Some aspects and perspectives of measuring Lense-Thirring with GNSS and geodetic satellites

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Content

- GNSS
  - Effects of solar radiation pressure (SRP)for GALILEO
  - A GPS trial to measure LT
- Geodetic satellites
  - New gravity models and recent LAGEOS analysis
- Summary

Major Forces Acting on Satellites

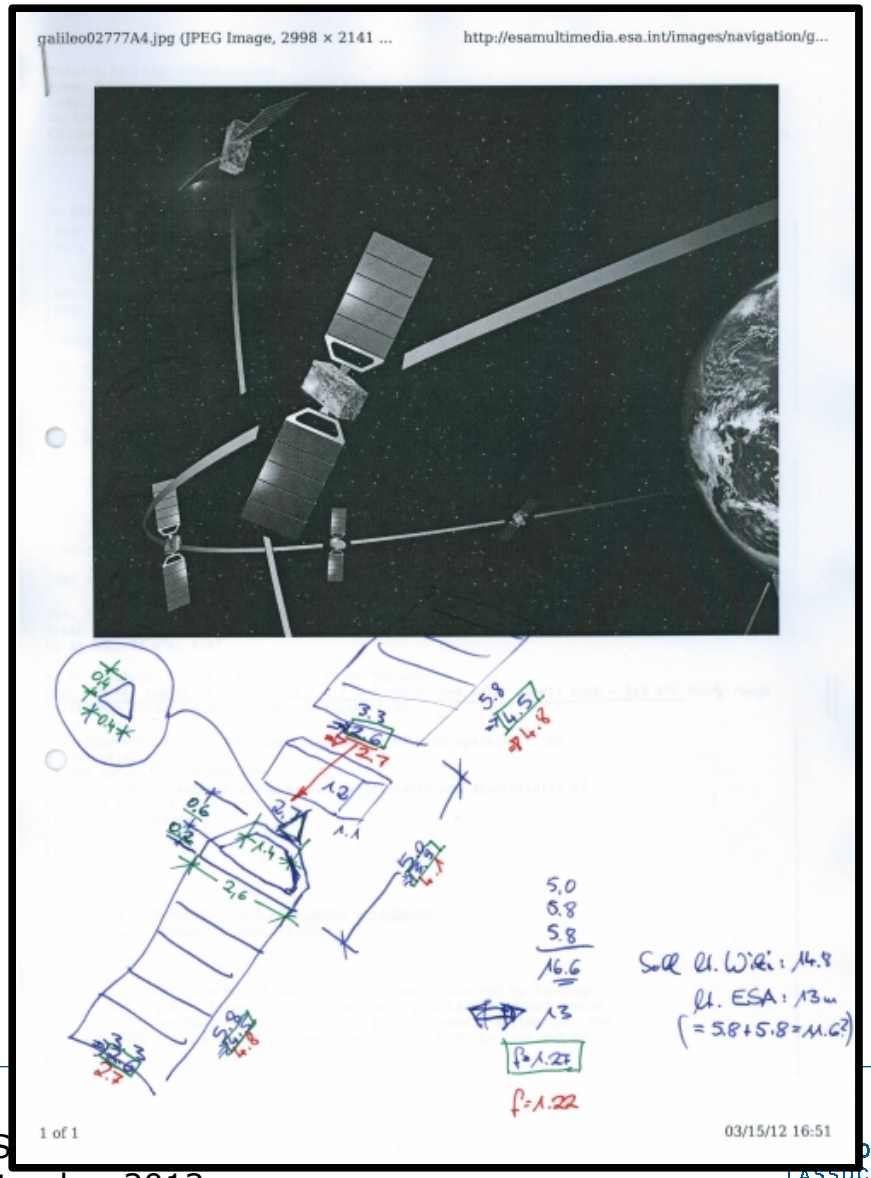
- GNSS
  - Huge satellites
  - Complicated shape
  - Large solar panels, mostly oriented towards Sun
  - Attitude steering
    - -> Challenging solar radiation pressure modelling
    - -> Challenging attitude/maneuver modelling
- Geodetic satellites
  - Small but heavy satellites
  - Canon ball shape
    - -> Relatively easy modelling of SRP and atmospheric drag

GNSS Macro Models

- A macro model is composed of an ensemble of simplest geometric figures that form the shape of the satellite
  - Larger than a lower bound for length, width, height; f.i. 10 cm
  - Rectangles, cylinders
  - Size of these geometries
  - Surface properties concerning reflectivity, diffusion, absorption wrt to visible and infrared radiation
- Attitude needed

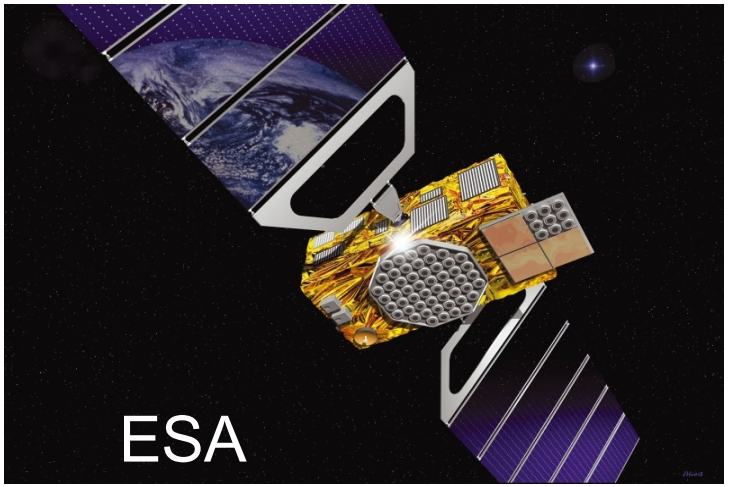
The GALILEO Macro Model

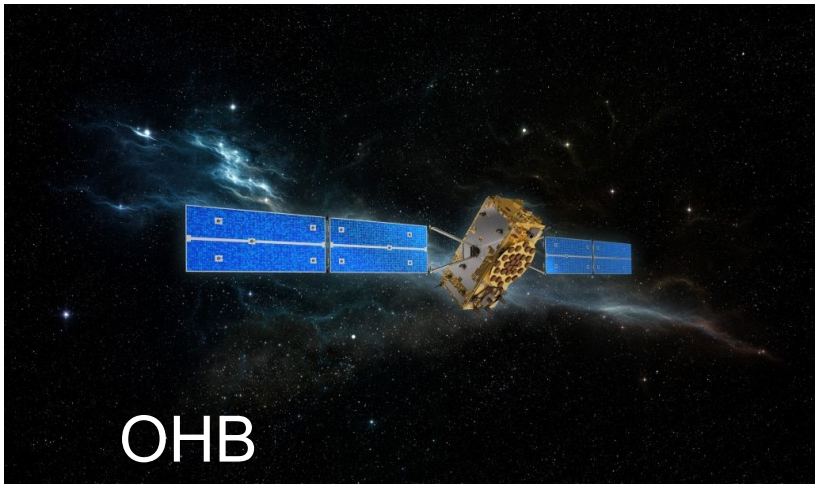
- Little or no information given by ESA
- We constructed a macro model from ESA and OHB web pages



The GALILEO Satellite

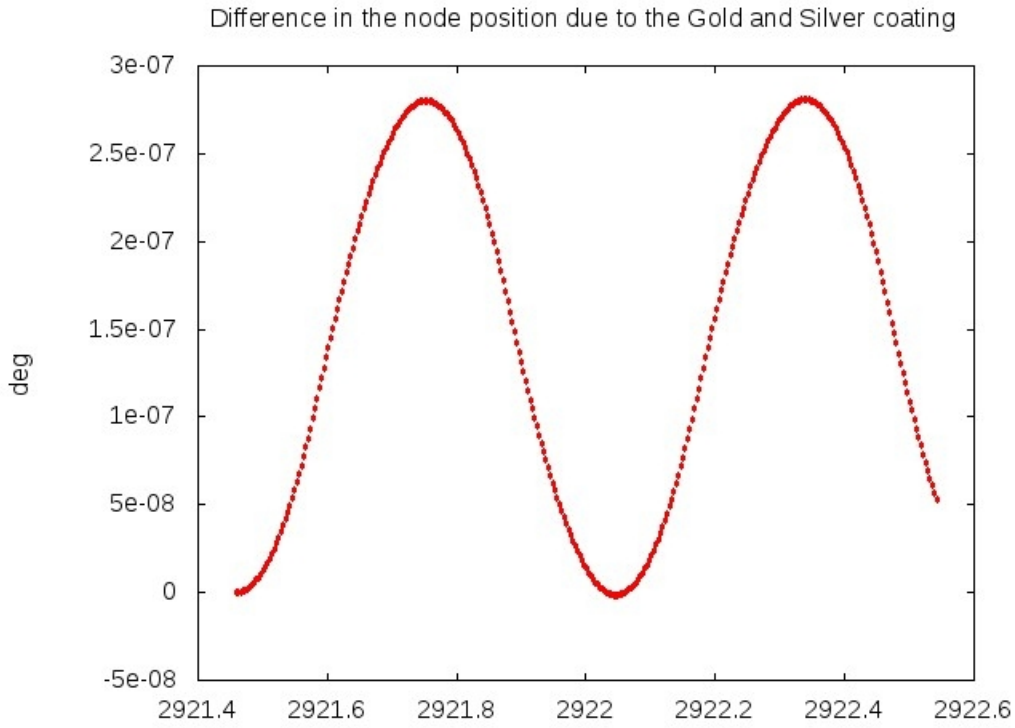
- Surface properties from ESA or OHB pictures either gold or silver/aluminium





The GALILEO Macro Model

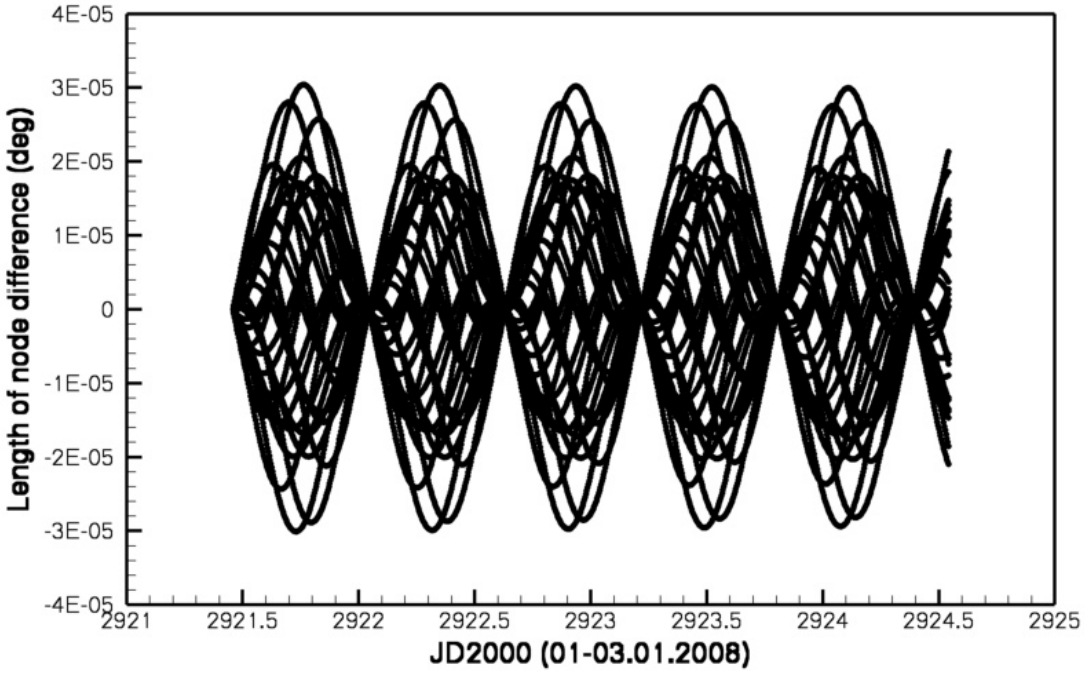
- Difference of the node observables for Lense-Thirring measurements due to gold or silver coating



LT = 1.7E-9 deg/d

Solar Radiation Pressure Mismodeling

- Not modeling SRP for GALILEO



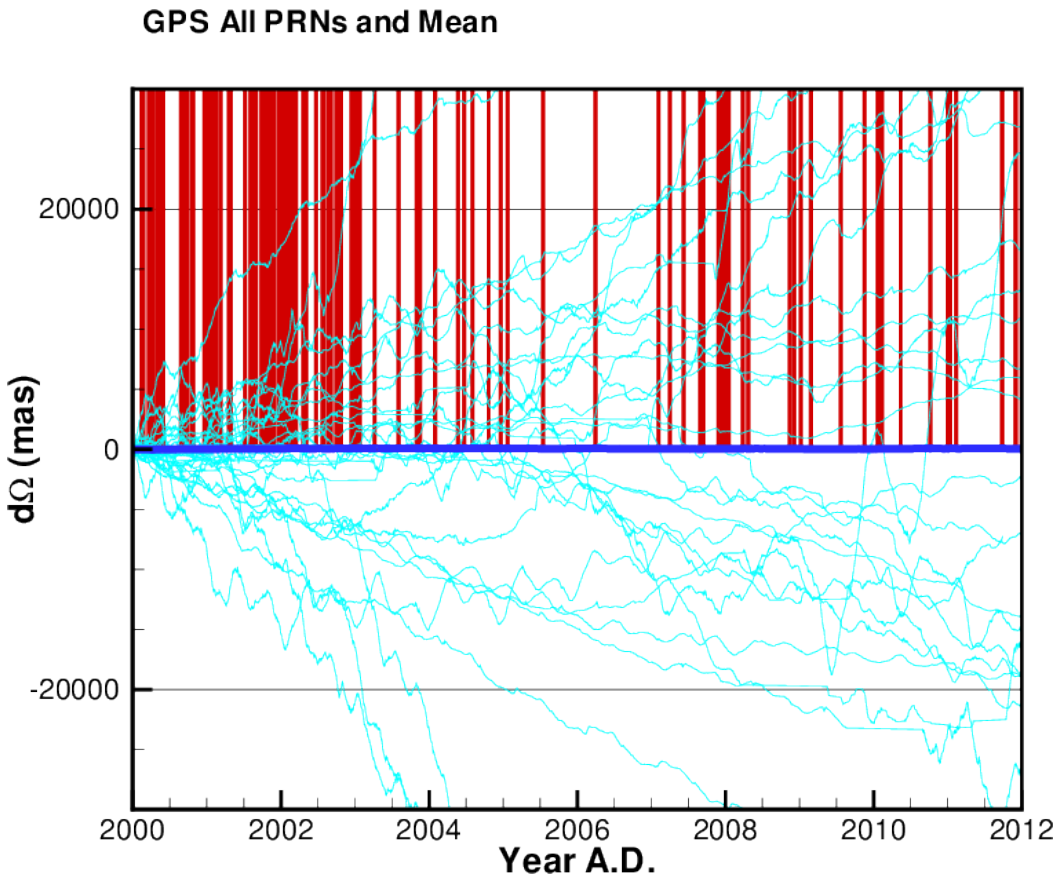
Global RMS:
1.2E-5 deg

Regression:
7.2E-9 ± 8.3E-8 deg/d
Theory:
1.7E-9 deg/d

Result:
SRP cannot be neglected

Measuring Lense-Thirring with GPS?

- Despite previous, SRP scaling parameter was highly constrained



Regression of mean curve:

`1.2 ± 0.1 mas/a`

Theory:

`2.2 mas/a`

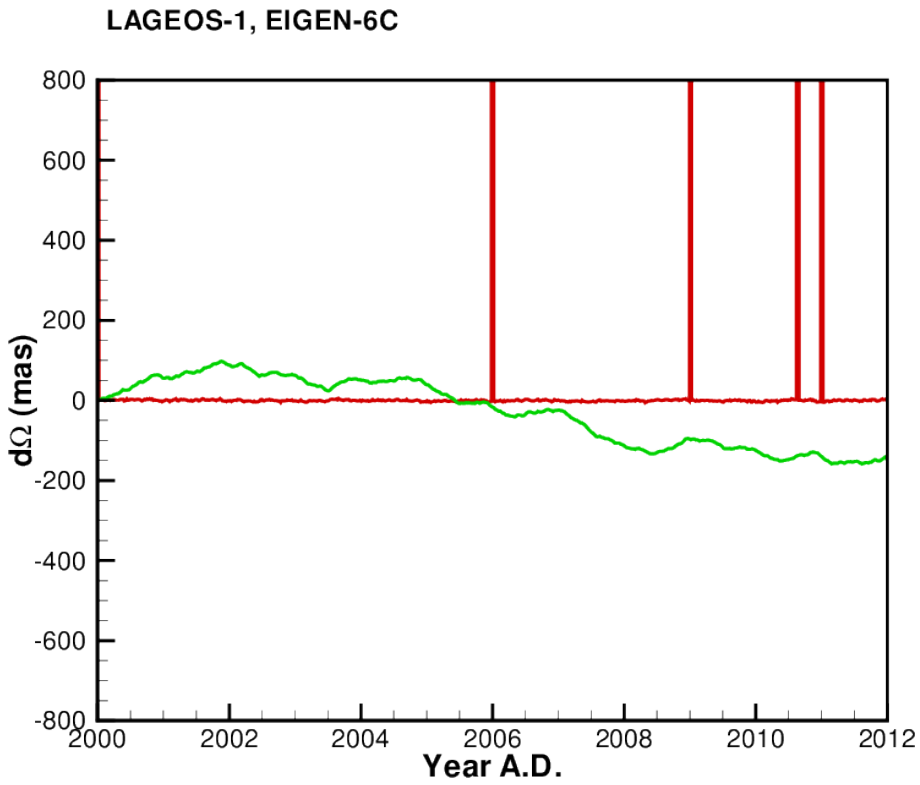
Recent Analysis with Geodetic Satellites

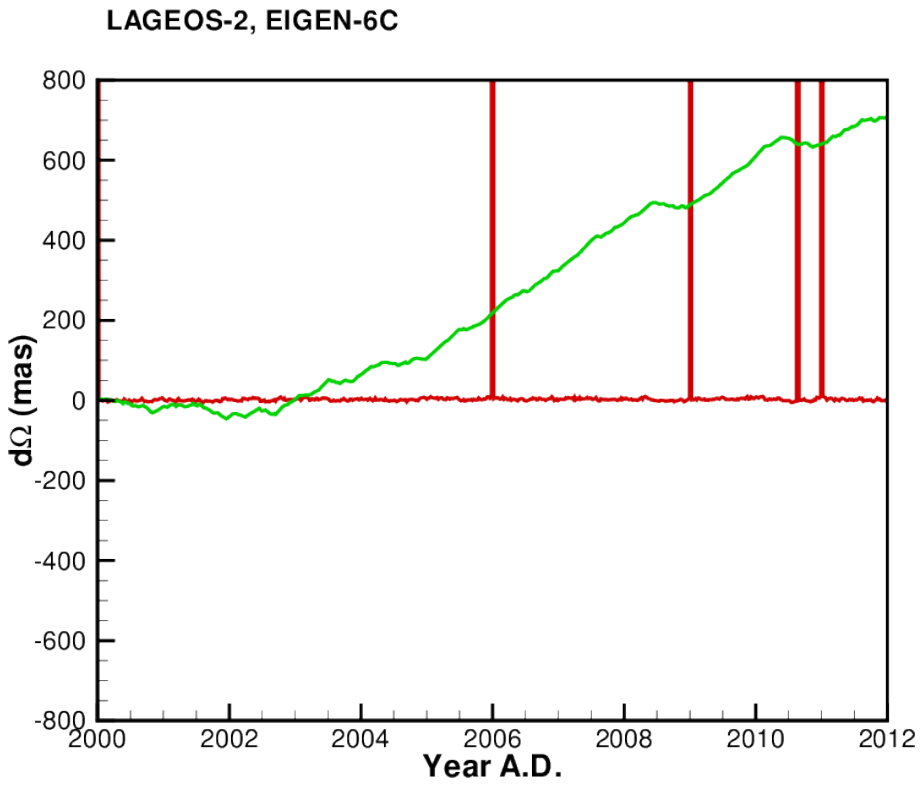
- Gravity field models used:

Model	Data basis	Max. D/O
EIGEN-6C	LAGEOS + GRACE JAN-2003 – JUN-2009, GOCE NOV-2009 – JUN 2010, DTU2010 global gravity anomalies	1420
EIGEN-6Sp.34	Static solution of the official ESA GOCE field GO_CONS_GCF_2_DIR_R3, LAGEOS + GRACE JAN-2003 – JUN-2009, GOCE NOV-2009 – APR 2011	240
EIGEN-51C	CHAMP + GRACE OCT-2002 – SEP-2008, DNSC08 global gravity anomalies	359
EIGEN-GRACE03S	GRACE FEB-2003 - JUL-2004	150

Effect of the Time Variable Part in EIGEN-6C

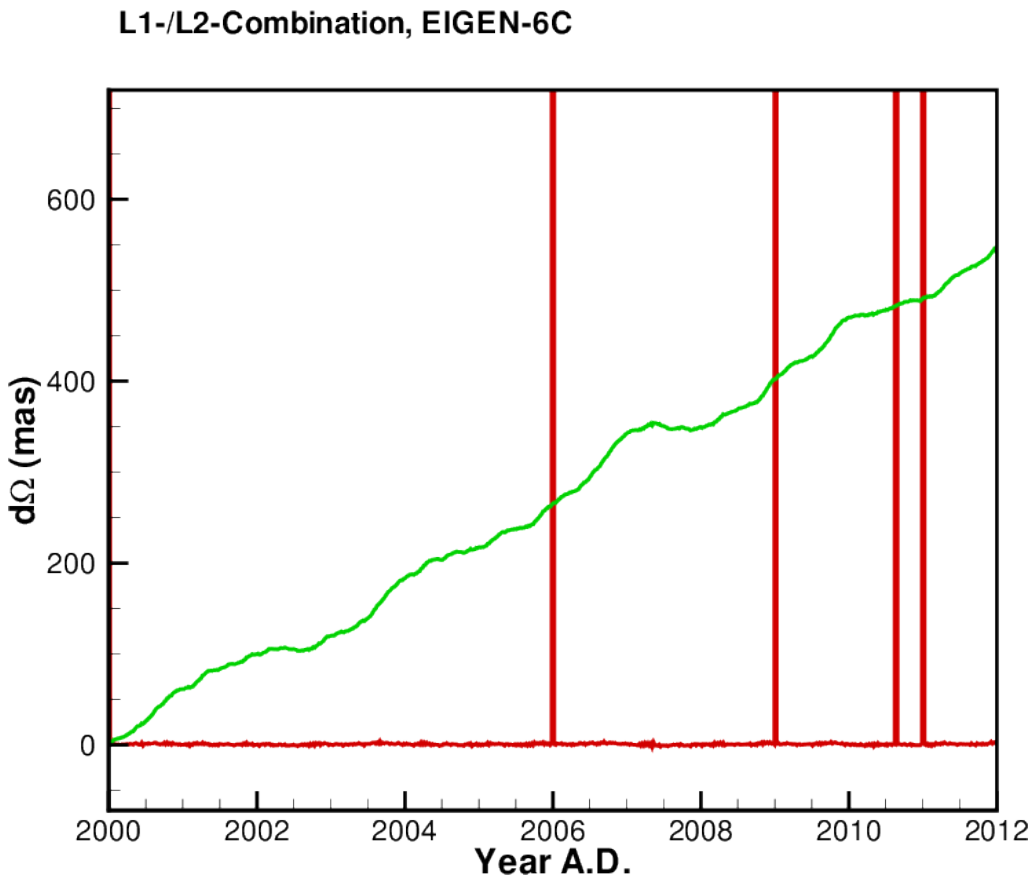
- Trend and annual and semi-annual variations considered





Effect of the Time Variable Part in EIGEN-6C

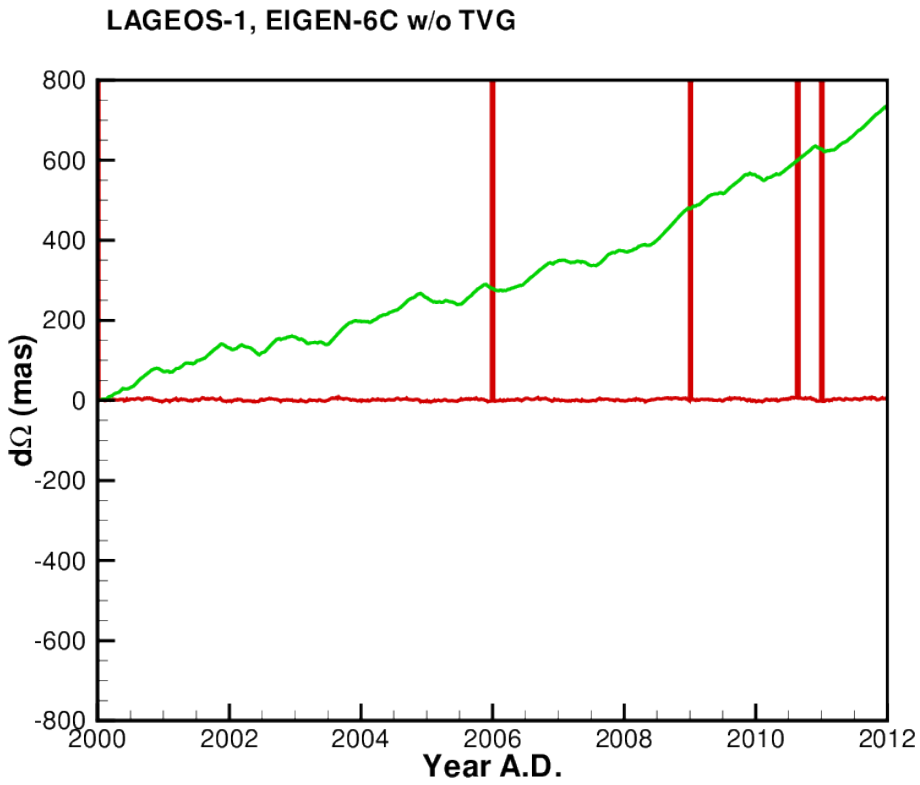
- LAGEOS and LAGEOS-2 combined

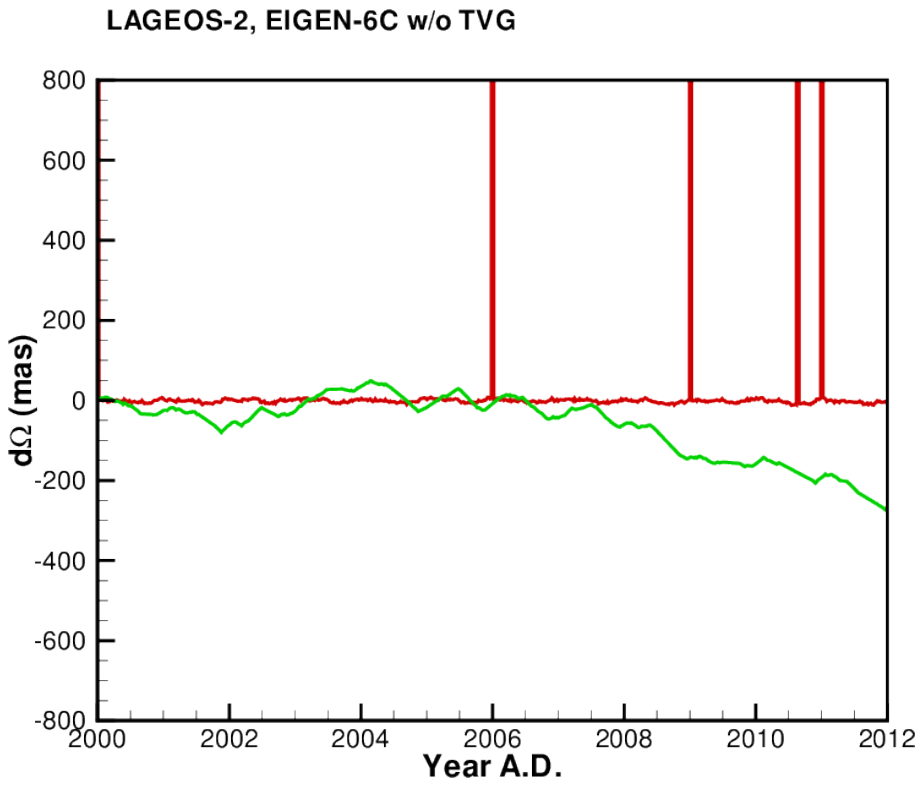


Regression:
44.9 ± 0.2 mas/a
Theory:
48.2 mas/a
Error:
6.9 %

Effect of the Time Variable Part in EIGEN-6C

- Trend and annual and semi-annual variations ***neglected***





Effect of the Time Variable Part in EIGEN-6C

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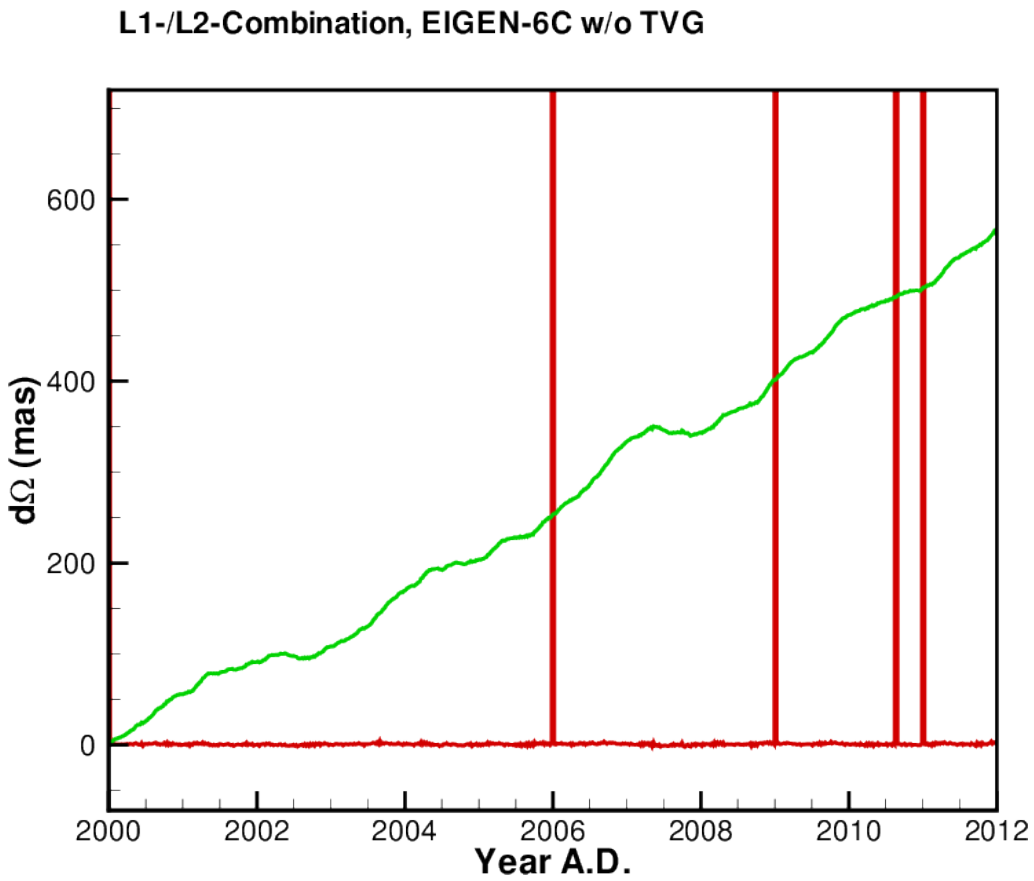
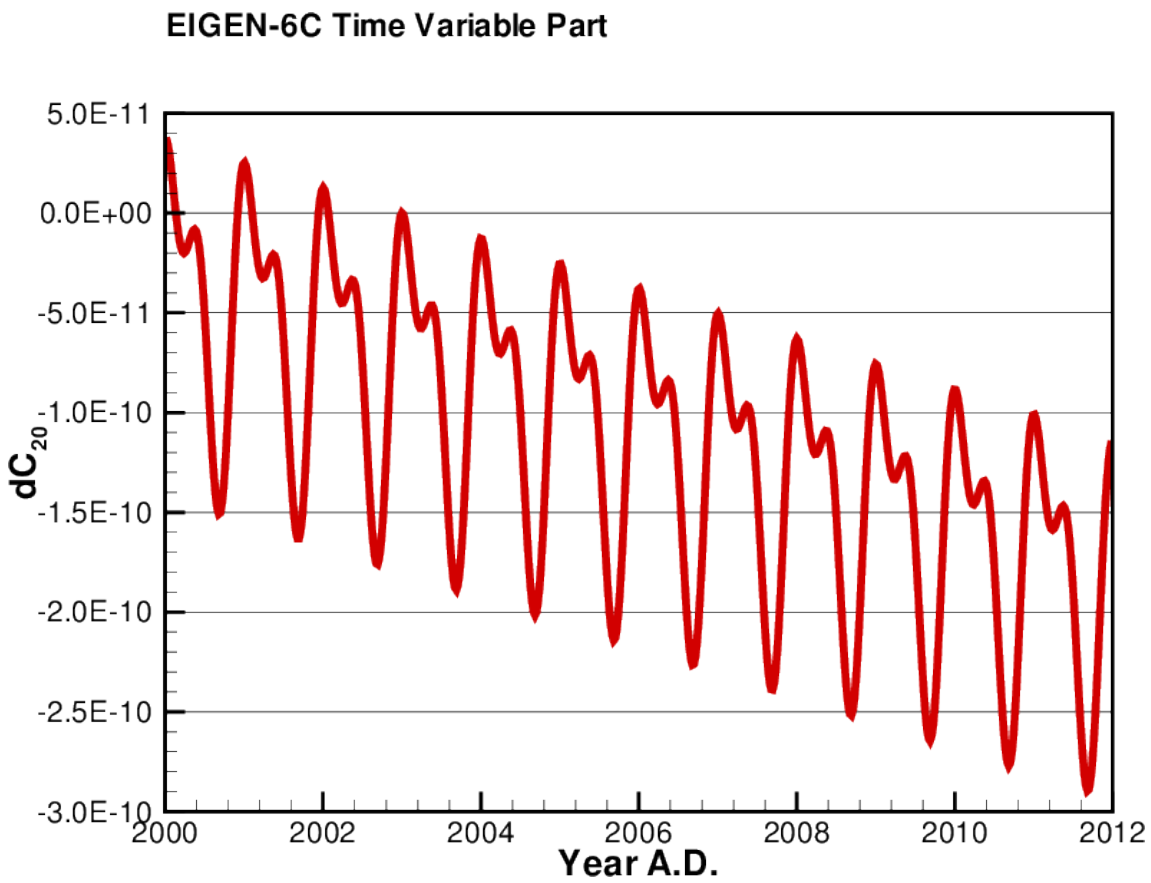


Regression:
46.5 ± 0.2 mas/a
Theory:
48.2 mas/a
Error:
3.5 %

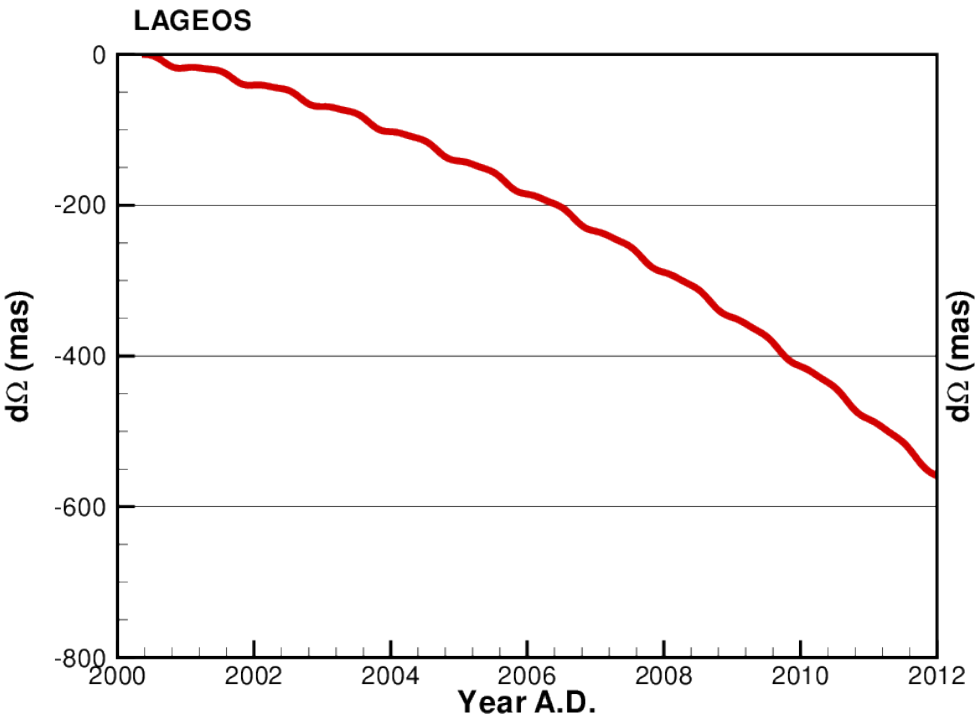
The Time Variable C(2,0) in EIGEN-6C

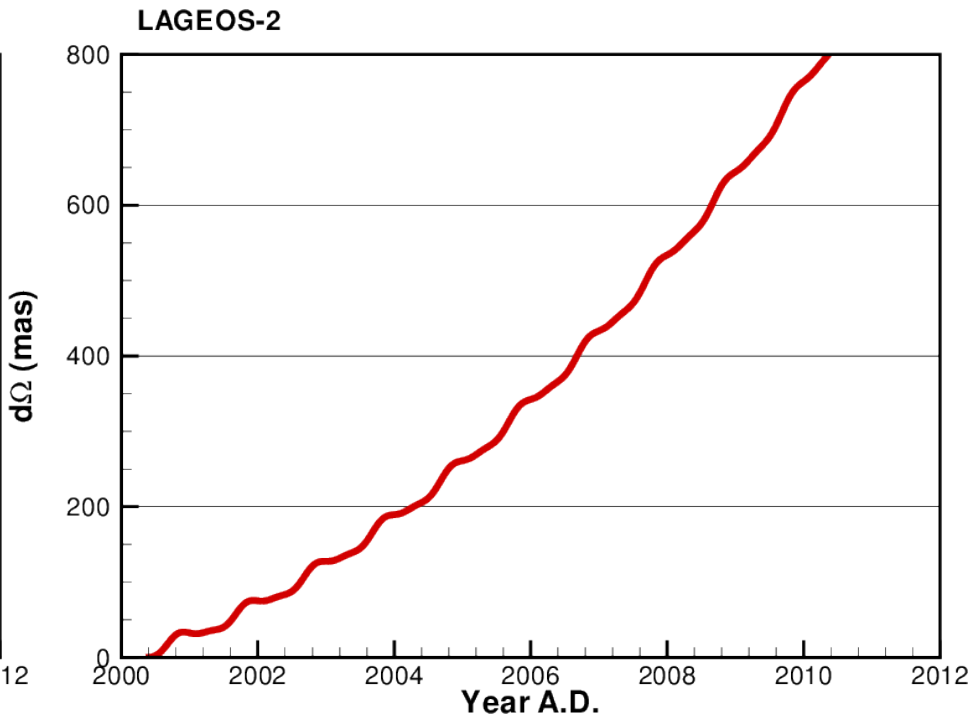
- For the analysis period



Effect of the Time Variable C(2,0) on the Node Observables

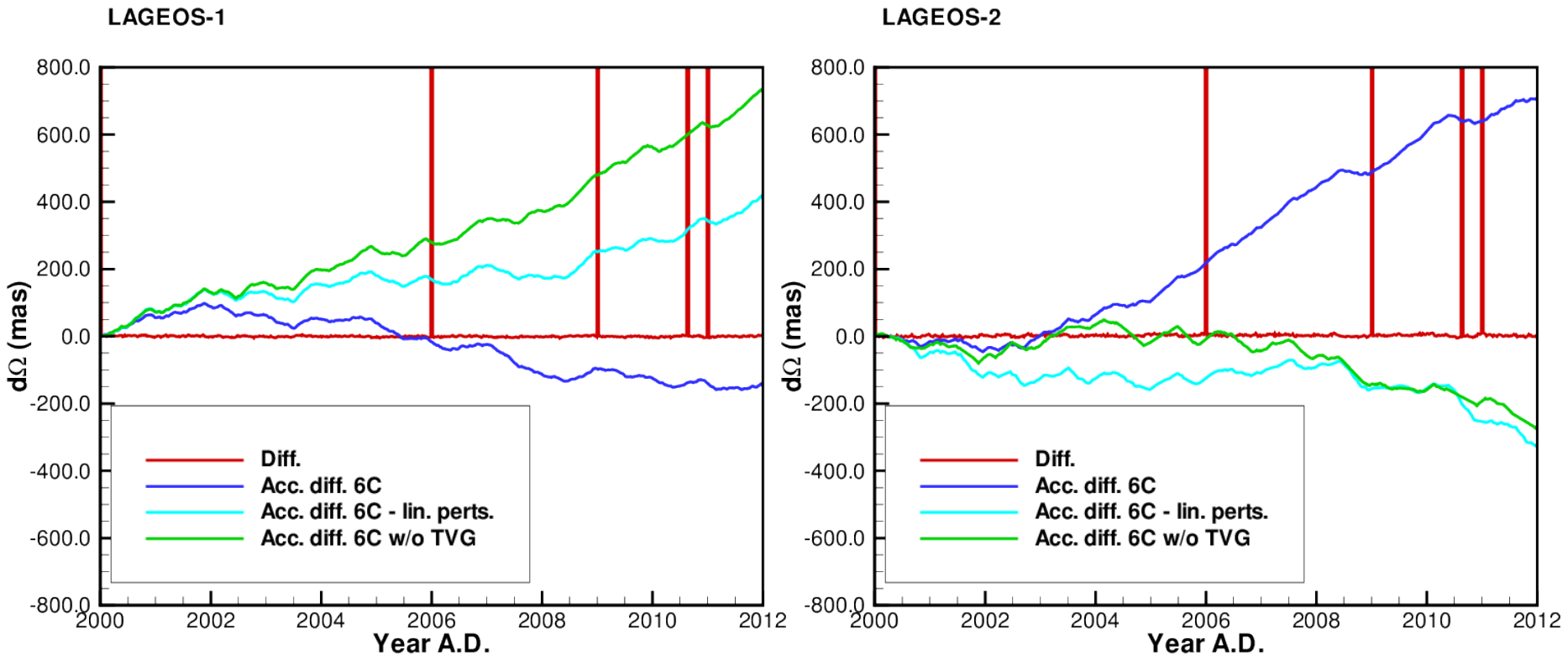
- Due to linear perturbation theory (Kaula, 1966):





Comparison of the Node Observables

- Due to dC(2,0):



Recent Analysis with Geodetic Satellites Summary

- LT measurements:

Model	LT (mas/a)	Error (%)
EIGEN-6C	44.9 ± 0.2	6.9
EIGEN-6C w/o TVG	46.5 ± 0.2	3.5
EIGEN-6Sp.34	44.5 ± 0.2	7.6
EIGEN-51C	42.1 ± 0.2	12.7
EIGEN-GRACE03S	51.4 ± 0.2	6.6

Summary

- GNSS
  - We'll further explore the potential of the GNSS constellations for measuring LT
- Geodetic satellites
  - New gravity models and recent LAGEOS analysis confirm the results published thus far