Estimation of phase center offset corrections for Sentinel satellites

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Introduction

• At AIUB precise orbit solutions of Sentinel satellites are computed (Copernicus POD Service QWG)

• Dynamic LEO Precise Orbit Determination (POD) using the Bernese GNSS Software on centimeter precision level (Mao et al. 2021)

• Knowledge of exact signal receiving point is essential, whereby receiving point is composition of Antenna reference point (ARP) and Phase Center Offset (PCO)
LEO Precise Orbit Determination

• Dynamic orbit representation
  ➢ Solar radiation pressure, Earth radiation pressure, airdrag
  ➢ No scaling factors for non-gravitational forces estimated
  ➢ Piecewise-constant accelerations in along- and cross-track every 30min, constrained to $0.5 \text{ nm/s}^2$

• Fixing integer ambiguities in the process of PCO correction estimation

• No phase center variations (PCV) applied
Processed LEOs

Sentinel-1A/B

Sentinel-3A/B

Sentinel-2A/B

Sentinel-6A

Image credit: ESA
Estimated PCO corrections (S1A/B, S2A/B, S3A/B)

→ Results using default settings for Sentinel POD at AIUB
Estimated PCO corrections (S1A/B, S2A/B, S3A/B)

→ Results using default settings for Sentinel POD at AIUB

→ β-dependency
Sentinel-1A

- Attitude: Quaternions vs nominal model
- Self-shadowing
- Trend in estimated PCO corrections
- Macro model modifications
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Sentinel-1A

- Attitude: Quaternions vs nominal model
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Sentinel-3A

- SLR Validation of Reduced-dynamic orbit solutions, original/corrected PCO used in POD

Original PCO
-3.17mm±8.62mm

Corrected PCO
1.15mm±8.56mm
Sentinel-6A

• PCO correction estimation for GPS and Galileo receiver

- GPS receiver
  - Correlation: 7.3mm/year
  - North offset: 8.4mm ± 2.3mm
  - Up offset: 4.7mm ± 1.3mm

- Galileo receiver
  - Correlation: 8.2mm/year
  - North offset: 8.6mm ± 2.4mm
  - Up offset: 6.4mm ± 1.7mm

- GPS/Galileo only solutions
- For both receivers an offset in north direction of ~8.5mm is estimated
- For both receivers a significant correction in up direction is estimated
Sentinel-6A

- SLR Validation of Reduced-dynamic orbit solutions, original/corrected PCO used in POD

Original PCO
3.08mm±9.63mm

Corrected PCO
-0.84mm±9.02mm
Summary

• PCO correction estimation with Bernese GNSS Software gives reliable results
• PCO correction estimation can serve as reference to detect modelling deficiencies
• According to SLR validation applying estimated PCO offset corrections lead to reduced-dynamic orbit solutions of improved quality, since mean and standard deviation are smaller when using a corrected PCO in the POD process
THANK YOU FOR YOUR ATTENTION!