

GIOVE Orbit and Clock Determination Based on the CONGO Network



Peter Steigenberger, Urs Hugentobler
Technische Universität München



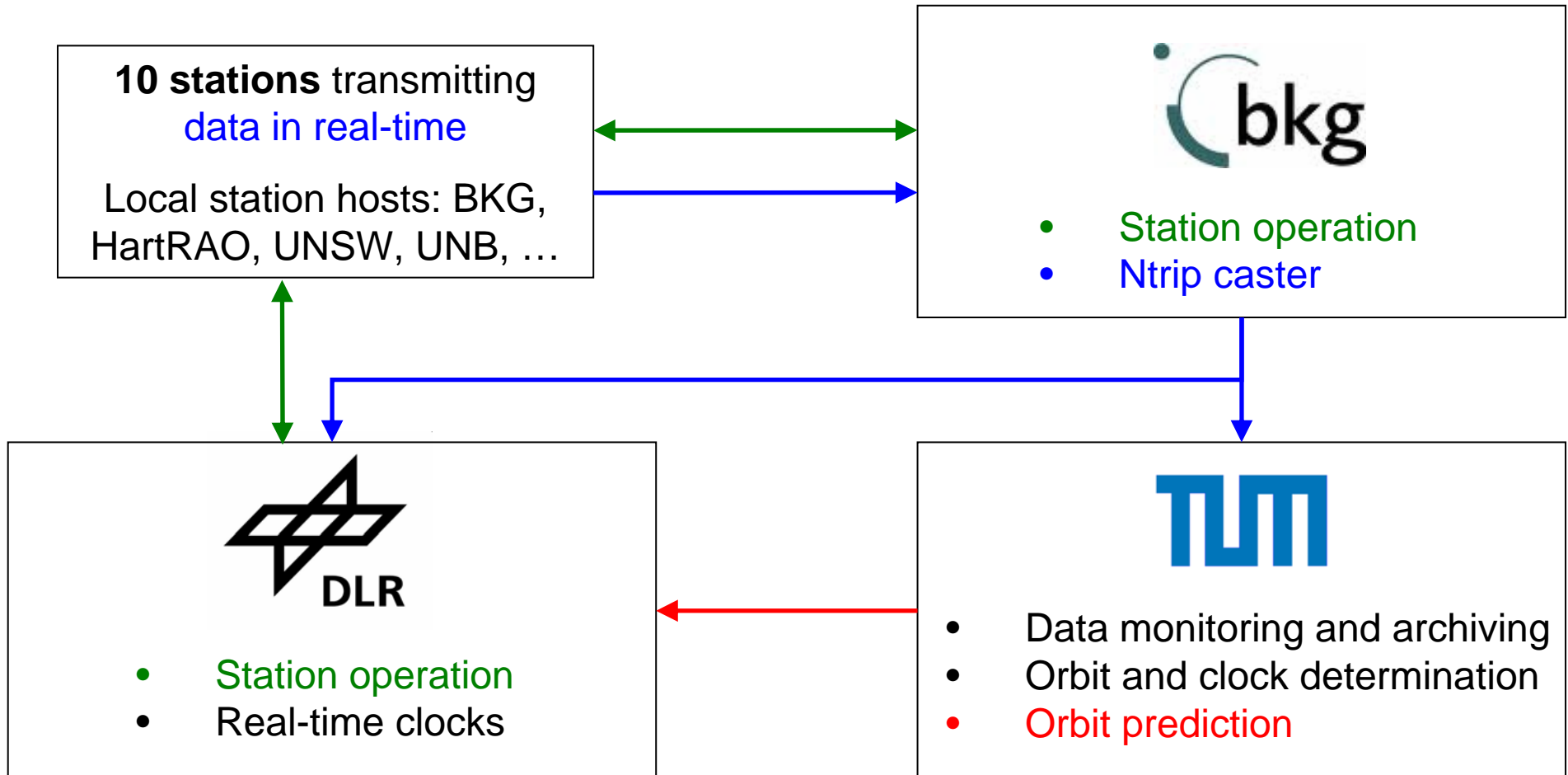
André Hauschild, Oliver Montenbruck, Thoralf Noack
Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen



Uwe Hessels, Georg Weber
Bundesamt für Kartographie und Geodäsie, Frankfurt am Main

COoperative Network for GIOVE Observations

- Global real-time tracking network for GPS and GIOVE signals



CONGO Tracking Network



CONGO Tracking Equipment



Septentrio GeNeRx



Javad Triumph



Leica GRX1200



Leica AX1203

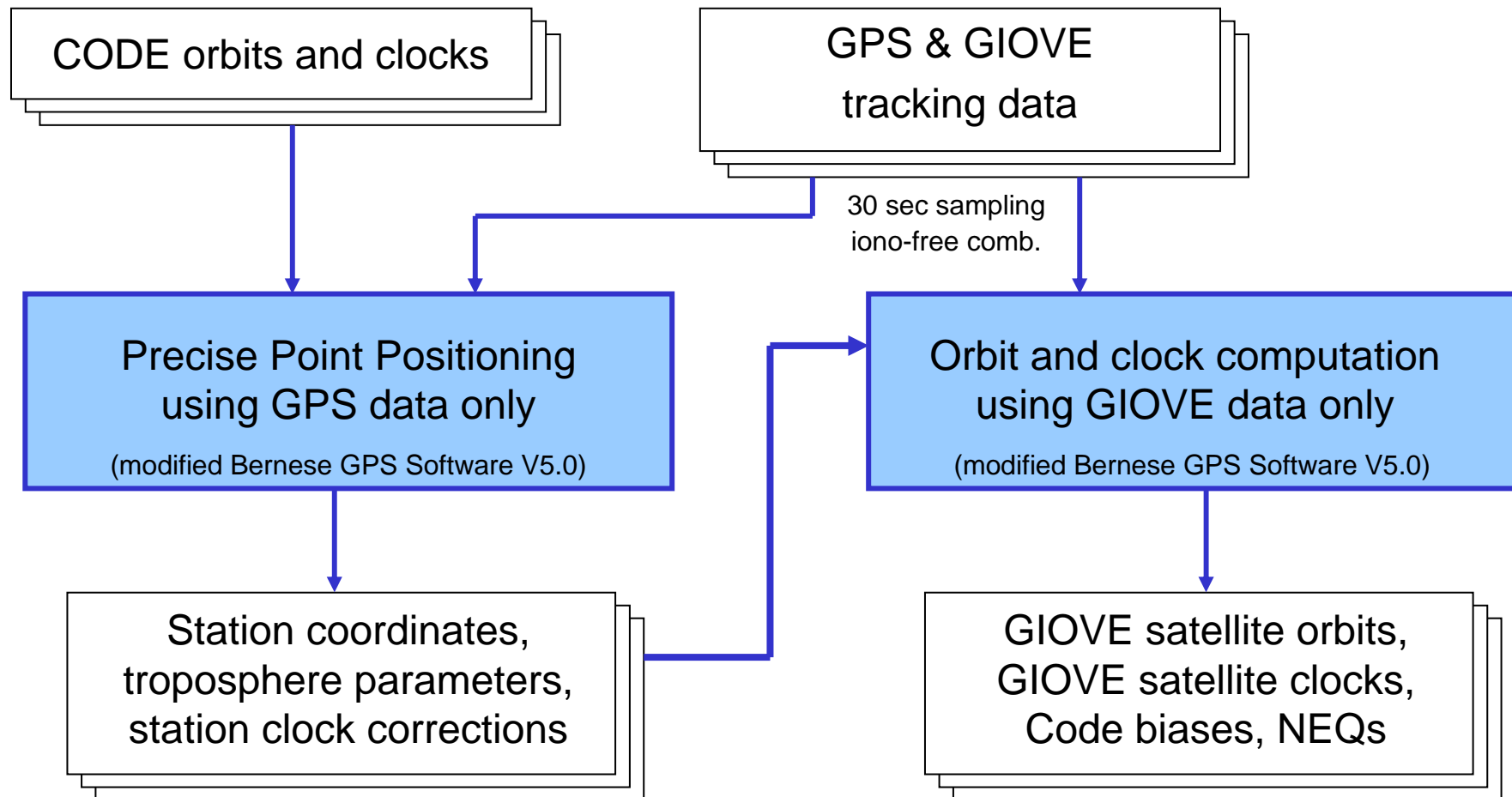


Leica AR25 (Rev. 3)



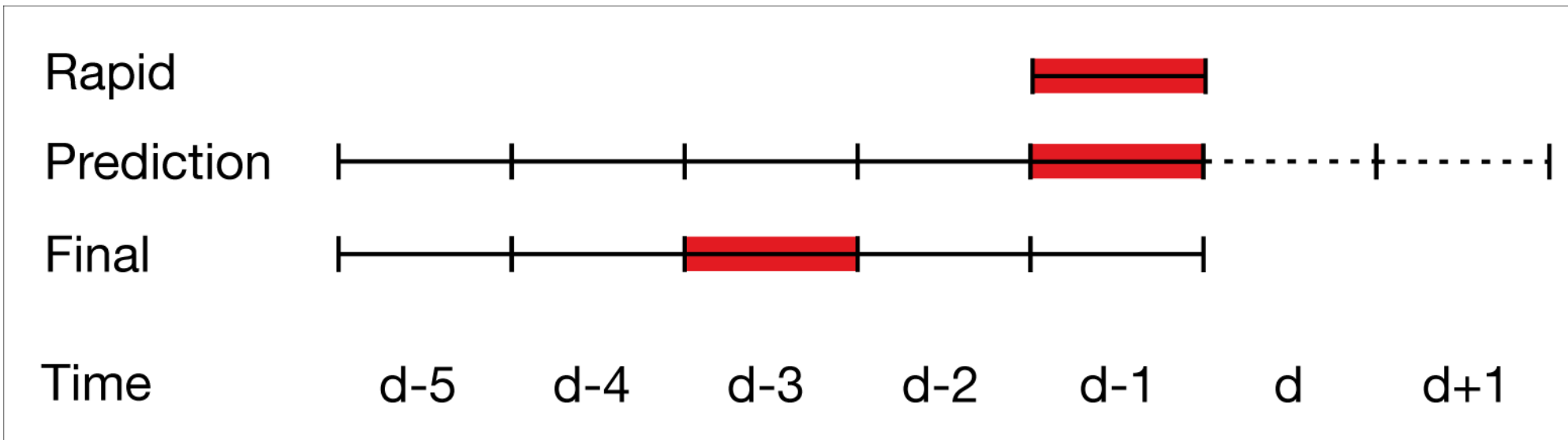
Trimble Zephyr 2

Operational CONGO Processing (1)

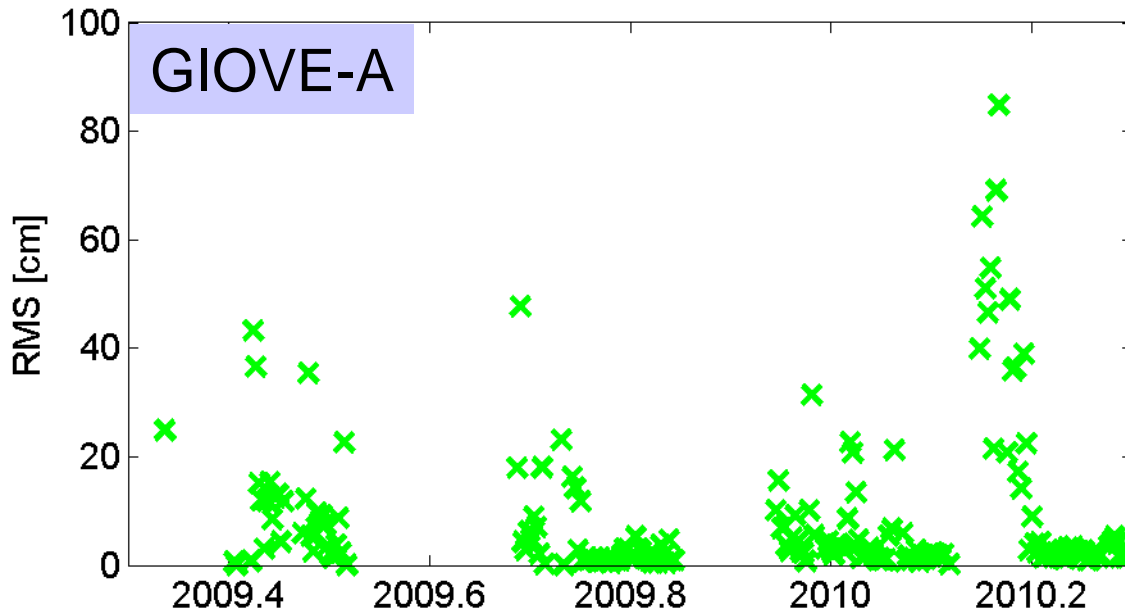


Operational CONGO Processing (2)

- **Rapid solution**
 - 1-day solution: NEQs
 - 5-day solution: 2-day orbit prediction
- **Final solution**
 - Orbit: middle day of a 5-day solution
 - Orbit fixed for the final clock solution
 - SLR residuals



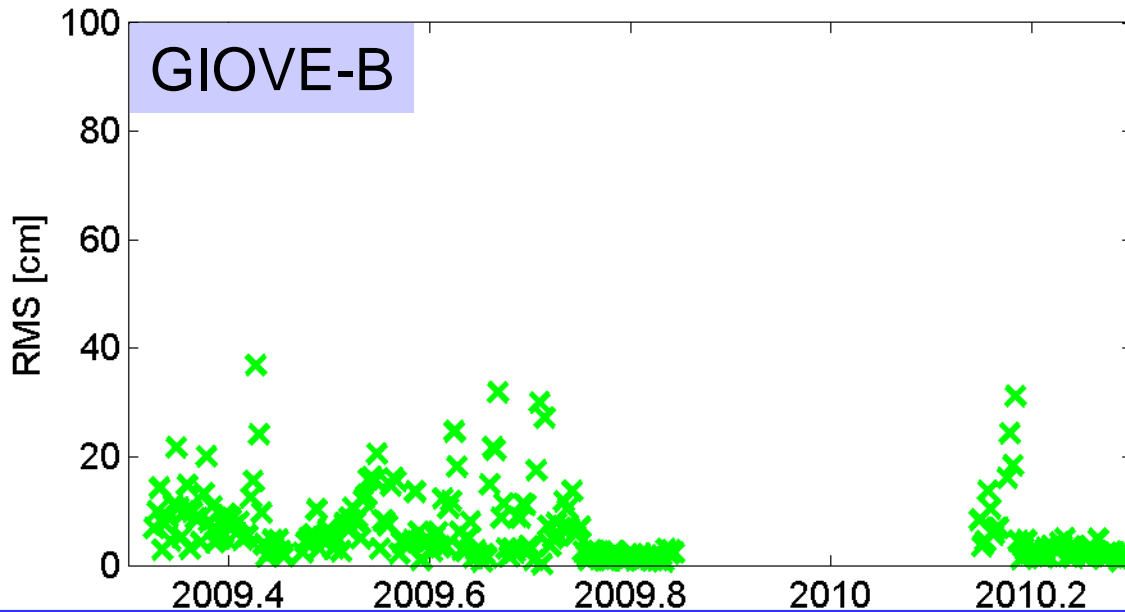
Orbits: Internal Consistency



RMS of 2-day orbit fits

Mean 8.5 cm

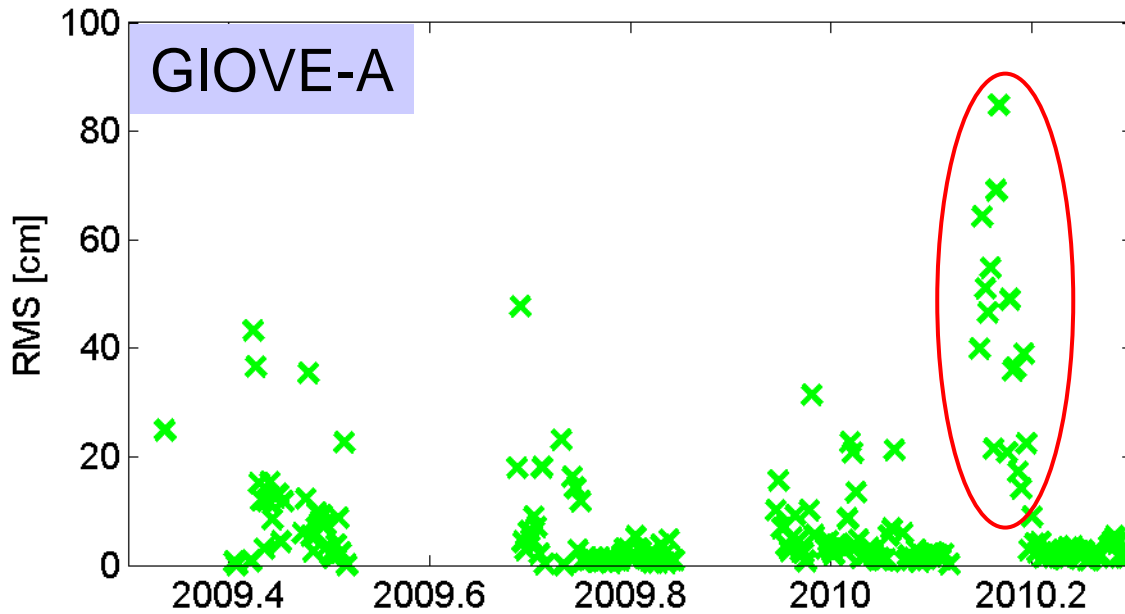
Recent Mean 3.2 cm



Mean 6.6 cm

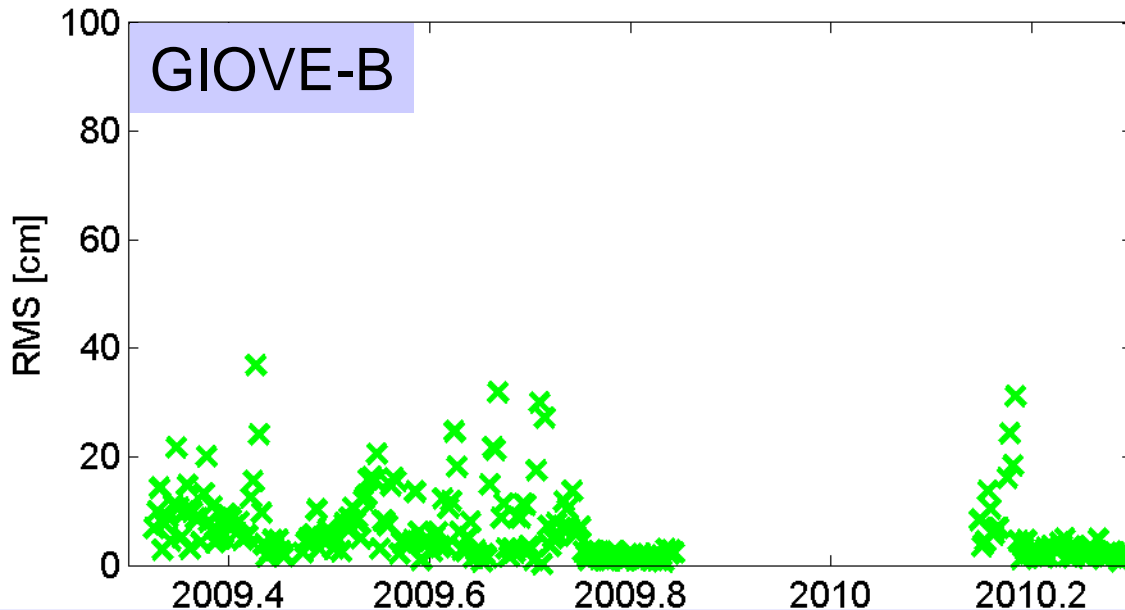
Recent Mean 2.5 cm

Orbits: Internal Consistency



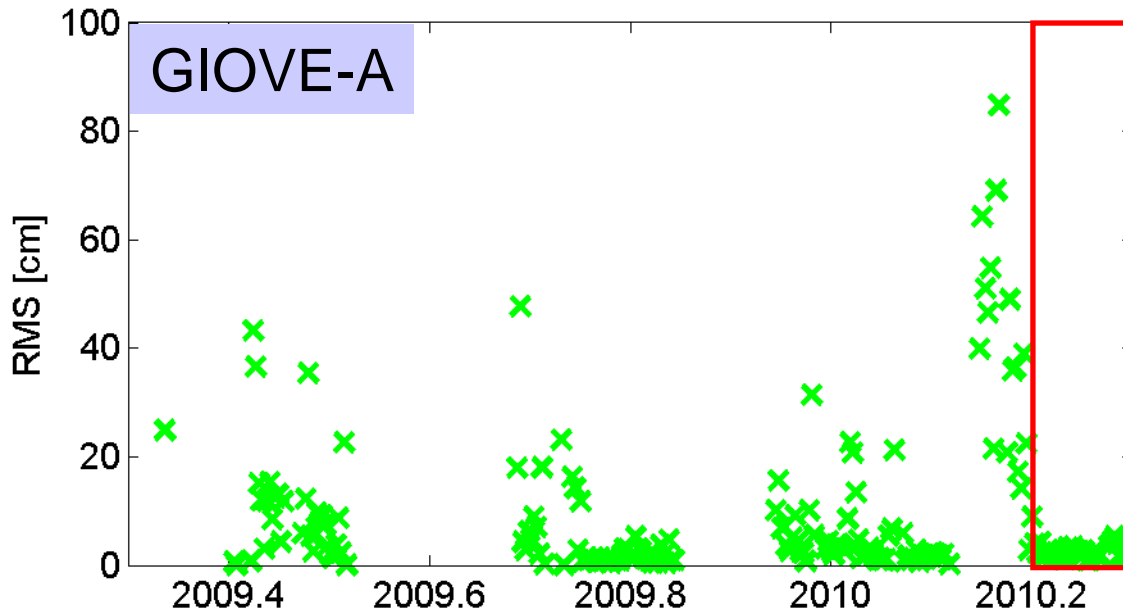
RMS of 2-day orbit fits

Mean	8.5 cm
Recent Mean	3.2 cm



Mean	6.6 cm
Recent Mean	2.5 cm

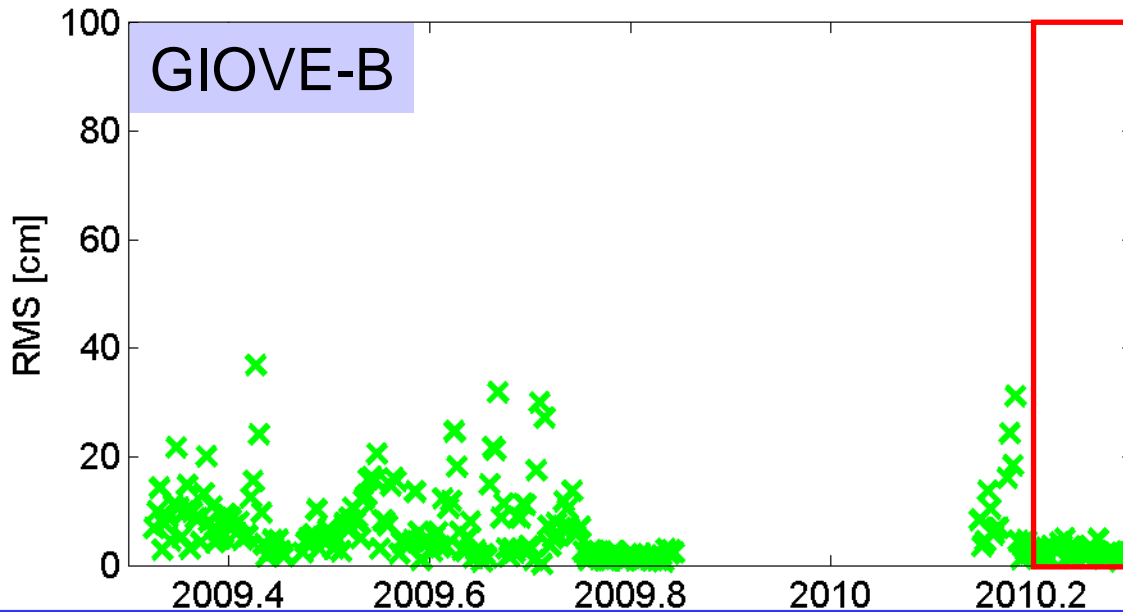
Orbits: Internal Consistency



RMS of 2-day orbit fits

Mean 8.5 cm

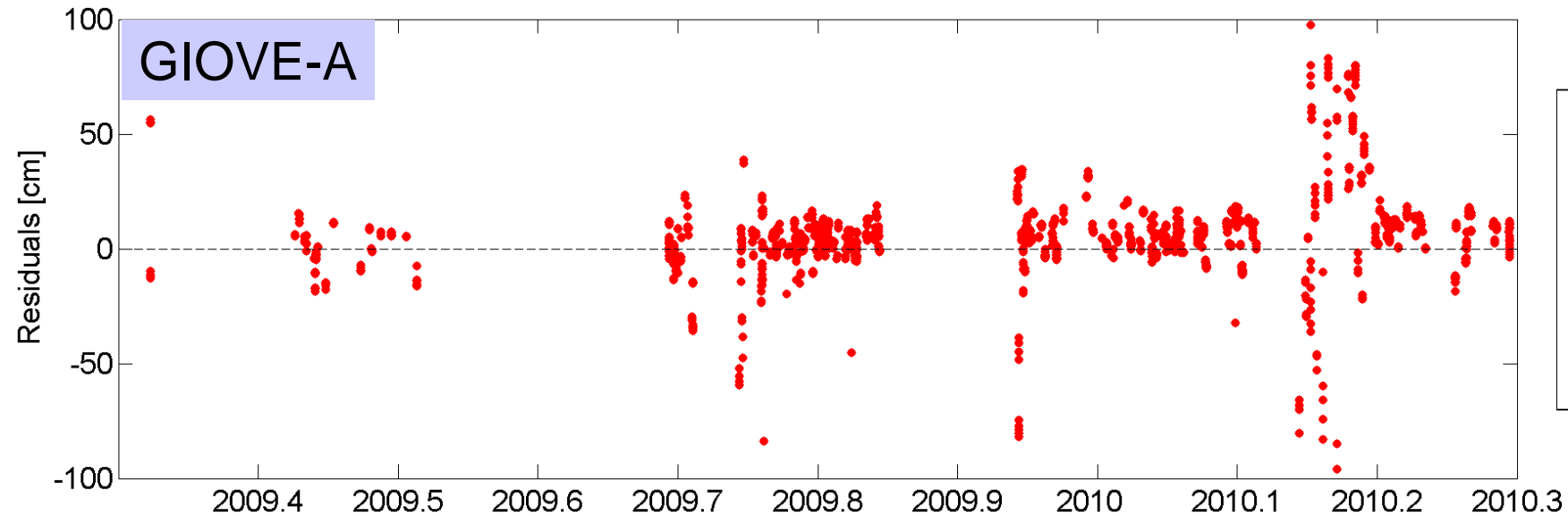
Recent Mean 3.2 cm



Mean 6.6 cm

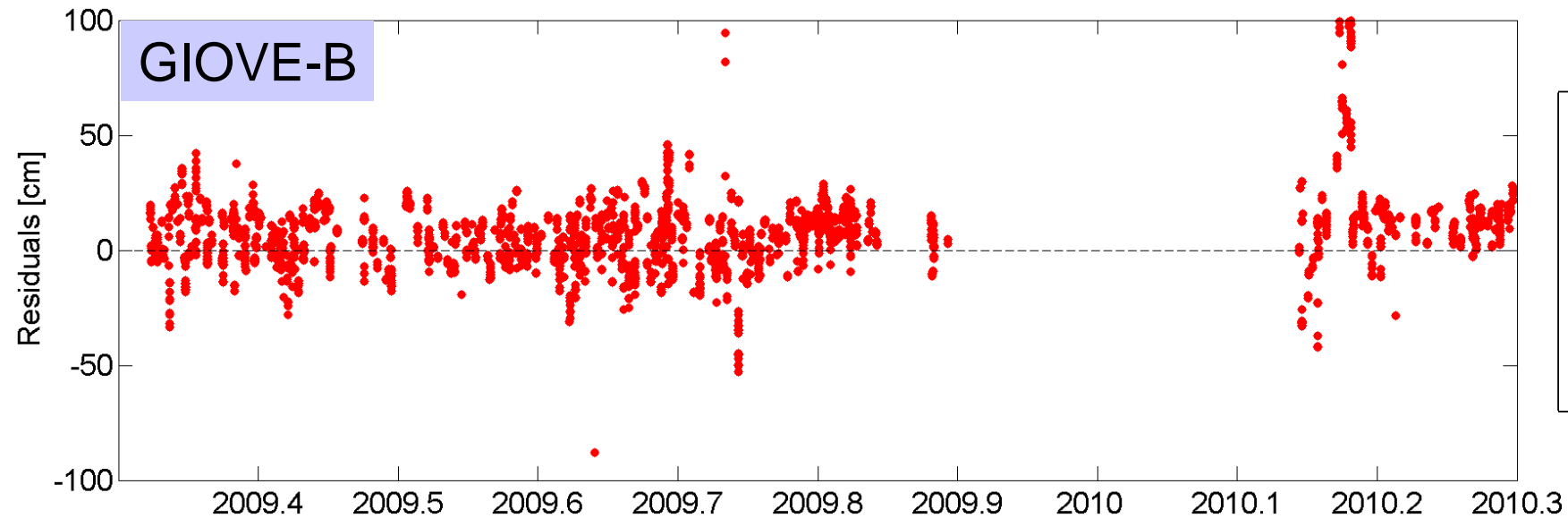
Recent Mean 2.5 cm

Orbits: SLR Residuals



Bias
4.8 cm

STD
11.0 cm

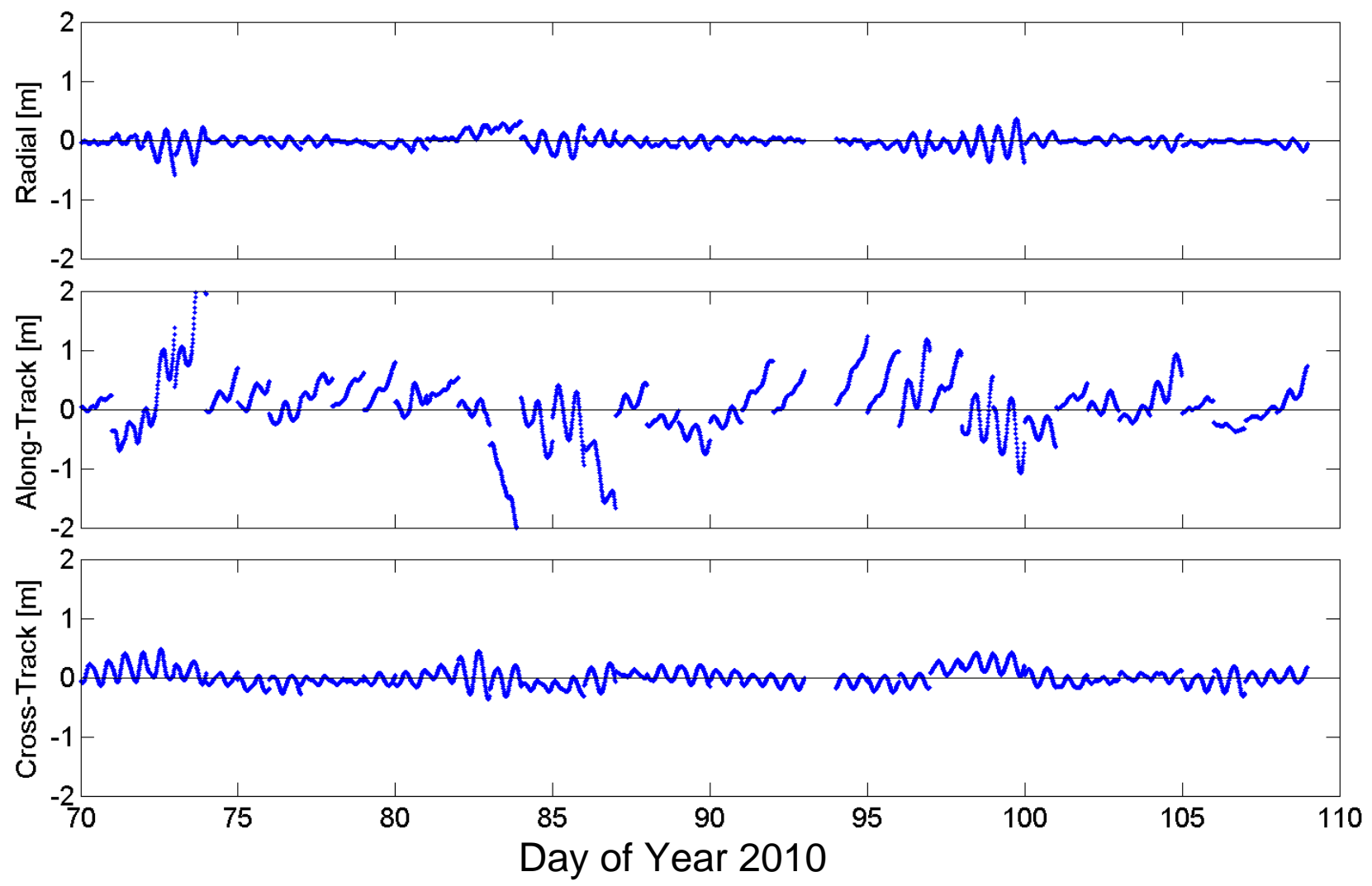


Bias
6.8 cm

STD
12.2 cm

Orbit Predictions

Differences of predicted GIOVE-B orbits w.r.t. final orbits



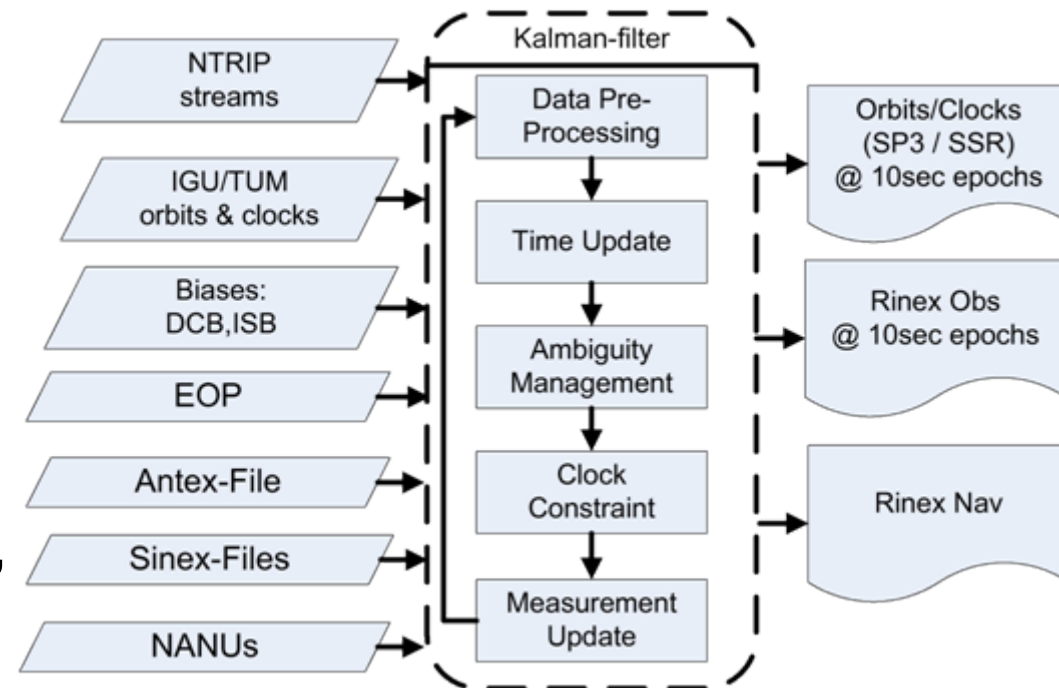
STD
10 cm

STD
52 cm

STD
14 cm

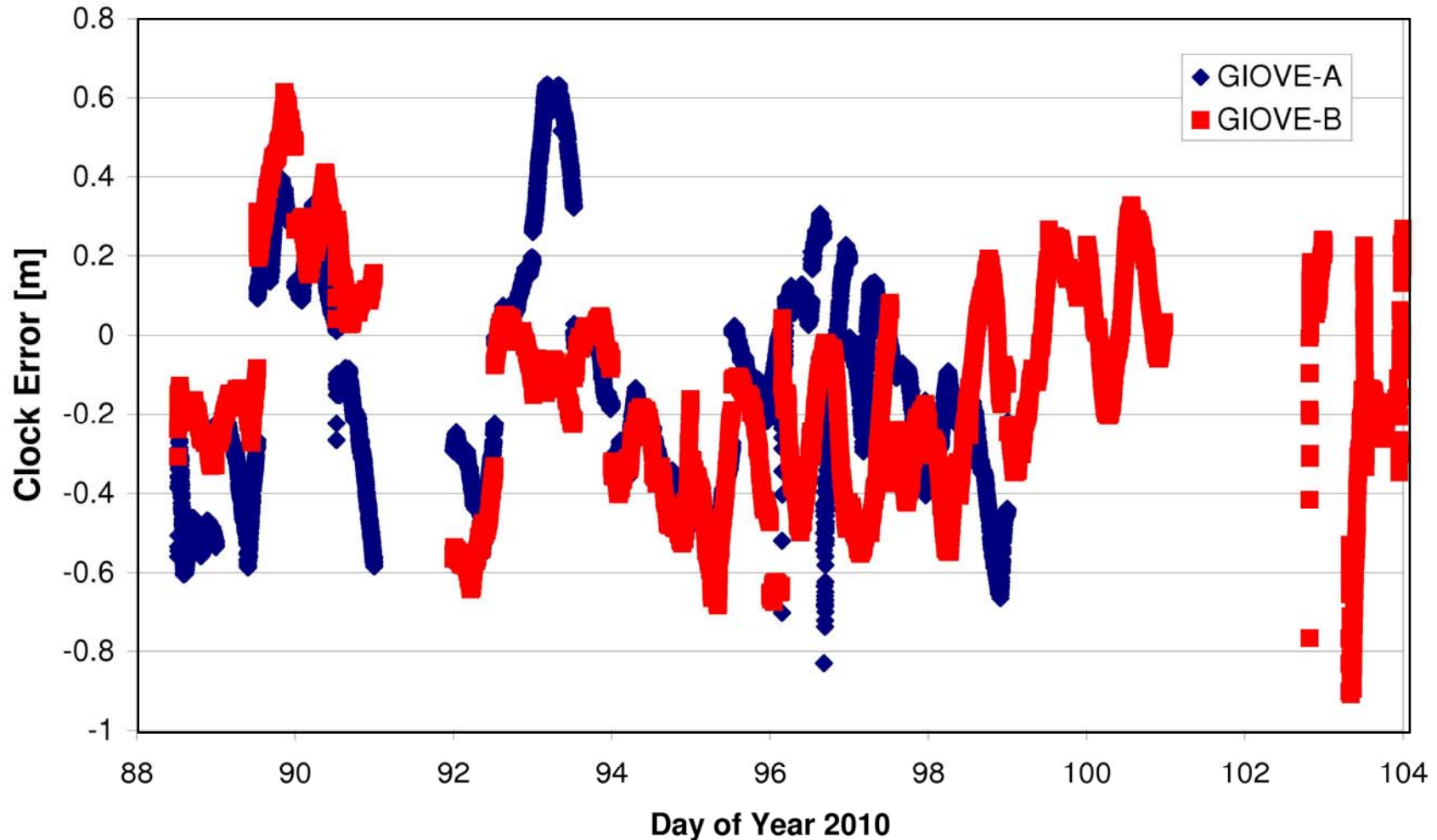
Real-Time GPS+GIOVE Clock Estimation

- DLR's Real-Time Clock Estimation system (RETICLE)
- Combined GPS+GIOVE clock estimation based on Kalman filter
- Data from global Ntrip network in real-time
- Ionosphere-free dual-frequency code and phase observations
- Estimation parameters:
 - Sat. clock offset & drift
 - Station clock offset
 - Trop. zenith delay
 - carrier-phase biases
- Predicted IGU orbits for GPS, TUM predictions for GIOVE
- GIOVE clock offset w.r.t. GPS time



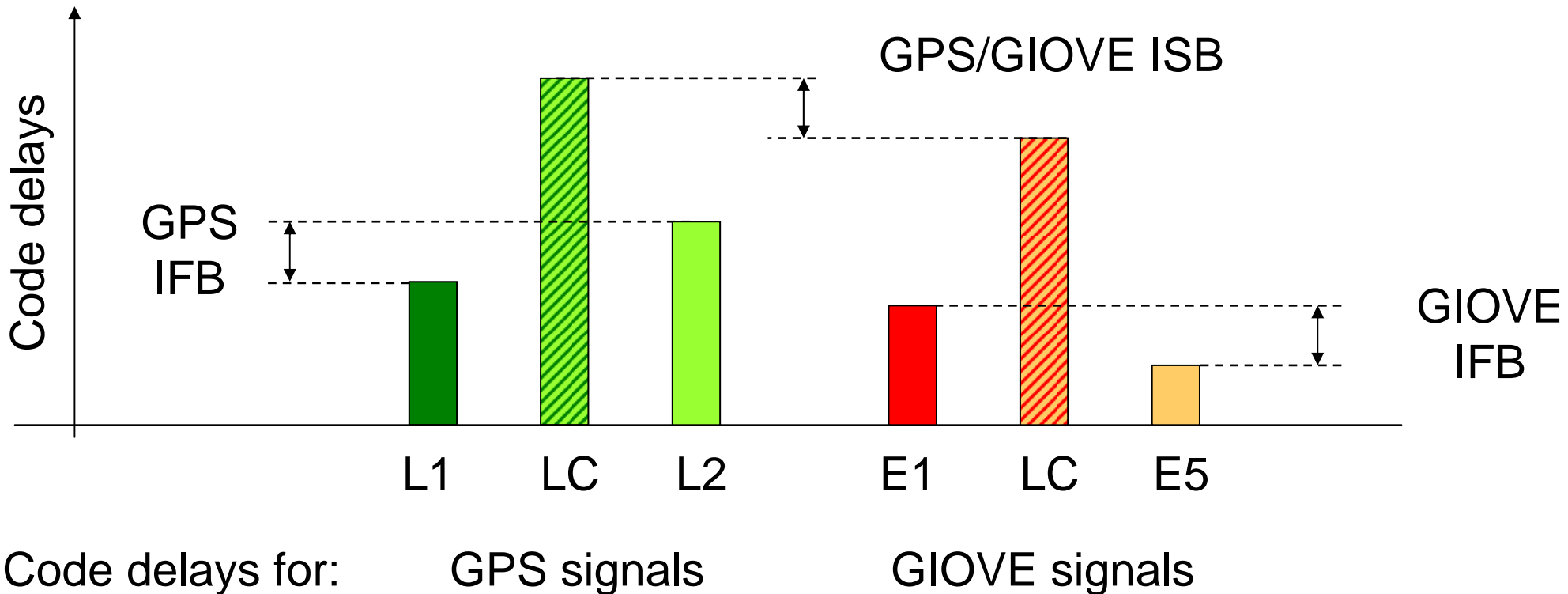
Real-Time GIOVE Clock Estimation

GIOVE clock errors w.r.t. TUM final clocks:



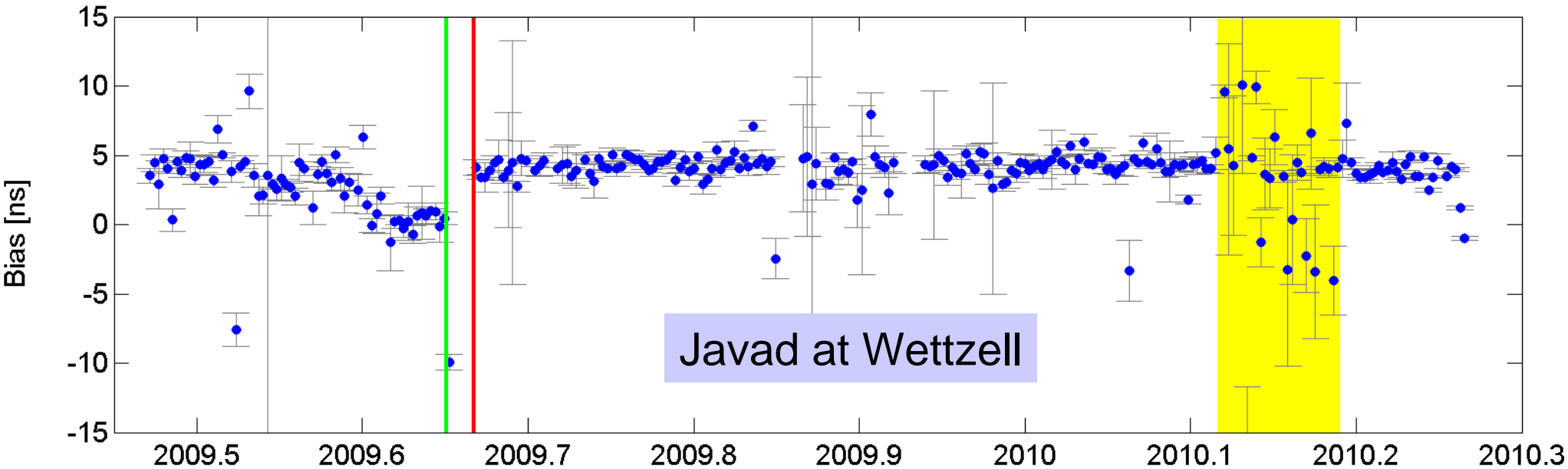
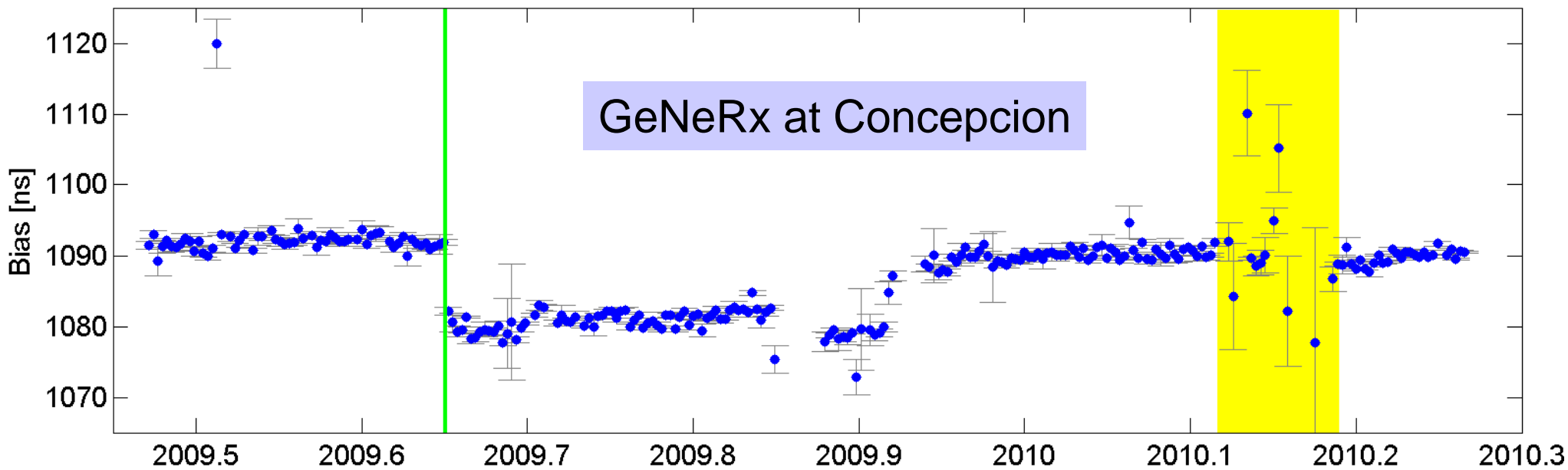
Inter-frequency and Inter-system Biases

Inter-frequency Bias: **IFB** Inter-system Bias: **ISB**
Ionosphere-free Linear Combination: **LC**



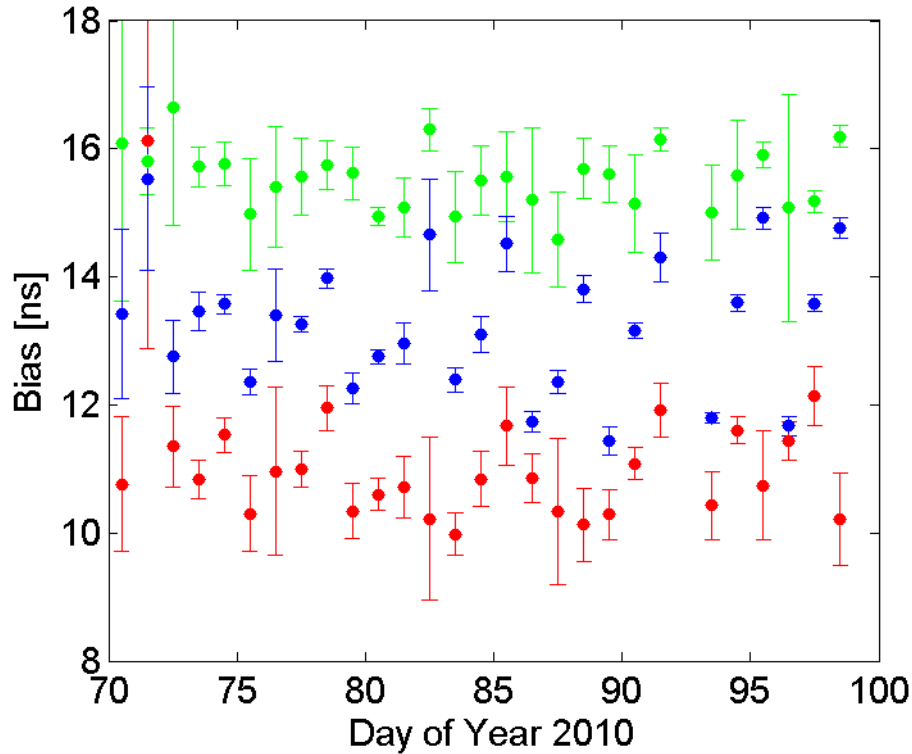
ISB estimation for all stations but one (Javad at New Brunswick)

ISB Time Series

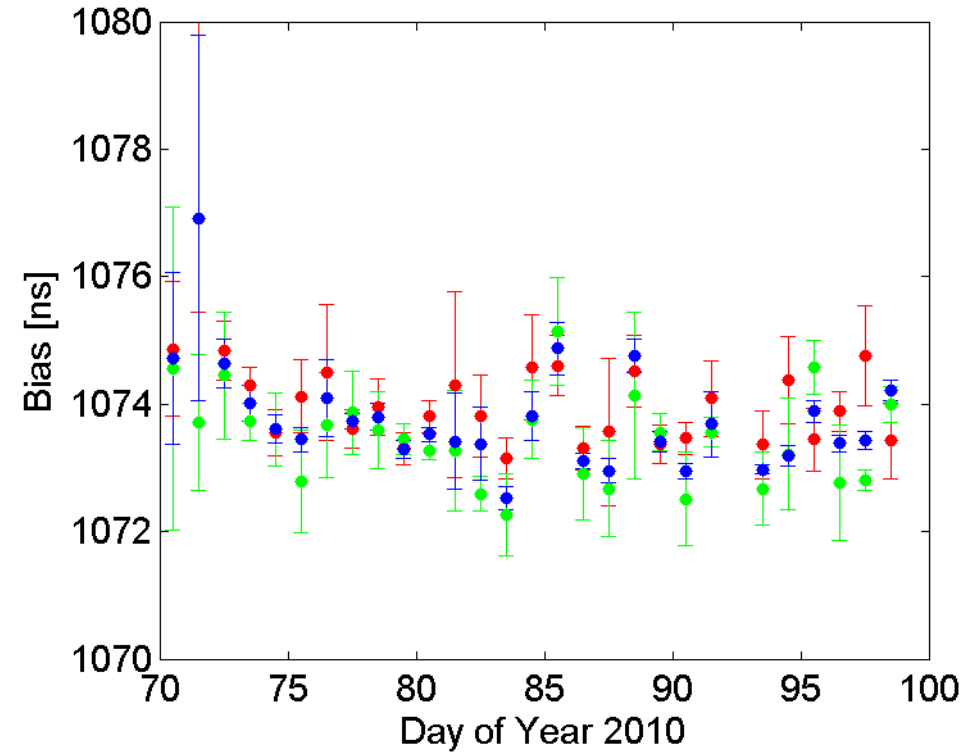


Satellite-specific ISB Estimation

Leica at O'Higgins



GeNeRx at Wettzell



GIOVE-A only 11.1 ± 1.2 ns

GIOVE-B only 15.5 ± 0.5 ns

Combined 13.3 ± 1.1 ns

96% sign.
differences

1074.2 ± 1.6 ns

1073.5 ± 0.7 ns

1073.8 ± 0.8 ns

16% sign.
differences

Summary and Conclusions

- The **CONGO network**
 - is jointly operated by **DLR**, **BKG**, and **TUM**
 - allows for a global tracking of the GIOVE satellites
 - provides **real-time data** of currently 10 stations
- Routine orbit determination and prediction by TUM
- Real-time clock determination by DLR
- **Decimeter accuracy** for the **orbits**
- **Meter accuracy** for the **real-time orbits and clocks**
- Significant **inter-satellite bias** observed for some CONGO stations
- **Improvements** expected due to **firmware and antenna updates**
- Further enhancement of the CONGO network planned

Access to GLOVE real-time orbits and clocks:

Server: `ftp.gsoc.dlr.de`

User: `Reticle`

Password: `getReticle`

