

# On benefits of High Performance Simulator for GRACE like missions

Lubos Vaci, Jacob Flury



# How well we know the GRACE?

## GRACE follow-on? Future gravity missions?

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### GRACE limitations:

#### Impact of spacecraft attitude variations on the GRACE scientific results

(Bandikova, Flury, Ko; Advances in Space Research; Volume 50, Issue 1; July 2012)

- Effect of AOCS in gravity gradient measurement (pointing accuracy)
- Sensitivity analysis (unmodeled sensor errors, better study of sensors)

#### Improved GRACE science results after adjustment of geometric biases in the Level-1B K-band ranging data

(Howrath, Lemoine, Biancale, Bourgoigne; Journal of Geodesy; Volume 85, Issue 1; 2011)

- Improvement of Calibration Analysis (more observation of the unwanted errors)

### GRACE follow-on and future Missions:

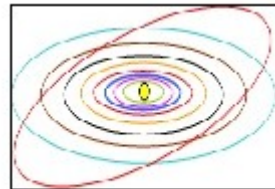
- **Inter satellite ranging:** LISA interferometry for future GRACE?
- **Pointing accuracy** and pointing jitter: AOCES accuracy?
- **Satellite constellations & orbits:**

More than one pair of GRACE satellites orbiting simultaneously ?

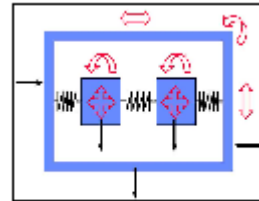
Satellite constellations and orbit design? Pendulum orbit? Iridium NEXT (66 satellites)



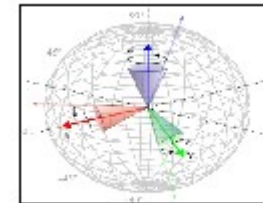
# What is HPS? (High Performance Simulator)



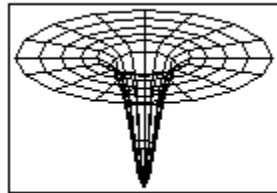
Epherides



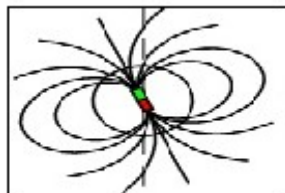
Dynamics



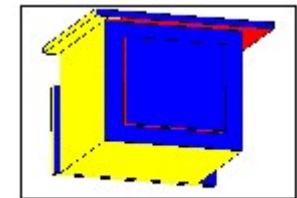
Transformation



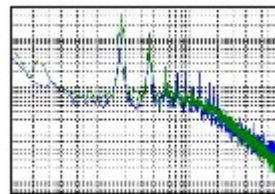
Gravity Field



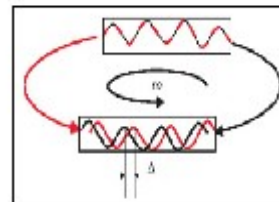
Magnetic Field



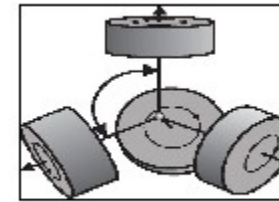
Surface Forces



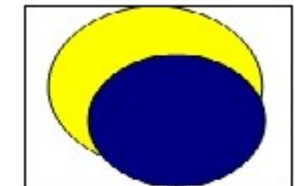
Atmosphere



Sensors

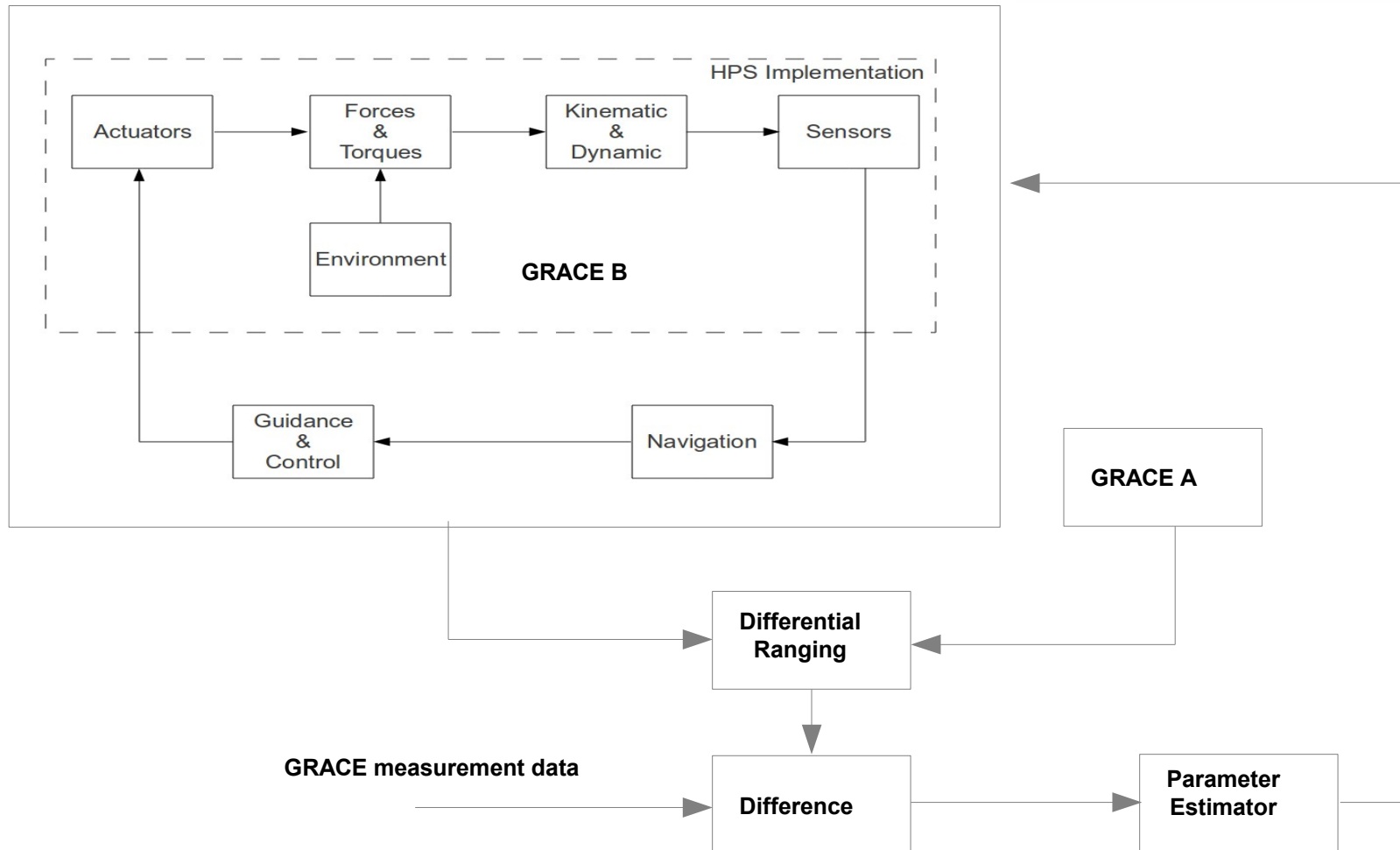


Actuators



Illumination

# GRACE mission modeling in HPS



# Effect of Solar Radiation on GRACE 1/2

## Single GRACE satellite

- Altitude = 456 km
- Inclination = 0 deg
- Eccentricity =  $2,25 \cdot 10^{-3}$
- Semi major axis = 6 873 km
- Orbit period = 1h 34min (2 circles)
- Mean Momentum flux =  $4,4 \cdot 10^{-6} \text{ kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$

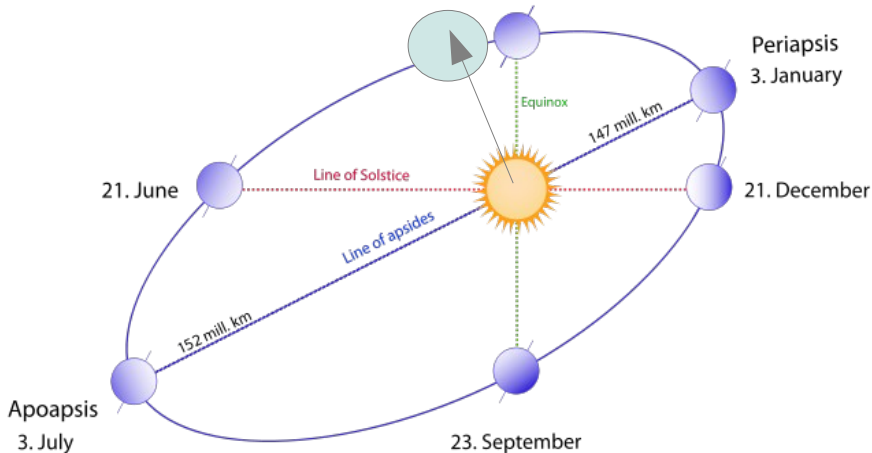
## Satellite & Sun & Earth positions

Northern spring/  
Southern fall

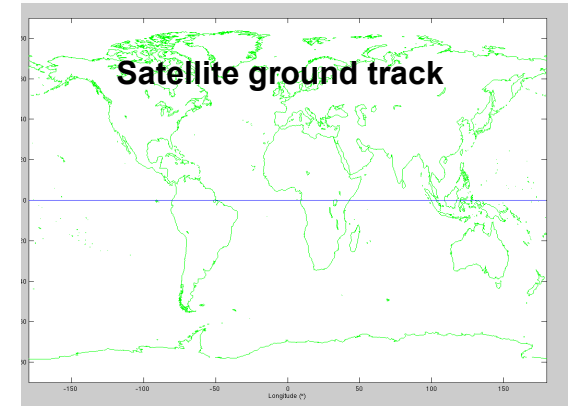
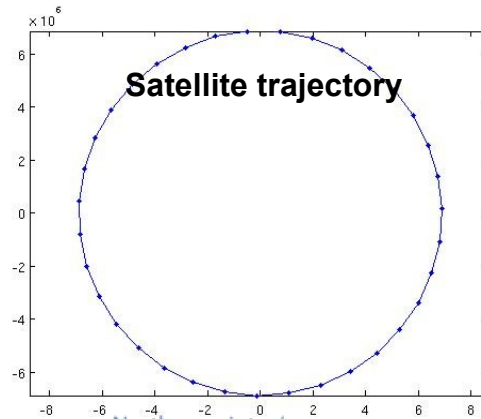
26<sup>th</sup> of March

21. March

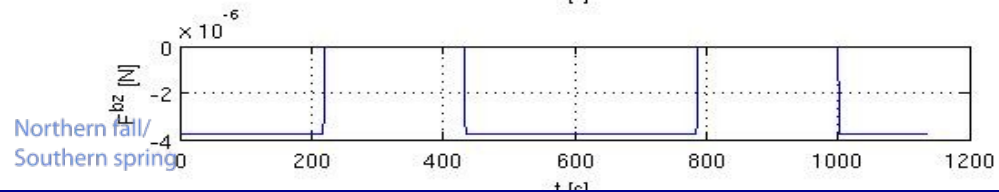
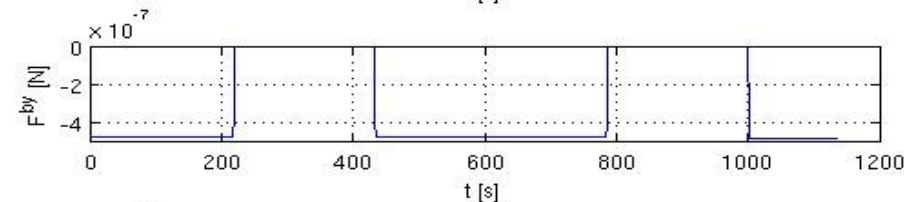
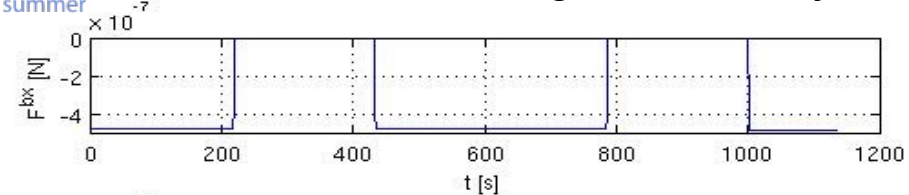
Northern winter/  
Southern summer



Northern summer/  
Southern winter



## Solar radiation force acting on satellite body

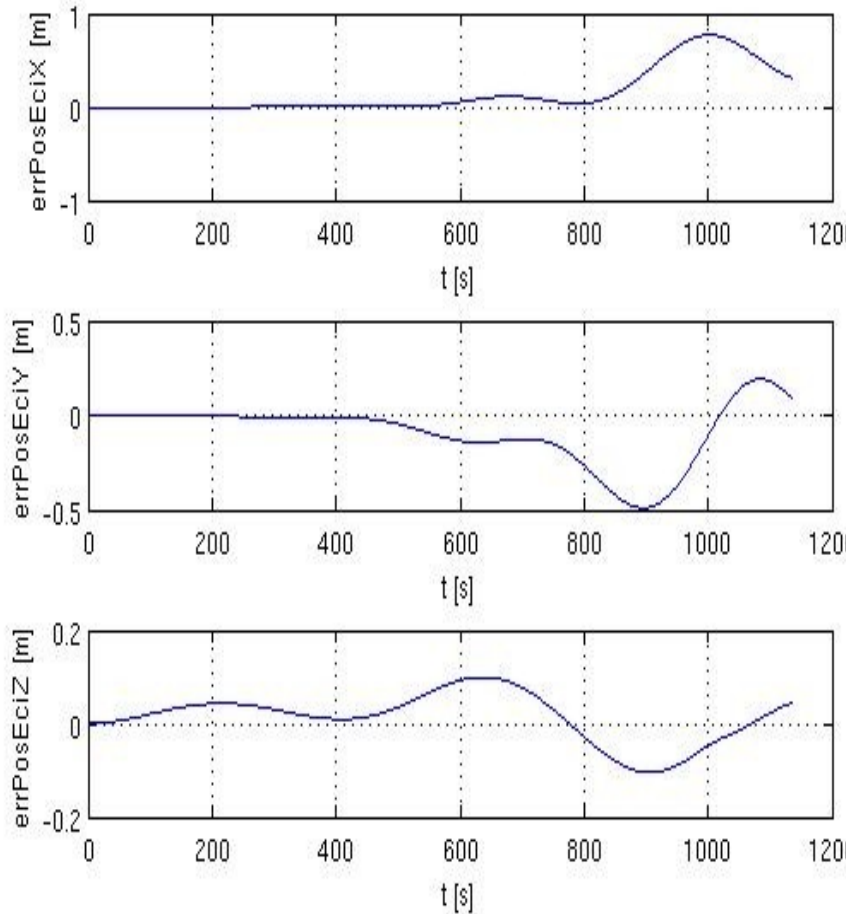


Northern fall/  
Southern spring

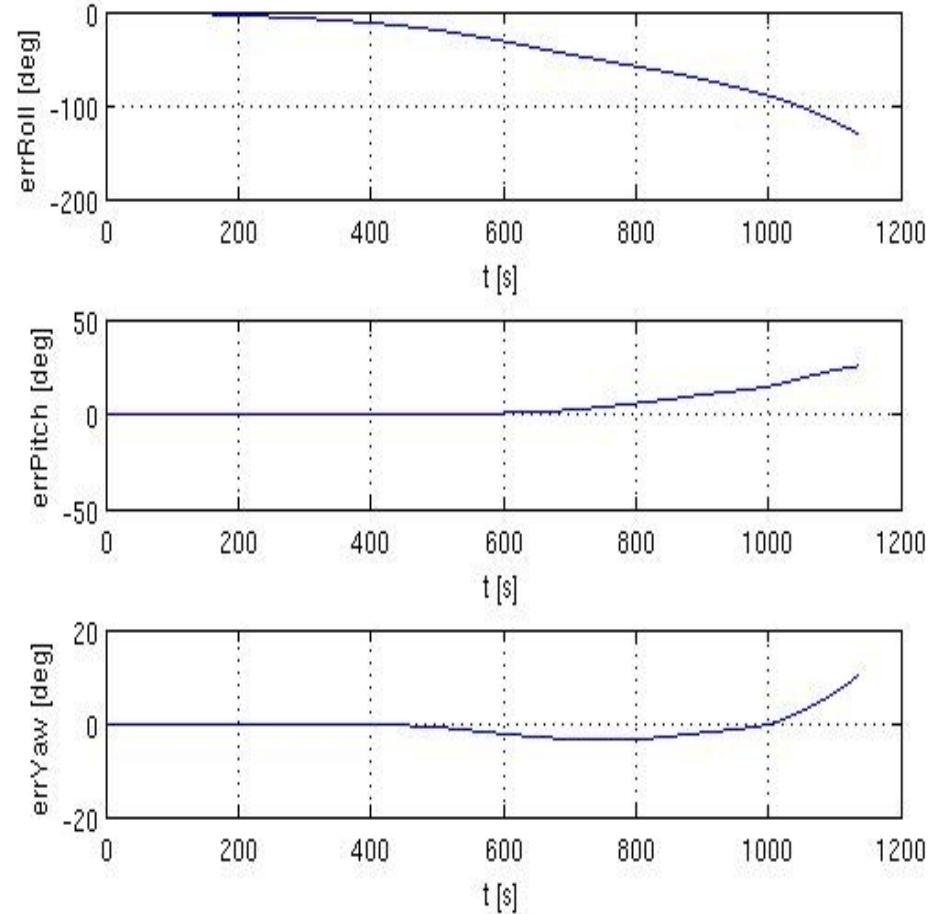


# Effect of Solar Radiation on GRACE 2/2

## Effect of solar radiation pressure on satellite position

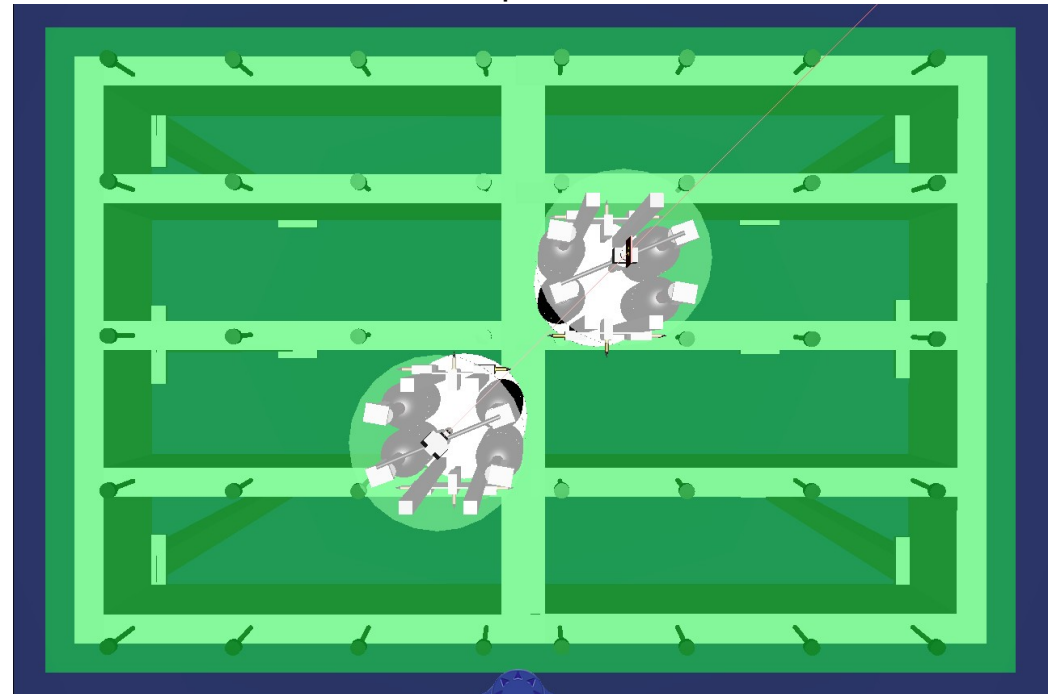
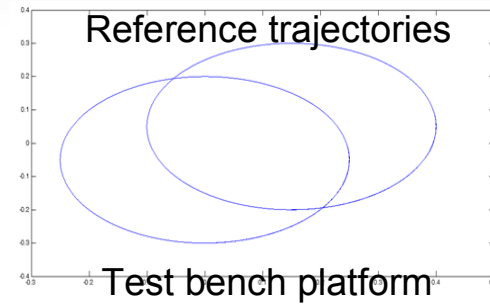
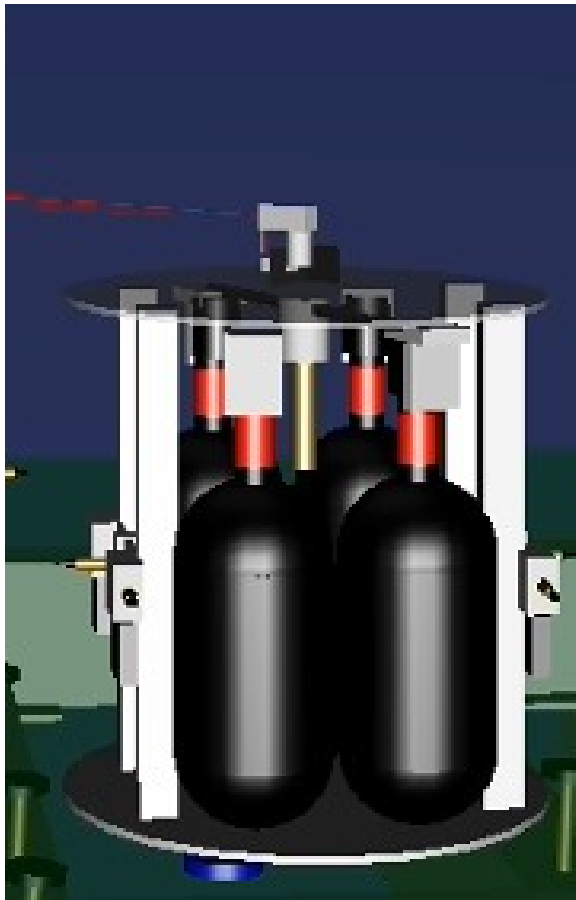


## Effect of solar radiation pressure on satellite attitude



# Synergies with other GNC projects

LuVex satellite simulator



# Conclusion

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## **GRACE mission simulation environment offers capabilities:**

- to study various effects acting on satellites and their influence on the Earth gravity field measurements.
- to perform better sensitivity analysis and to study the contribution of each subsystem to overall error budget.
- to identify parameters of certain phenomena and augment existing models by comparison of the mathematical models with the real data.
- to test new algorithms.
- to evaluate new concepts for future gravity missions.

