rules)

Estimated Global Parameters

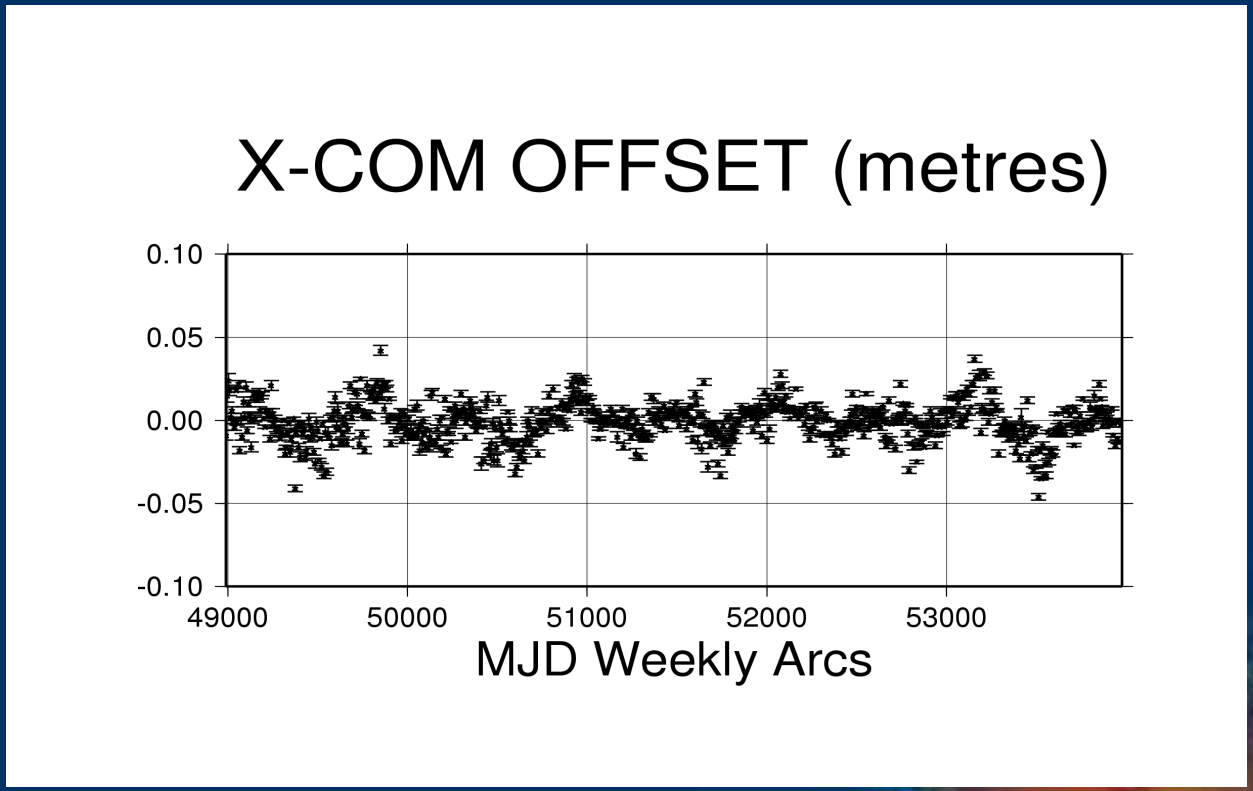
- Station Coordinates
- X,Y Pole, LOD
- Gravity Coefficients to (2,2)



Lageos: COM Results

Dominant Periods

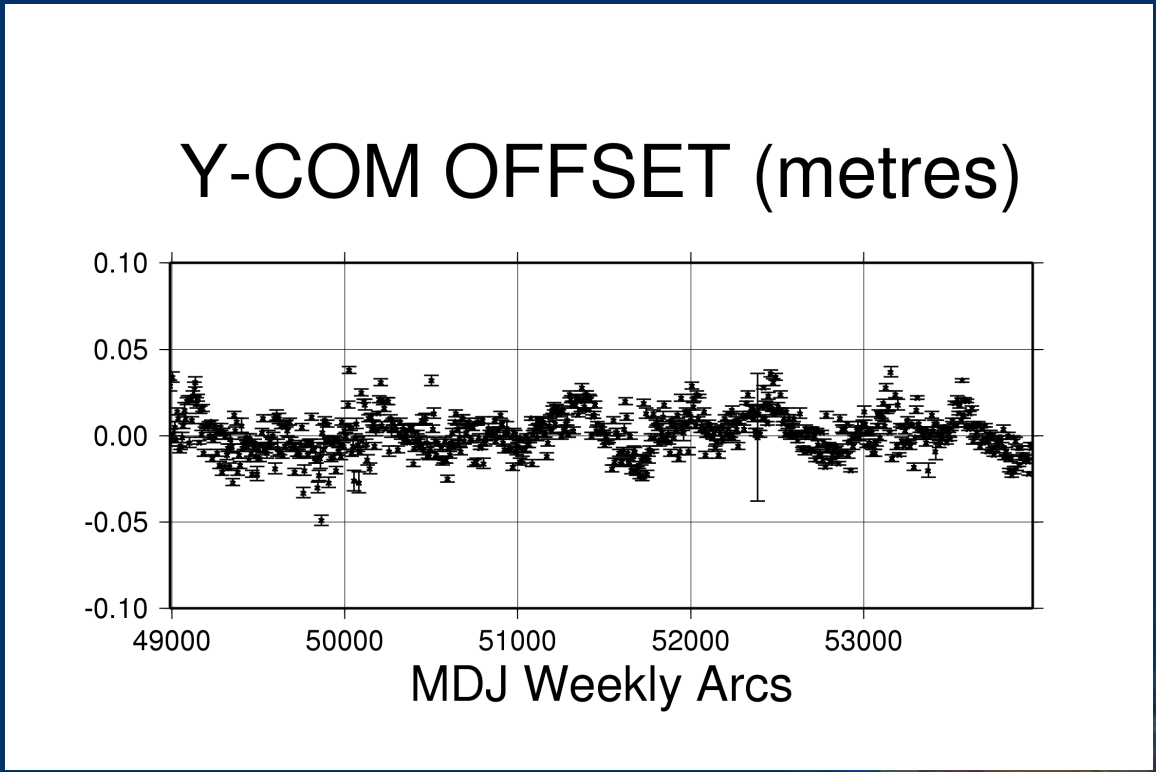
- *≈ 1200 days (39 months) – 3 cm*
- *≈ 720 days (2 years) – 3.5 cm*
- *≈ 18 months*



Lageos: COM Results

Dominant Periods

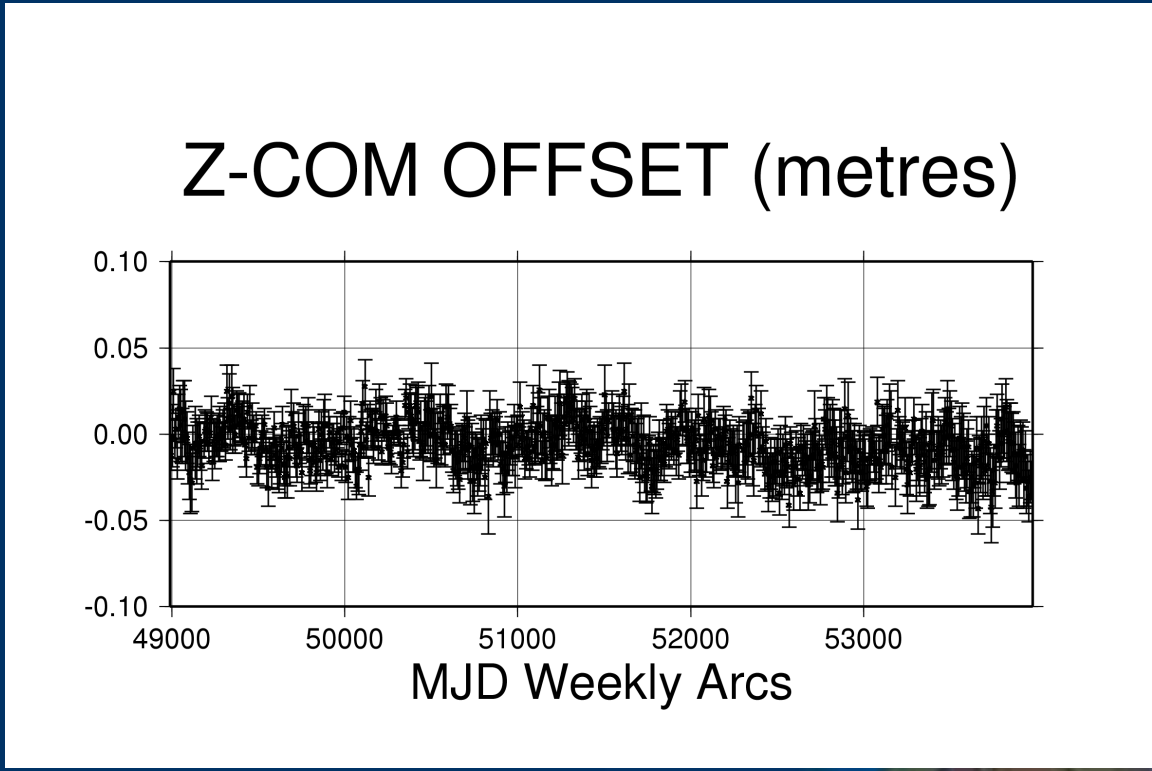
- *≈ 1200 days (39 months) – 2 cm*
- *≈ 900 days (30 months) – 3 cm*
- *≈ 18 months – 3 cm*



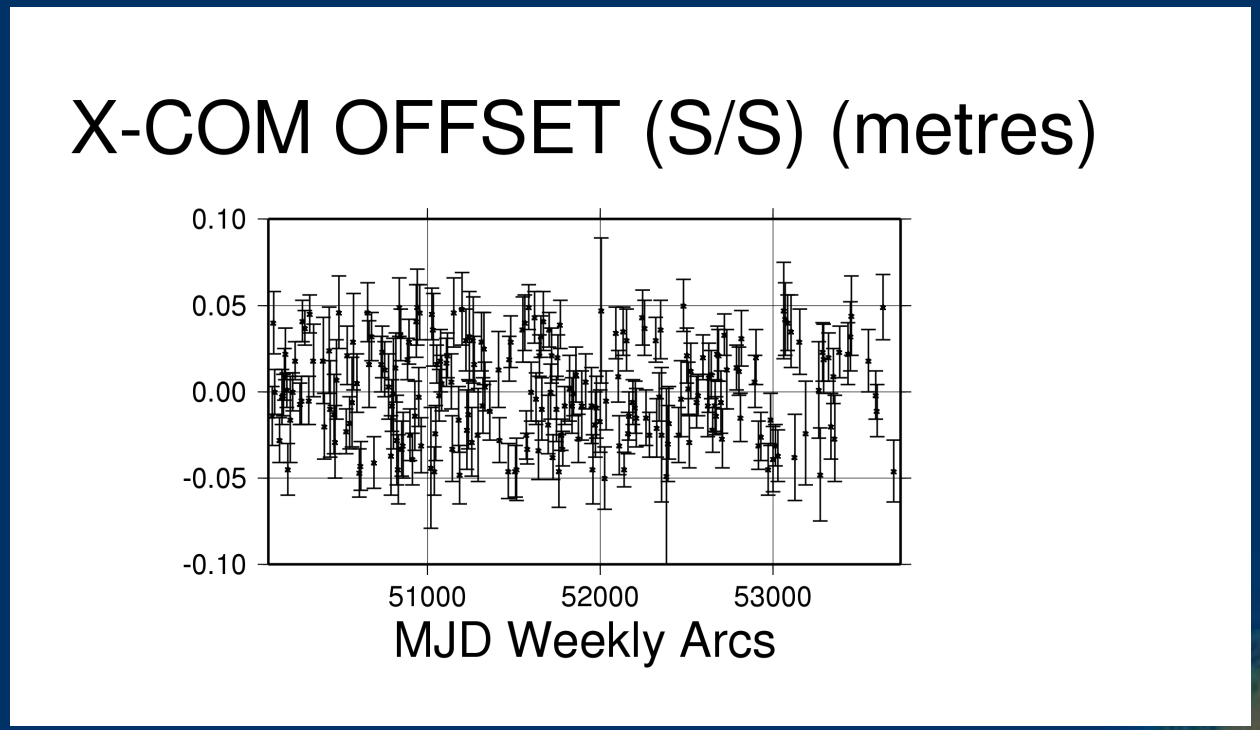
Lageos: COM Results

Dominant Periods

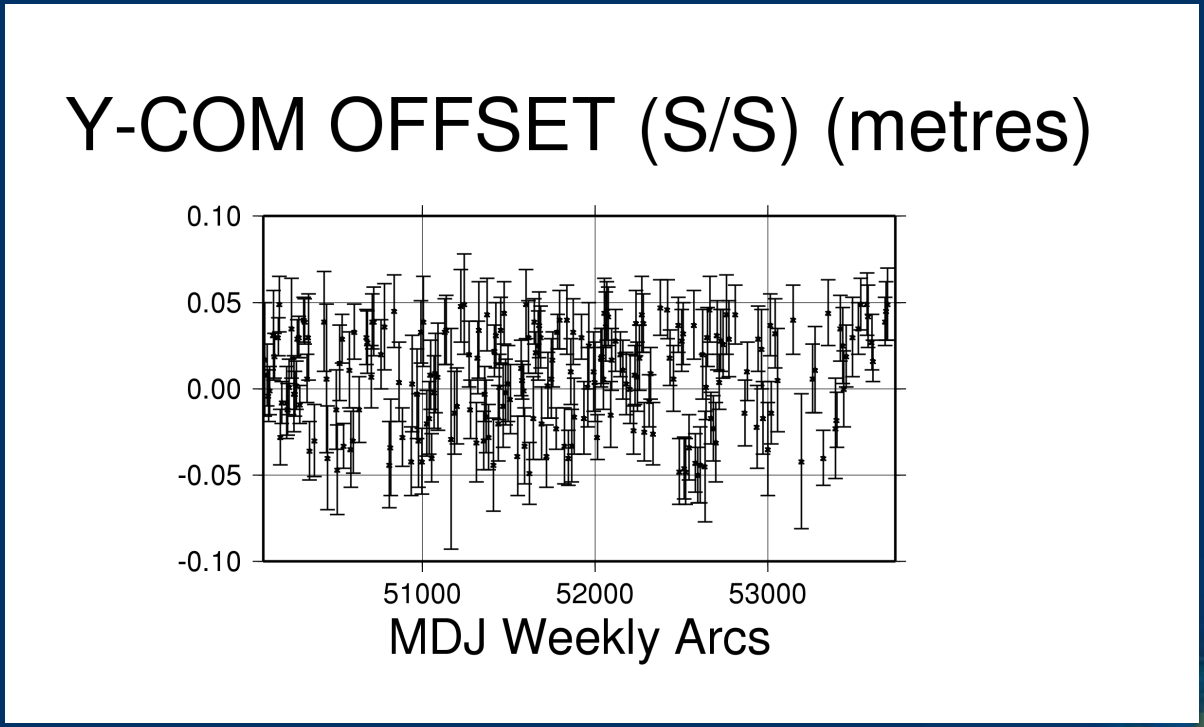
- *≈ 1200 days (39 months) – 3 cm*
- *≈ 900 days (30 months) – 2 cm*
- *≈ 310 days – 1.5 cm*



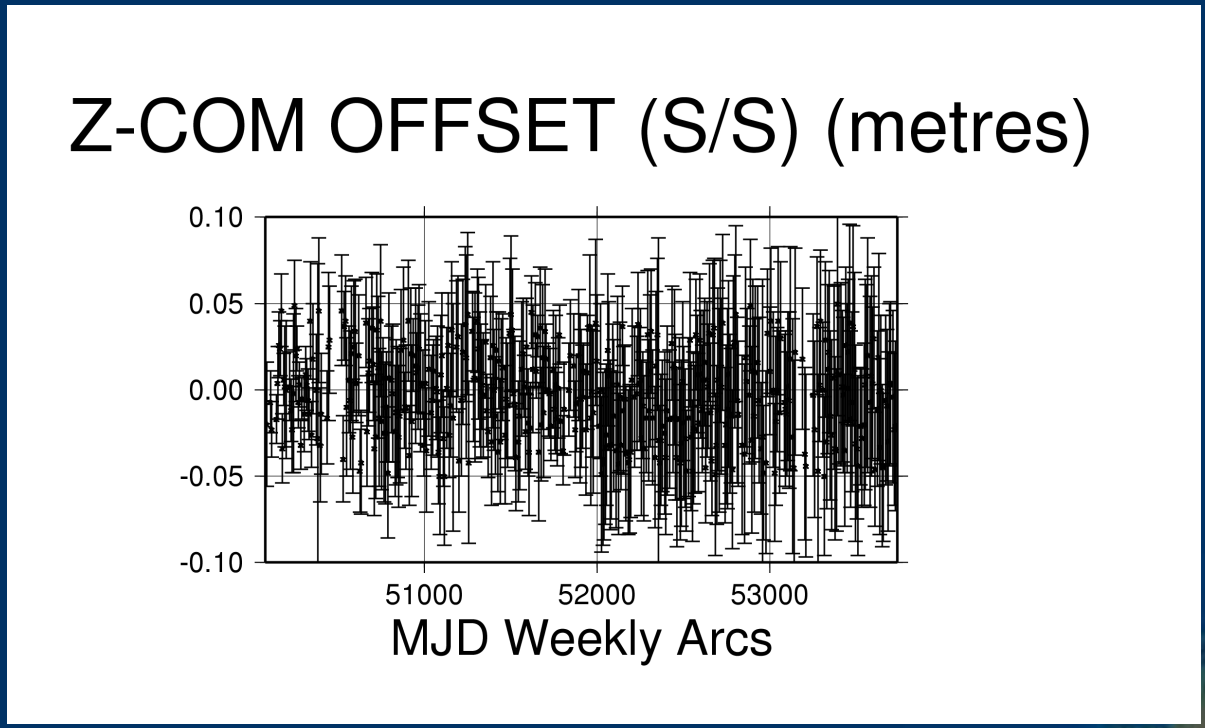
Stella/Starlette: COM Results



Stella/Starlette: COM Results

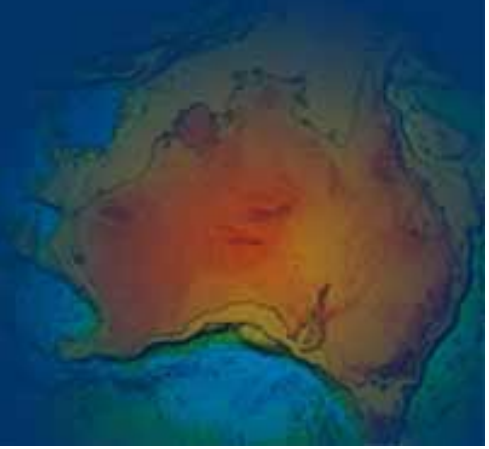


Stella/Starlette: COM Results



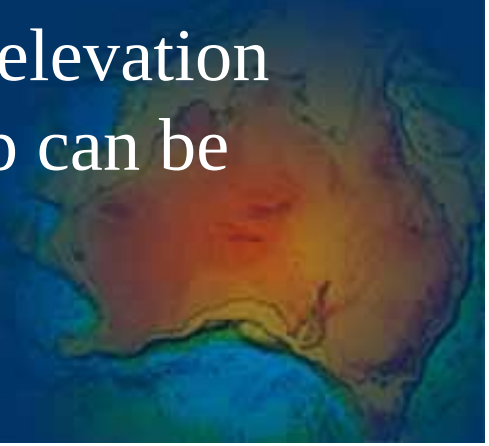
Summary from Lageos Results

- All the CoM components vary with periods of approximately 40, 30 and 18 months as their dominant periods
- X-component has an additional period of 24 month period
- A 10 year period registers but not conclusive in a 14-year data set.



Conclusion

- 14 years of Lageos-1,-2 data and 10 years of Stella/Starlette data was processed and weekly CoM determined.
- Periodic motion of the CoM established.
- Next Steps:
  - Visualise the motion of the geocentre on the equatorial plane (XY or Azimuth) and elevation (z) so that some directional relationship can be established.



Conclusion

- Next Steps
  - Compute changes in moments of inertia ΔI_{xx}, ΔI_{yy}, ΔI_{zz} using the changes in the estimated gravity coefficients
  - Improve the Stella/Starlette solutions to see if there are any definitive “messages” in the data set
  - Torque