Raw Observation PPP and Global Network Solution

TECHNISCHE UNIVERSITÄT DARMSTADT

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Outline

1. Observation modelling
2. Challenge of parametrisation
3. Comparison vs. Common approaches
4. Benefits of raw processing
5. Conclusions

Observation equation

General (Raw)

$$Pr(t)^{sat}_{rec,freq,sig} = |\vec{x}(t)_{rec} - \vec{x}(t-\tau)^{sat}| + c * \delta t(t)_{rec} - c * \delta t(t)^{sat} - \delta trop_{rec} + \delta ion(t)^{sat}_{rec,freq} - \delta ucd^{sat}_{rec,freq,sig} - mod - \delta mod - \delta mp - \epsilon$$

$$Ph(t)^{sat}_{rec,freq,sig} = |x\vec{(t)}_{rec} - x(t \vec{-} \tau)^{sat}| + c * \delta t(t)_{rec} - c * \delta t(t)^{sat} - \delta trop_{rec} - \delta ion(t)^{sat}_{rec,freq} - \delta upd^{sat}_{rec,freq,sig} - N * \lambda - mod - \delta mod - \delta mp - \epsilon$$

Name	Meaning
Pr / $Ph(t)$	Phase/Code observation
$\vec{x}(t-\tau)^{sat}$	Satellite Position at transmission time
$\vec{x}(t)$	ECEF Position reception time t
δt	Clock error (Receiver/Sat)
$\delta trop$	Troposphere (unmodelled)
δucd / upd	Uncalibrated Code/Phase Delay
mod	Models (PCO/PCV, Trop., ...)
δmod	Model errors
δmp	Multipath
ϵ	Noise
sat	Satellite
rec, $freq$, sig	Receiver, Frequency, Signal
$N * \lambda$	Carrier phase ambiguity * Wavelength
c	Speed of light

Observation equation

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In general, for reasons of simplicity, UCDs/UPDs are assumed to be dividable into receiver and satellite components.

Observation equation

Ionosphere free LC

$$Pr(t)^{sat}_{rec,freq,sig} = |\vec{x}(t)_{rec} - \vec{x}(t-\tau)^{sat}| + c*\delta t(t)_{rec} - c*\delta t(t)^{sat} - \delta trop_{rec} + \delta ion(t)^{sat}_{rec,freq}$$
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Observation equation

Single Difference (SD) Ionosphere free LC (1x stat, 2x sat)

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Observation equation

Double Difference (DD) Ionosphere free LC (2x stat, 2x sat)

$$Pr(t)^{sat}_{rec,freq,sig} = |\vec{x}(t)_{rec} - \vec{x}(t-\tau)^{sat}| + c * \delta t(t)_{rec} - c * \delta t(t)^{sat} - \delta trop_{rec} \cancel{+ \delta ion(t)^{sat}_{rec,freq}}$$
$$\cancel{- \delta ucd^{sat,freq,sig} - \delta ucd_{rec,freq,sig}} - mod - \delta mod - \delta mp - \epsilon$$

$$Ph(t)^{sat}_{rec,freq,sig} = |\vec{x}(t)_{rec} - \vec{x}(t-\tau)^{sat}| + c * \delta t(t)_{rec} - c * \delta t(t)^{sat} - \delta trop_{rec} \cancel{- \delta ion(t)^{sat}_{rec,freq}}$$
$$\cancel{- \delta upd^{sat,freq,sig} - \delta upd_{rec,freq,sig}} - N * \lambda - mod - \delta mod - \delta mp - \epsilon$$

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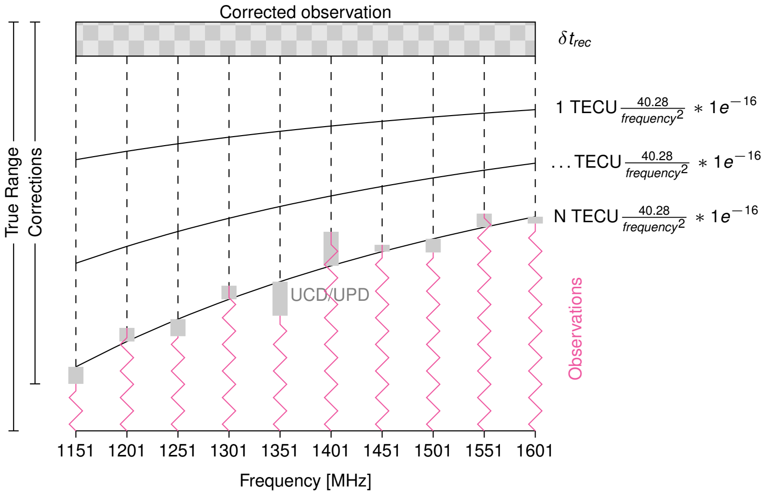
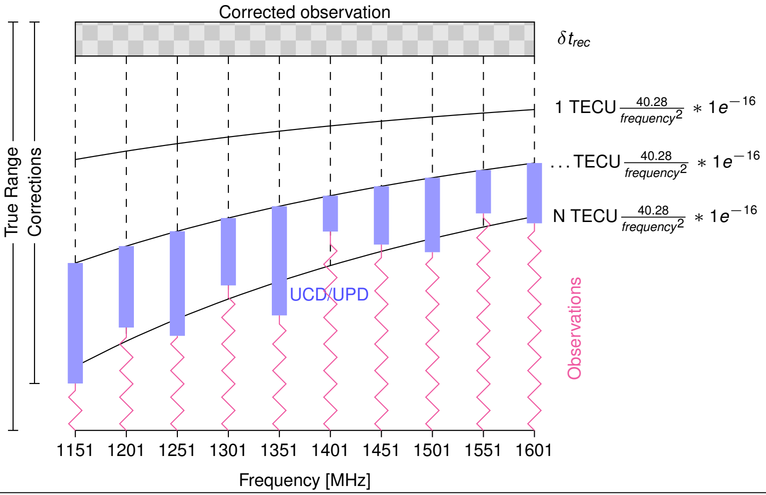
Relations between parameters



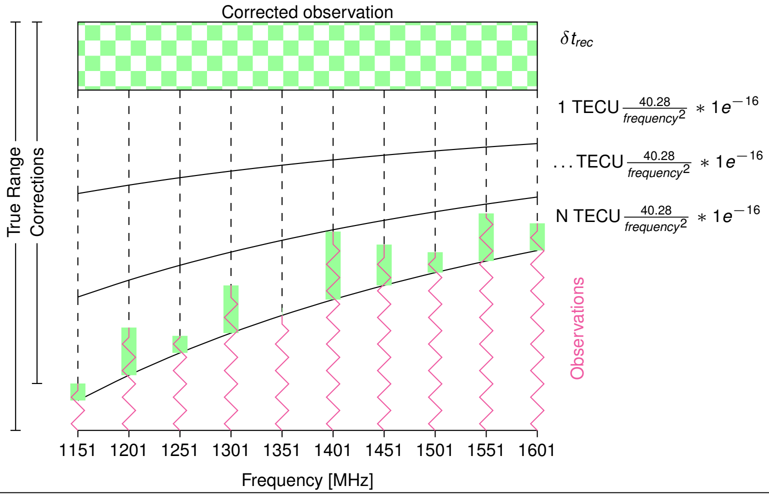
Relations between parameters

TEC difference compensated by UCD



Relations between parameters

Clock difference compensated by UCD



Clock definition

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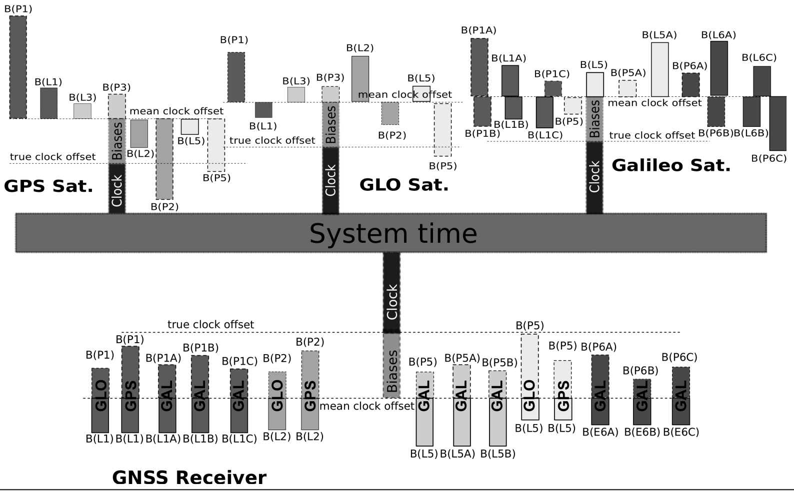


Orbit and clock comparison vs. IGS Finals

60 station global network (days 231-237 2011)

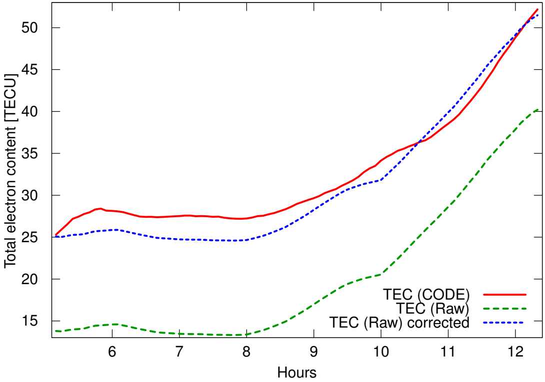
Orbit RMS [mm]	231	232	233	234	235	236	237
Iono. free LC	40.9	39.8	46.9	40.3	39.7	44.7	41.7
Raw	39.2	40.8	43.8	38.6	41.9	43.9	38.7

Clock Std [mm]	231	232	233	234	235	236	237
Iono. free LC	0.075	0.088	0.101	0.096	0.080	0.077	0.093
Raw	0.072	0.077	0.087	0.105	0.079	0.140	0.070

Results comparable to reference solution (Ionosphere free LC)

Comparison of absolute TEC level

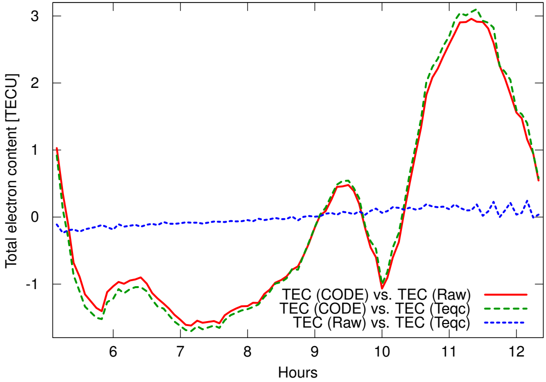
Raw vs. CODE IONEX (1 Satellite path)



TEC (Raw) corrected => DCB - UCD - Difference considered

Comparison of TEC variations

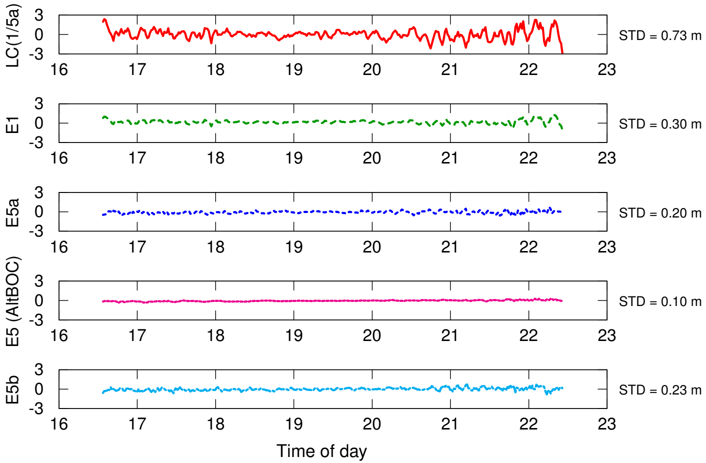
Raw, CODE IONEX vs. Teqc (1 Satellite path)



Mean TEC removed

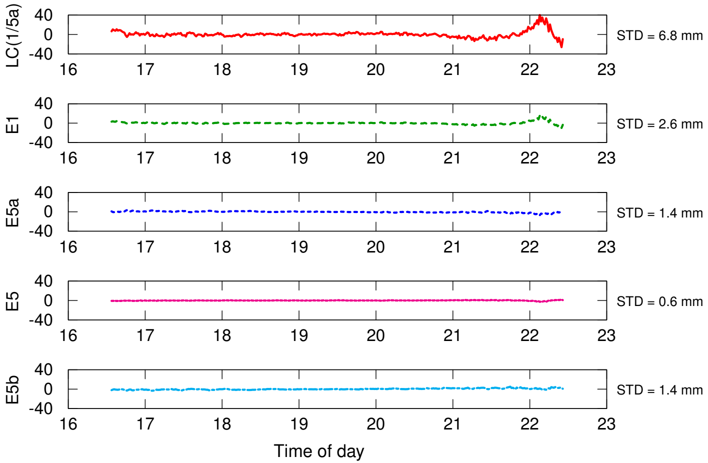
Code residuals (m) GIOVE-B

tracked at DARX receiver TU-Darmstadt



Phase residuals (mm) GIOVE-B

tracked at DARX receiver TU-Darmstadt



Conclusions

Raw signal processing:

- allows a better analysis of individual signals.
- allows a better traceback of individual biases to their real sources.

Dual-Frequency case

- is comparable to common processing strategies.

Multi-Frequency case

- allows the combination of arbitrary GNSSs and signals.
- is expected to provide more accurate parameter estimates, if multiple signals are available.

Thank you for your attention!

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