CONGO - Characterization of User Equipment in a Heterogenous GIOVE Tracking Network

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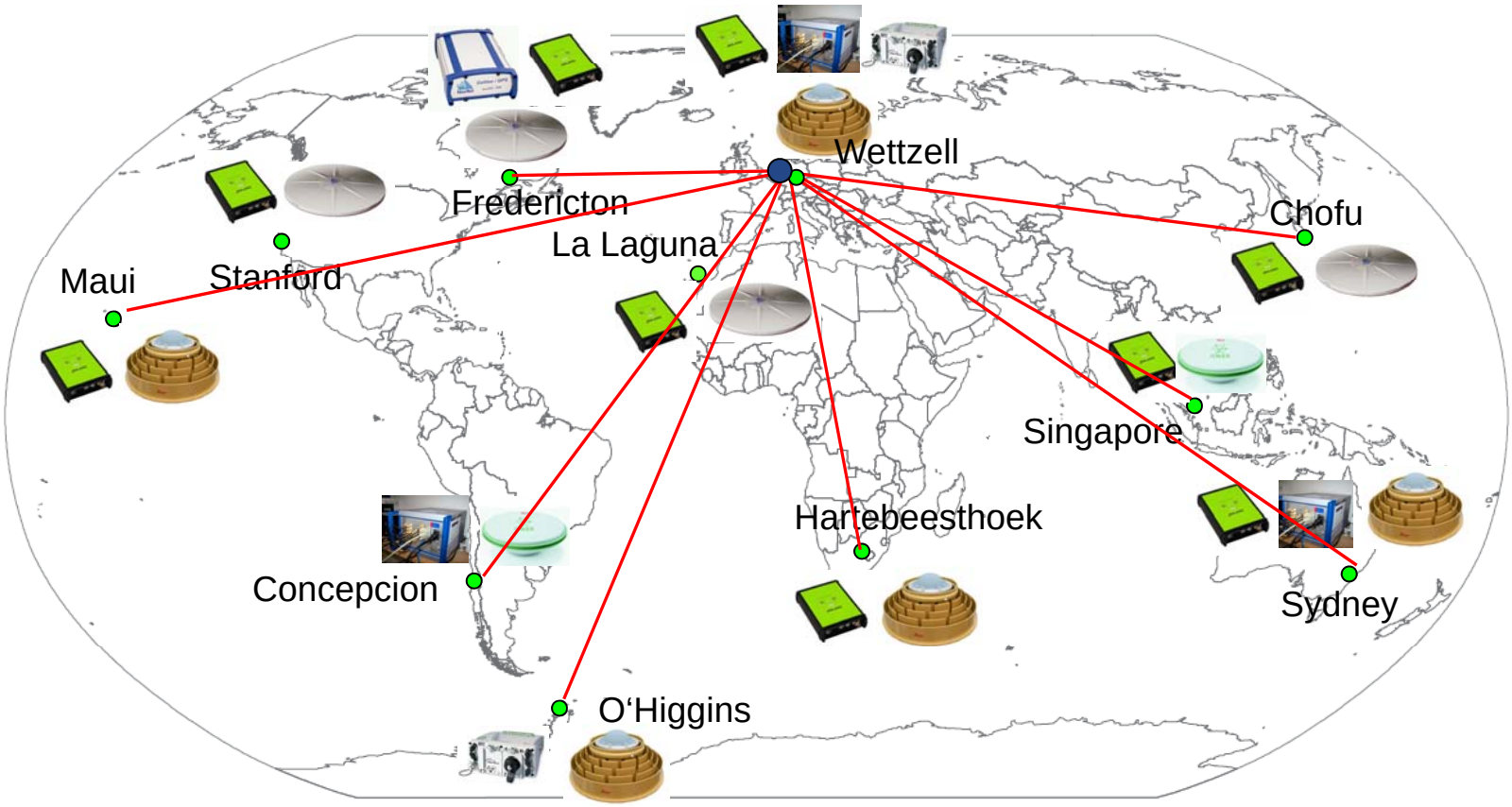
CONGO –
The Cooperative Network for GIOVE Observation

- Global network of GNSS receiver stations for tracking of GPS and GIOVE signals
- Jointly established by DLR and BKG
- 11 sites operational
- User equipment from public vendors
- Real-time data transfer via NTRIP

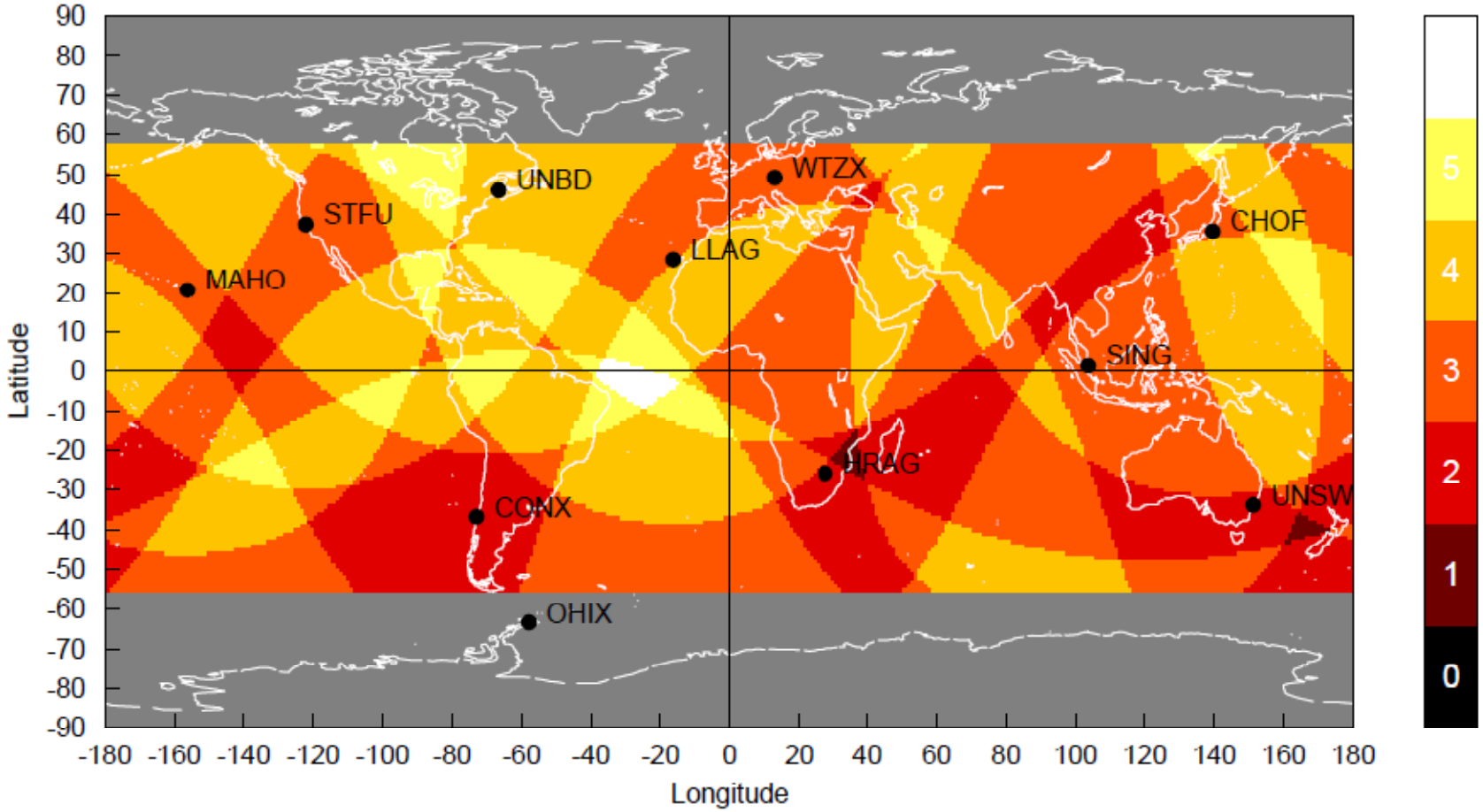
- Basis for early familiarization and experimentation with new signals

CONGO Network



● Ntrip Caster at BKG Frankfurt

Depth of Coverage



Antennas

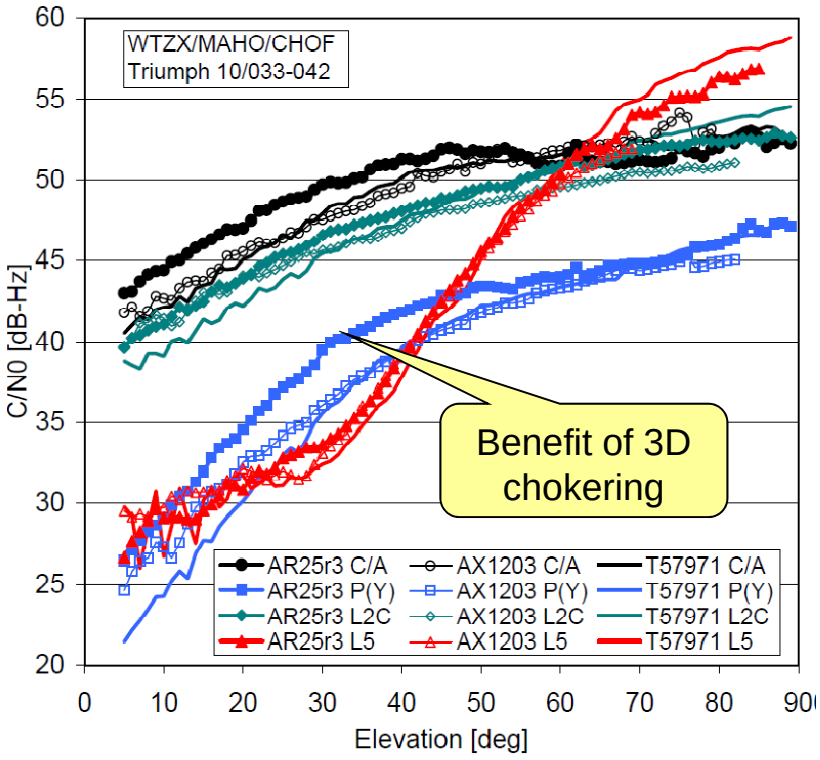
			
Space Engineering „GESS“ Antenna	Leica AR25R3	Leica AX1203+	Trimble Zephyr Geodetic II
	39 dB	29 dB	50 dB
Same as Galileo Experimental Sensor Stations	Dorne Margolin element 3D choke ring	Pinwheel antenna element	Very high gain

Receivers

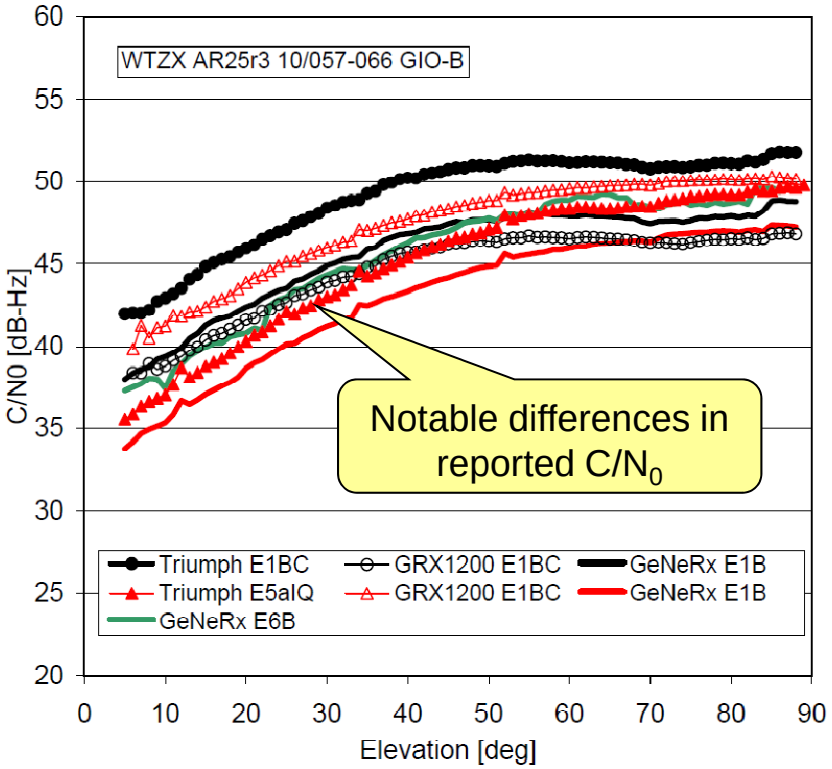
			
Septentrio GeNeRx1 („GETR“)	NovAtel Europak15a	Javad Triumph DeltaG2T/G3TH	Leica GRX1200+GNSS
GPS L1 C/A, L1 P(Y), L2 P(Y) GIOVE E1-A/B/C, E5a-I/Q, E5b-I/Q, E5-I/Q, E6-A/B/C	GPS L1 C/A, L5 GIOVE E1-B/C, E5a-I/Q	GPS L1 C/A, L1 P(Y), L2C, L2 P(Y), L5 GIOVE E1-B&C, E5a-I&Q GLONASS L1 C/A, L1 P, L2 C/A, L2 P SBAS L1,L5	GPS L1 C/A, L2C, L2 P(Y), L5 GIOVE E1-B&C, E5a-I&Q, E5b-I&Q, E5-Q GLONASS L1 C/A, L1 P, L2 C/A, L2 P SBAS L1,L5
E6, E5 AltBOC	no GPS L2	216 channels	E5 AltBOC, no P1

Signal Strength

GPS Block IIR-M (Delta-G2T)

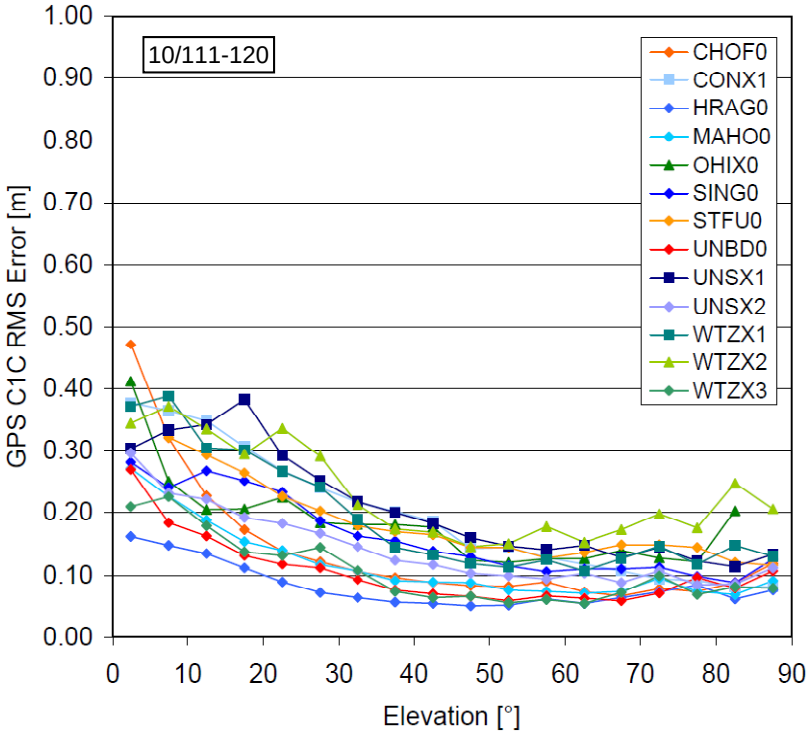


GIOVE-B (AR25r3)

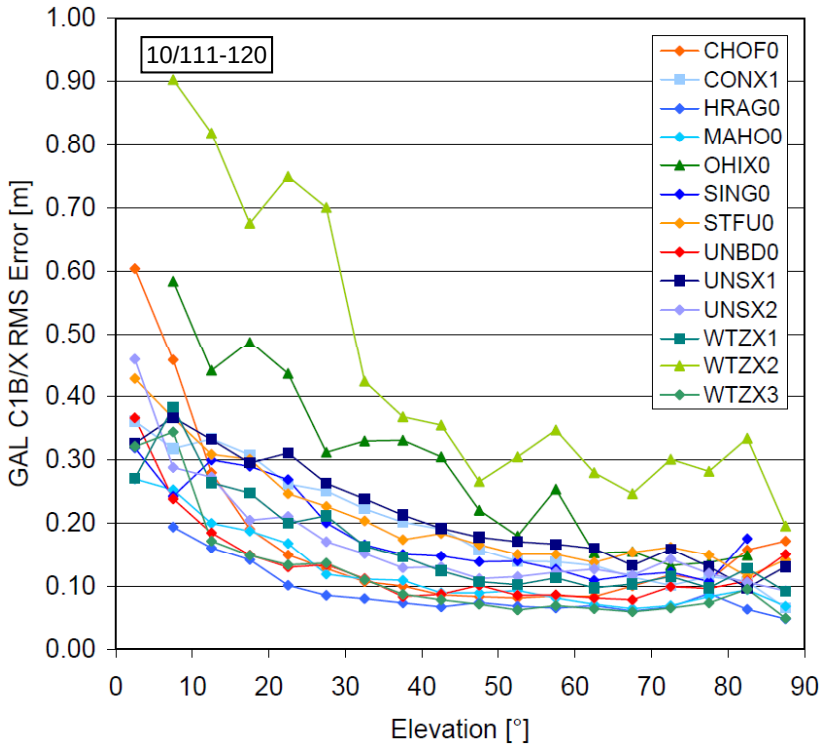


Noise and Multipath (I)

GPS C/A
(50s smoothing)

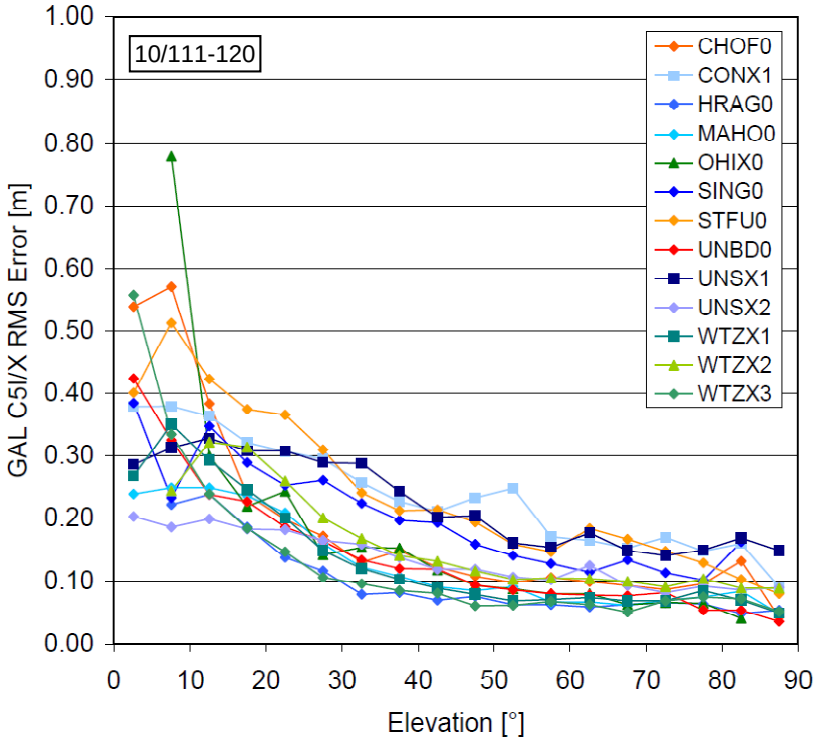


GIOVE E1 O/S
(50s smoothing)

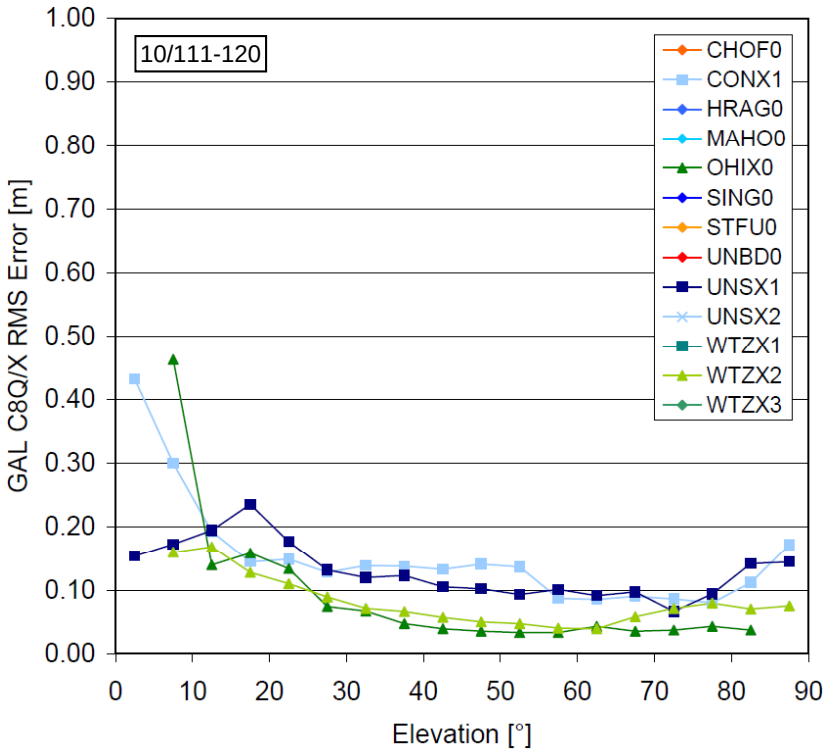


Noise and Multipath (II)

GIOVE E5a
(50s smoothing)



GIOVE E5 AltBOC
(50s smoothing)



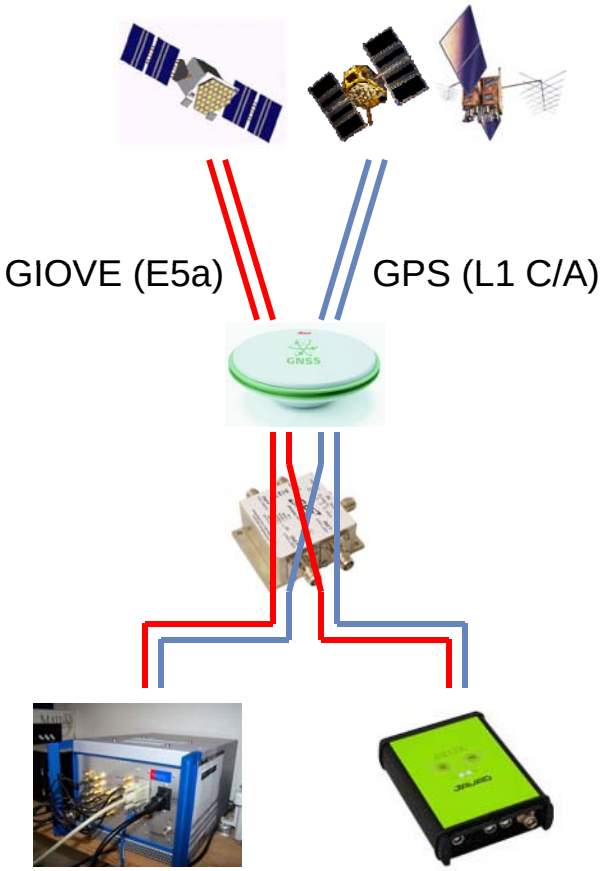
Double-Difference Biases (Concept)

- Zero-baseline Configuration
- Signal-specific receiver-receiver single-differences eliminates geometry, etc.
- Averaging across tracked satellites gives differential clock offset
- Differencing across signals gives double-difference of biases

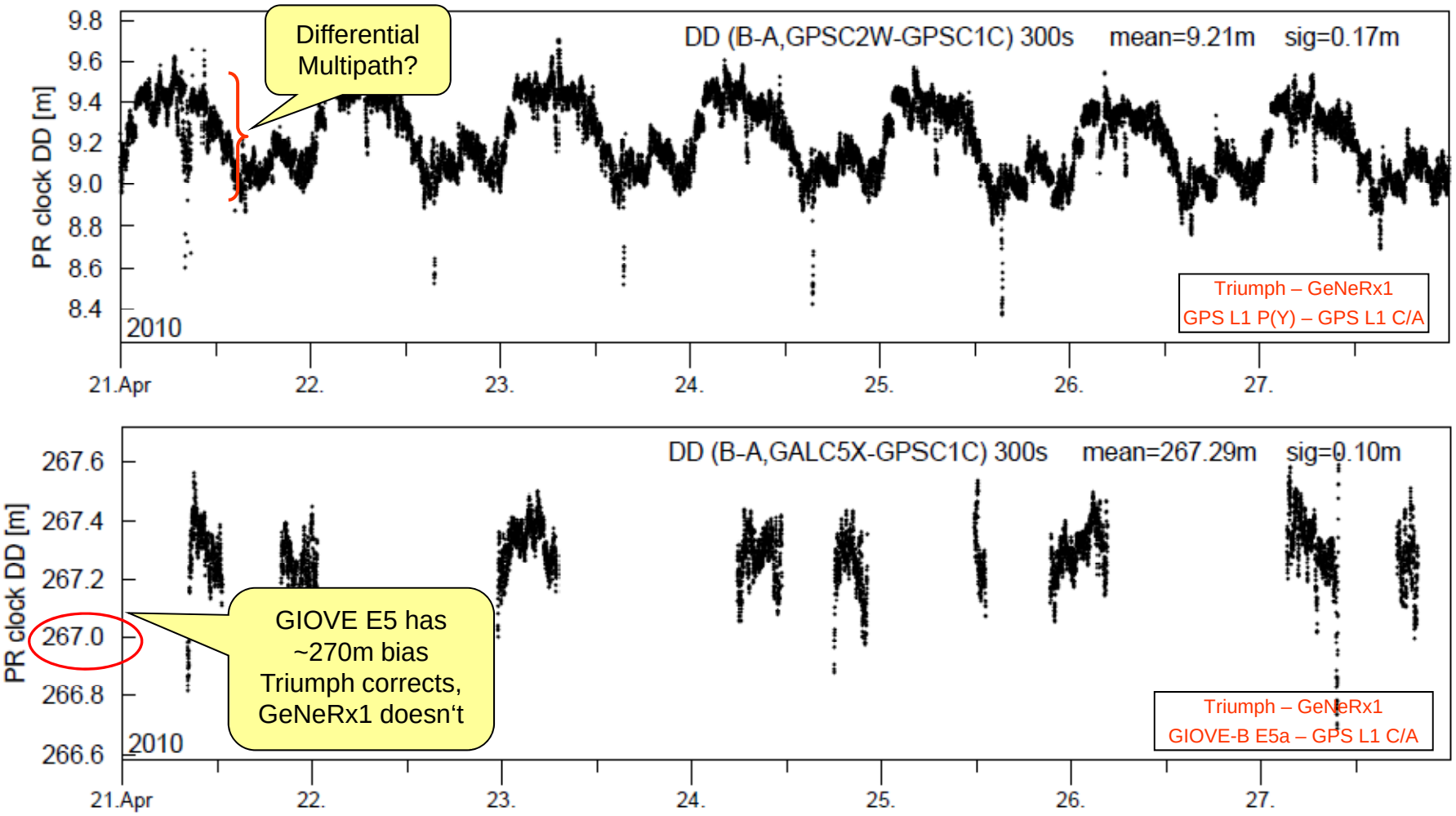
$$\begin{aligned}\rho \quad = \quad & \left| \boldsymbol{r}_{\text{rcv}} - \boldsymbol{r}^{\text{sat}} \right| + c \cdot (\delta t_{\text{rcv}} - \delta t^{\text{sat}}) \\ & + T^{\text{sat(sig)}}_{\text{rcv(sig)}} \pm I^{\text{sat(sig)}}_{\text{rcv(sig)}} + P^{\text{sat(sig)}}_{\text{rcv(sig)}} + (N\lambda)^{\text{sig}} \\ & + B_{\text{rcv(sig)}} + B^{\text{sat(sig)}} \\ & + M^{\text{sat(sig)}}_{\text{rcv}} + \varepsilon\end{aligned}$$

$$\nabla\Delta B^{\text{y-x}}_{\text{B-A}} = \overline{\Delta\rho^{\text{y}}_{\text{B-A}}} - \overline{\Delta\rho^{\text{x}}_{\text{B-A}}}$$

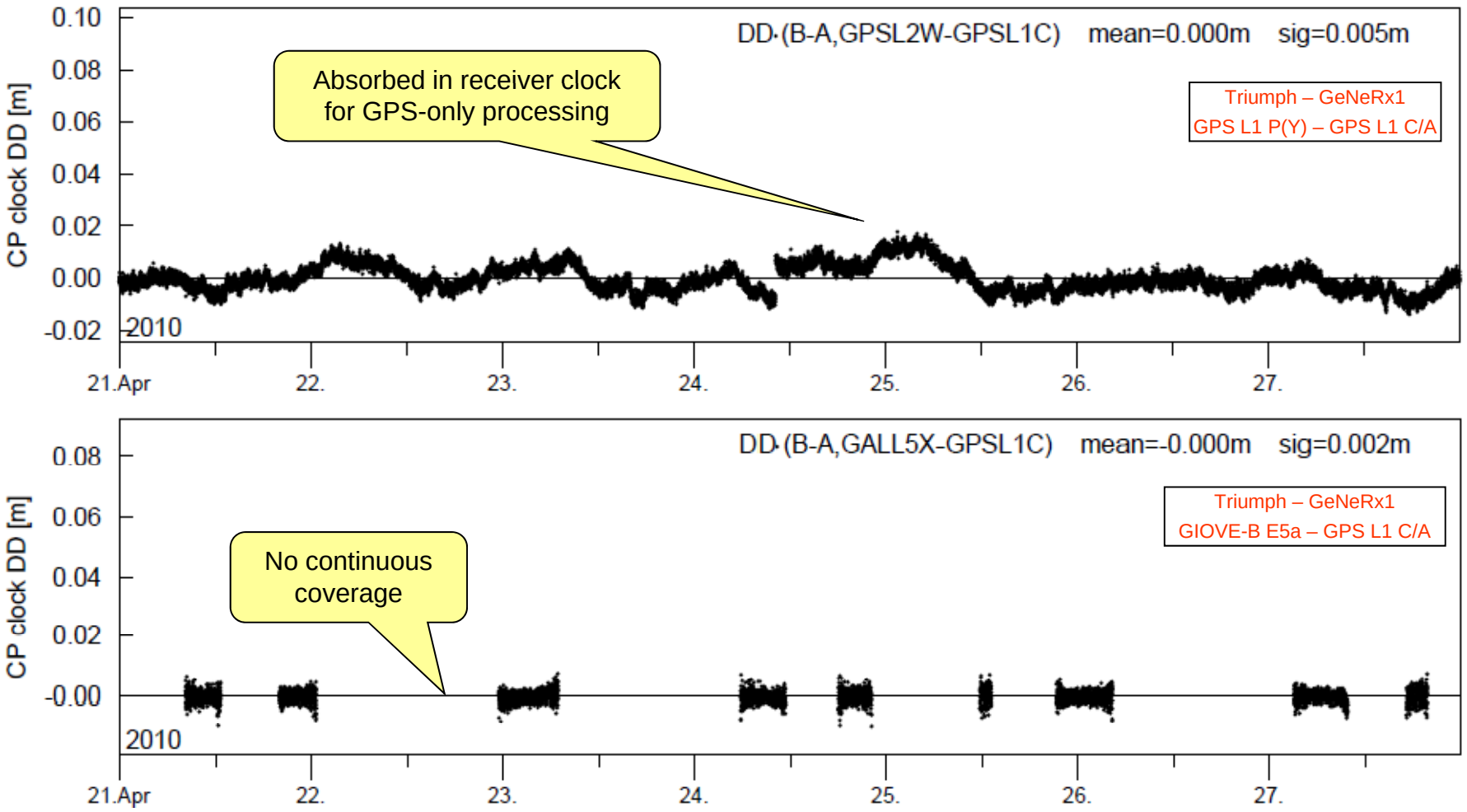
Example:



Double-Difference Biases (Code)



Double-Difference Biases (Phase)

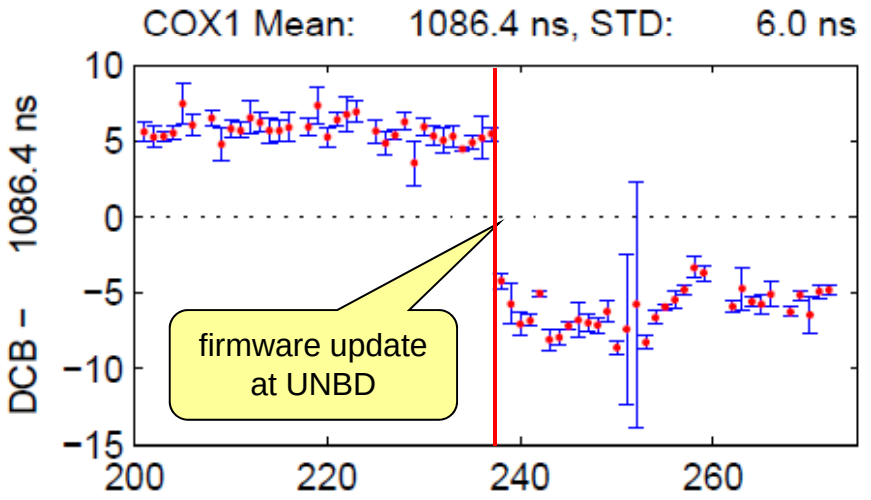


Intersystem Bias in Combined GPS/GAL Processing

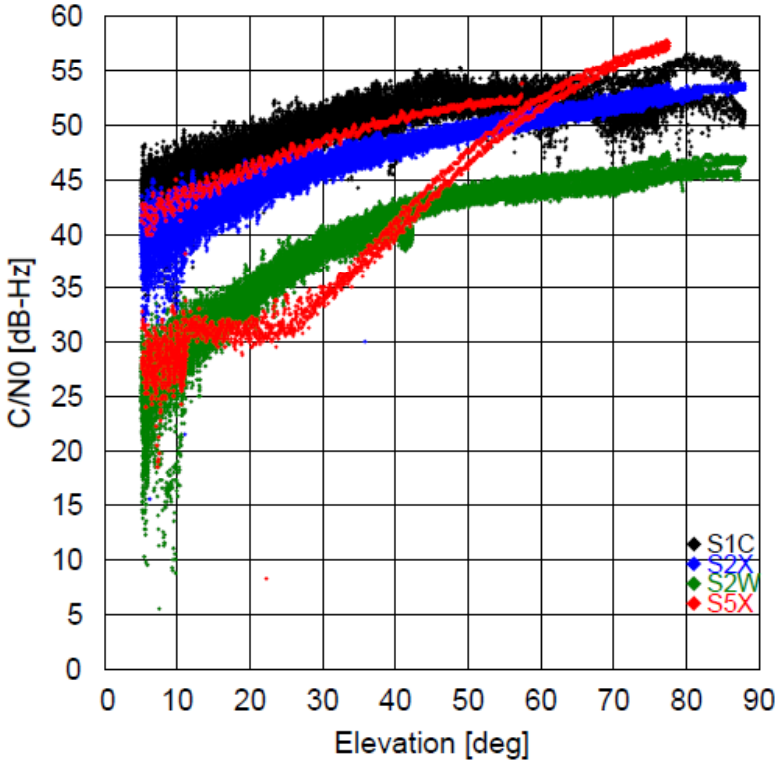
- GPS uses iono-free L1/L2 P(Y)
- GAL uses iono-free E1/E5a (for example)
- ISB „maps“ GAL to GPS
- ISB = difference of „iono-free“ combination of elementary biases
- Zero ISB for one reference station (CONGO: UNBD)
- ~320m ISB for GeNeRx1 stations

$$\rho = \left| \boldsymbol{r}_{\mathrm{rcv}} - \boldsymbol{r}^{\mathrm{sat}} \right| + c \cdot (\delta t_{\mathrm{rcv}}^{(\mathrm{GPS})} - \delta t^{\mathrm{sat}}) + \mathrm{ISB} + \ldots$$

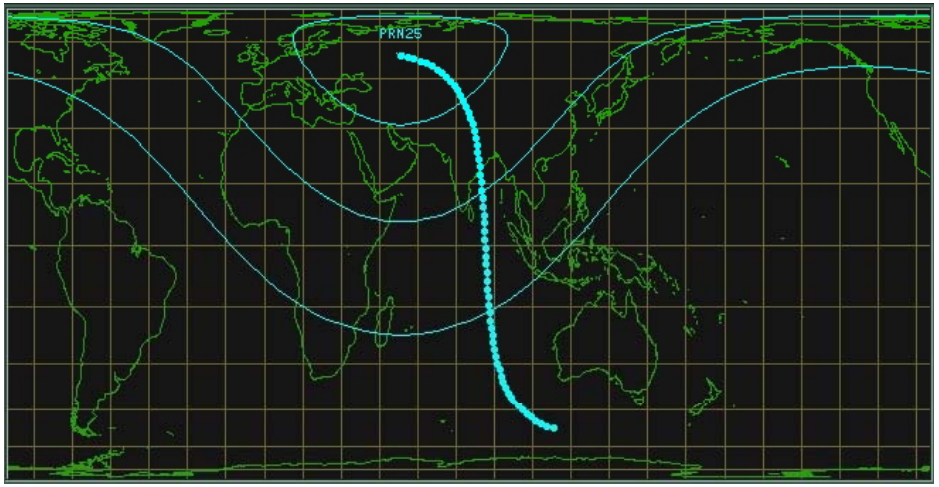
$$\begin{aligned} \mathrm{ISB}_{\mathrm{Rcv}}^{\mathrm{GAL}} = {} & (1+\beta)\nabla\Delta B_{\mathrm{Rcv\text{-}Ref}}^{\mathrm{GALC1X\text{-}GPSC1C}} - \beta\nabla\Delta B_{\mathrm{Rcv\text{-}Ref}}^{\mathrm{GALC5X\text{-}GPSC1C}} \\ & -(1+\alpha)\nabla\Delta B_{\mathrm{Rcv\text{-}Ref}}^{\mathrm{GPSC1W\text{-}GPSC1C}} + \alpha\nabla\Delta B_{\mathrm{Rcv\text{-}Ref}}^{\mathrm{GPSC2W\text{-}GPSC1C}} \end{aligned}$$



Sneak Preview: GPS L5



- First L5 reported transmission of PRN25 on 17 June 2010
- 5.5h over Diego Garcia
- Favorable C/N0 and code quality
- Carrier phase data analysis pending



Summary and Conclusions

- First global GIOVE tracking network for science users
  - Postprocessed GIOVE orbit and clock products (TUM; →Talk P.Steigenberger)
  - Real-time clock solutions (DLR; → Poster A. Hauschild!)
- Ongoing equipment validation, characterization and improvement
  - Lacking phase patterns
  - Stability of intersignal/intersystembiases?
- Similar pseudorange performance for all signals except E5 AltBOC
  - Advanced multipath mitigation techniques
  - Frontend bandwidth
- Substantial effort for multi-GNSS processing s/w
  - Increased complexity, inflationary number of data types
  - Need for epoch-wise inter-system biases?

Long road ahead before prospects of new signals and constellations can be fully materialized

Disclaimer

The choice of receivers and antennas in the CONGO network has largely been driven by the availability of equipment for multi-frequency multi-GNSS tracking in the early deployment phase. It does not indicate an a priori preference of DLR or BKG for one manufacturer over another. Readers are, however, advised to independently assess the suitability of specific instrumentation for their own needs and to consult other sources where available. For the GRX1200+GNSS receiver, a prototype firmware was made available by the manufacturers that supports reception of the experimental GIOVE signals but does not necessarily represent the tracking performance envisaged for the final Galileo constellation.