Real-time clock estimation for precise orbit determination of LEO-satellites

André Hauschild

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Agenda

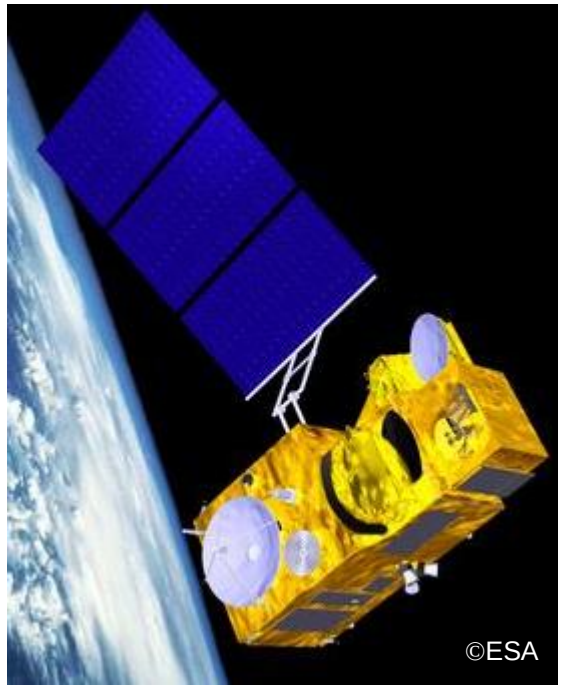
- Background and Motivation
- Introduction of the Clock Estimation Algorithm
- Results of a Precise Orbit Determination
- Conclusion and Future Work

Background and Motivation

- German Spaceflight Operations Center (GSOC) routinely performs precise orbit determination for current missions

- Near real-time precise orbit determination (decimeter level) required for
  - Occultation measurements
  - Altimeter missions (e.g. Sentinel-3)

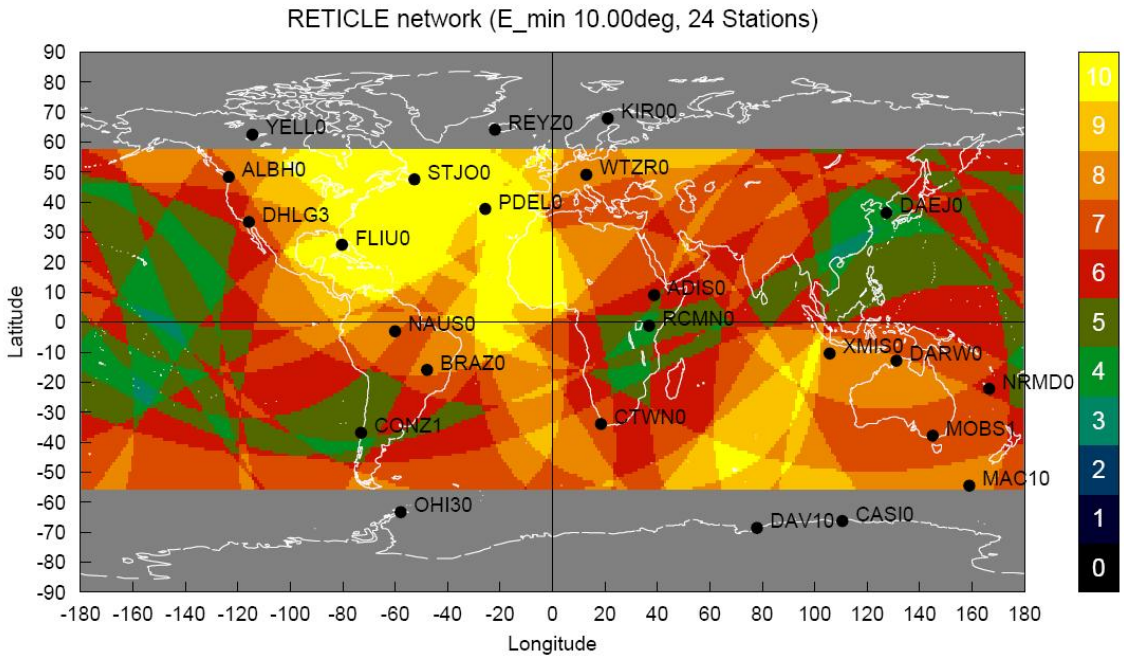
- IGS ultra rapid predicted products:
  - Orbits: several centimeter accuracy
  - Clocks: several decimeter accuracy



- Precise GPS clock estimation in real-time is currently established at GSOC to support upcoming space-missions

Clock Estimation Algorithm

- Real-Time Clock Estimation (RETICLE) algorithm based on Kalman filter
- Data from global NTRIP-Network (~25 stations) in real-time
- Processing of ionosphere-free pseudo-ranges and carrier-phases
- Estimation parameters:
  - GPS clock offset & drift
  - station clock offset
  - trop. zenith delay
  - carrier-phase biases
- Clock parameters based on most recent IGU predicted orbits

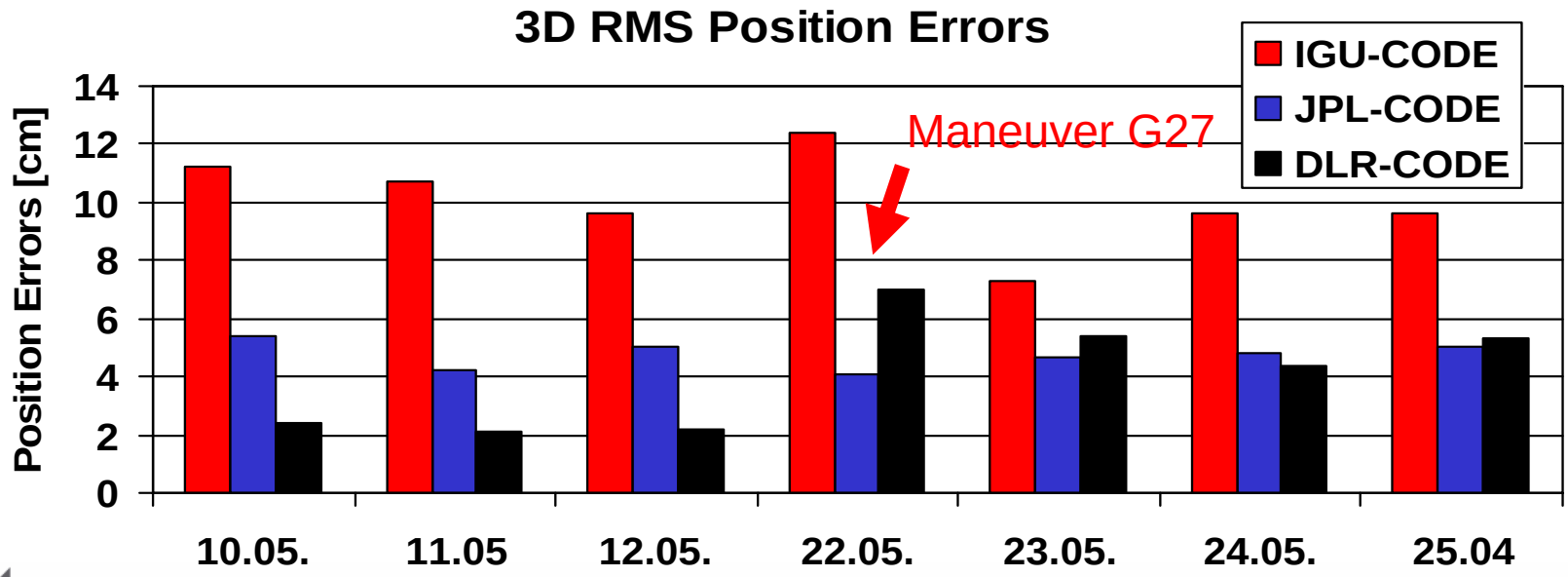


Clock Estimation Algorithm (cont.)

- Station coordinates from IGS Sinex-files or PPP-fit
- Modeled observations include corrections for:
  - solid earth tides
  - (ocean loading)
  - polar tides
  - tropospheric delay
  - phase center offsets and variations
  - differential code biases (P1-C1)
  - phase wind-up
- Generation of SP3-file as clock/orbit product with 30s epochs

Assessment of Clock Product Quality

- TerraSar-X 24h POD with 3 different orbit/clock-products: IGU, JPL, DLR
- POD with iterative least-squares fit using un-differenced measurements
- CODE final/rapid products used to generate TerraSar-X reference orbit
- LEO orbit generated with real-time products are compared to reference orbit



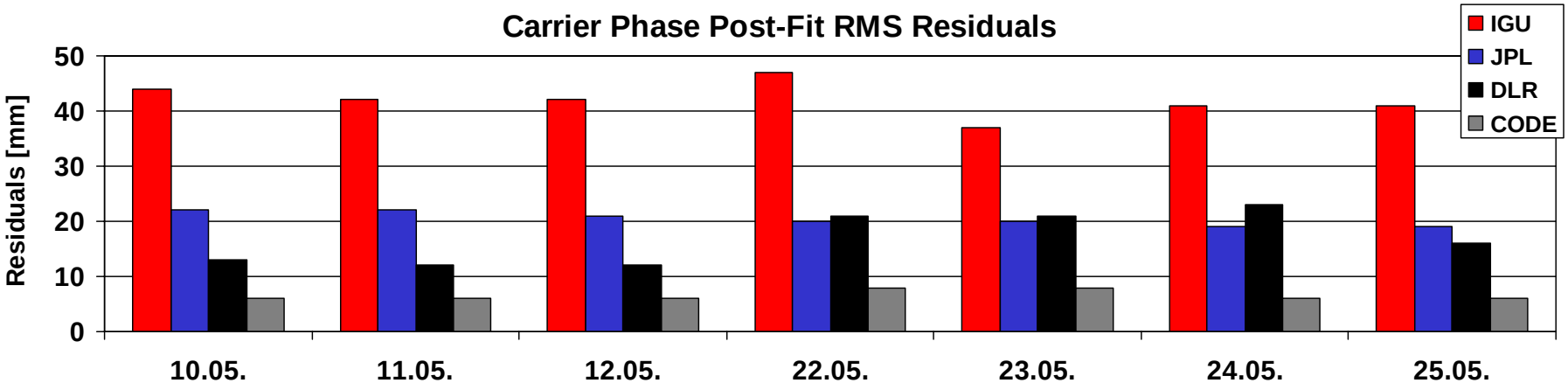
Assessment of Clock Product Quality (cont.)

- Comparison of pseudo-range and carrier phase post-fit RMS residuals

- Pseudo-range: ~70-75 cm for CODE, JPL and DLR

  ~100 cm for IGU

- Carrier phase:



Conclusions and Future Work

- RETICLE orbit and clock products fulfill requirements for LEO-POD
- Further improvements:
  - Exclude GPS satellites during maneuvers
  - Eliminate effects of noon turns and eclipse phases
  - Refine data editing (accuracy vs. robustness)
- Current NTRIP-network is sufficient for global precise clock estimation
- Additional stations beneficial for improving global coverage
- Check consistency between daily Rinex-files and data streams