POSITIONING UNDER ADVERSE CONDITIONS USING HIGH SENSITIVITY GPS SENSORS

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OUTLINE

1. GNSS in normal conditions
2. GNSS under adverse conditions
3. Development of custom procedures for autonomous and DGPS solutions
4. Examples

1. GNSS in normal conditions

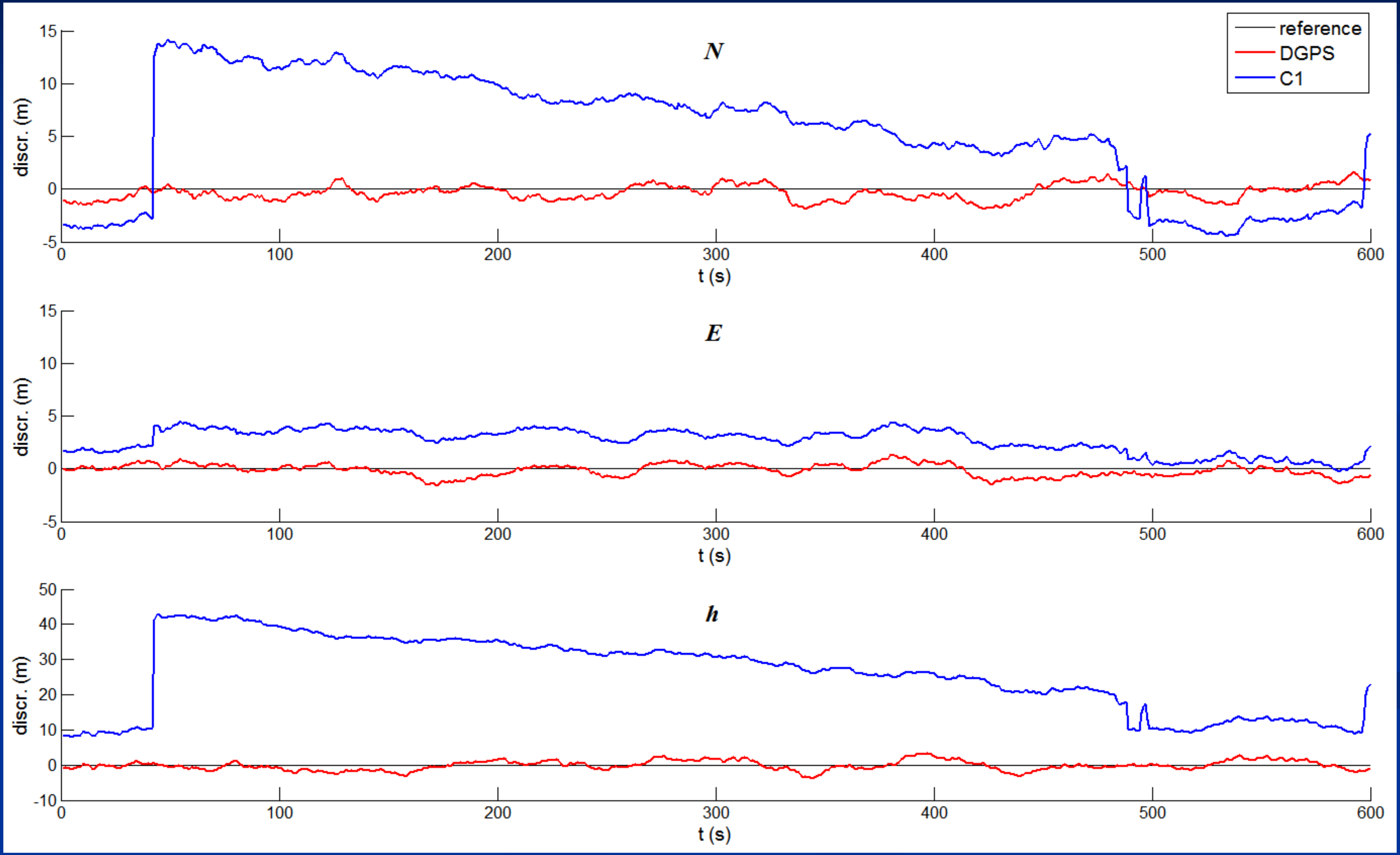
Positioning modes

Autonomous – single receiver
- Basic mode – LSA, code observations
- Several biases and errors – position accuracy around 10 m

Differential GNSS (DGNSS, DGPS) – common processing of data from several receivers, reference receiver on known point
- Code – accuracy few m
- Phase and code – accuracy on a cm-level
- Similar conditions for all receivers are assumed

SBAS - regional corrections from geostationary satellites
- Position accuracy around 5 m

Autonomous and DGPS positioning in normal conditions



2. GNSS under adverse conditions

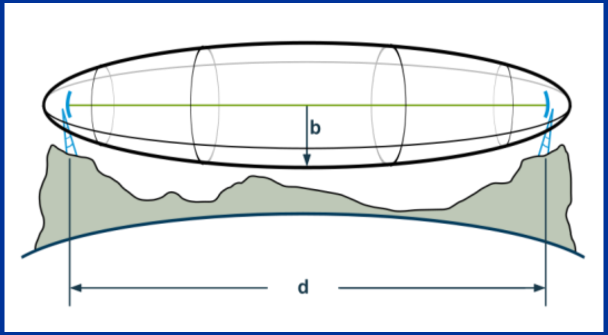
Adverse conditions: signal reflection, signal attenuation (weakening)

Adverse (obstructed, challenging) conditions/environments:

- urban canyons
- indoors (inside objects)
- thick vegetation

Common GPS receivers

Line-of-sight to satellites



Tracking signals with SNR > 35
Several 10 correlators
Time of signal integration a few ms

Use in obstructed environments very limited!

High Sensitivity GPS receivers

Enable tracking of very weak signals (up to SNR 10)

How do they do it?

1. Extending integration time to several 100 ms (a few ms for common receivers)
2. Several 100.000 or 1 million and more correlators (less than 100 for common receivers)

Enabling use in:

- urban canyons,
- thick vegetation,
- inside objects (limited)

Signal attenuation levels

glass (19 mm)	3,5 dB
dry wood (76mm)	4,3 dB
wet wood	5,5 dB
dry brick	5,0 dB
concrete (203 mm)	26,0 dB
s.r. concrete (203 mm)	29,0 dB

Models of HS GPS receivers

manufacturer	SiRF		u-blox		QinetiQ
website	www.sirf.com		www.u-blox.com		www.qinetiq.com
chip	SiRFstarIII	SiRFstarIV	u-blox 5	u-blox 6	Q20
sensitivity acqusition* acqusition AGPS tracking	 - 172 dBW - 185 dBW - 189 dBW	 - 178 dBW - 188 dBW - 193 dBW	 - 171 dBW na - 189 dBW	 - 177 dBW na - 190 dBW	 - 174 dBW - 185 dBW - 189 dBW
nr. of correlators	> 200.000	na	> 1.000.000	> 2.000.000	na
nr. of channels	20	48	50	na	na

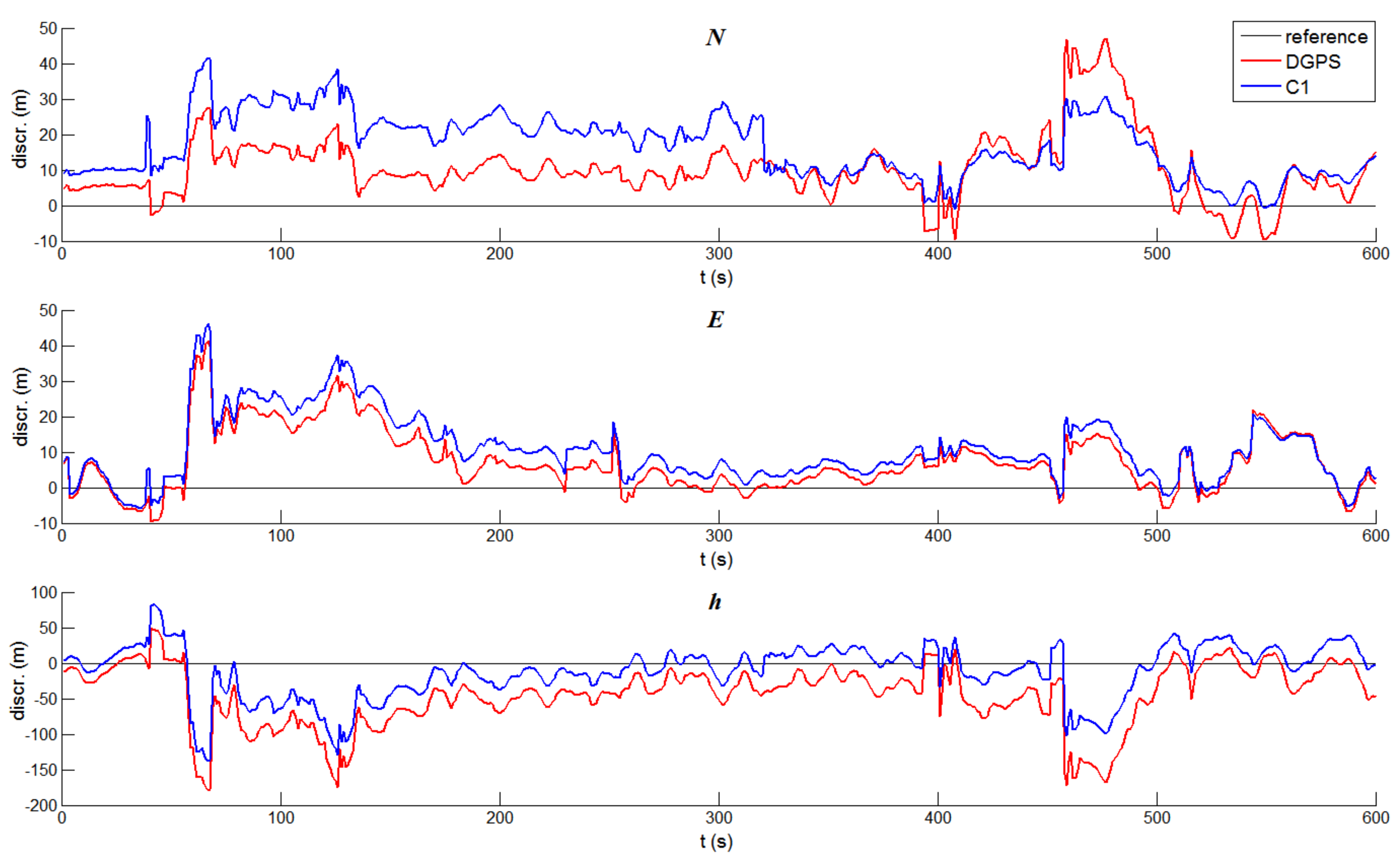
* cold start

Processing of GPS observation data under adverse conditions requires careful and consistent treatment.

Why?

Because large errors can occur!

Autonomous and DGPS solutions in attenuated conditions



2. Development of custom procedures

Method	Normal conditions	Adverse conditions
LSA (Least sq. adj.)	✓	✗
DGPS	✓ ✓	✗
SBAS	✓	
Elevation weighing	✓	✗
SNR weighing	✓	✗

3.1. Custom procedure – autonomous positioning

Use of Doppler observations – similar characteristics to carrier phase observables

Use of robust statistics (L_1-norm) – works better with such data – LSA assumes absence of gross and sistematic errors

Separate determination of receiver clock error and position – use only Doppler data for receiver clock error estimation, use all observation data for position estimation

Initial position has to be determined the usual way (Doppler positioning requires reference ranges).

3.2. Conditional DGPS

Common (unconditional) DGPS performs well only in good conditions

Conditional DGPS

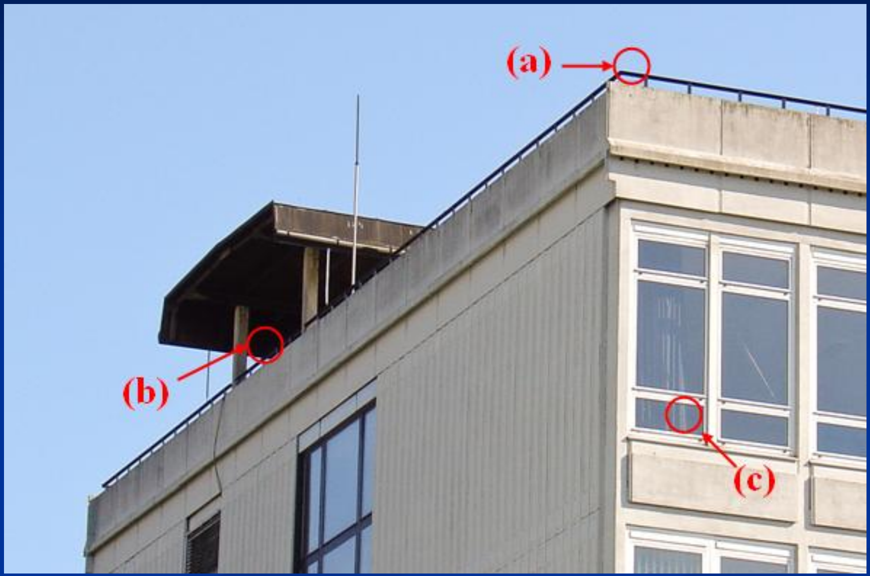
- Only signals with SNR > 35
- At least 6 „strong“ signals observed by the reference receiver at the same time
- Data from a reference receiver: own, permanent station network, VRS

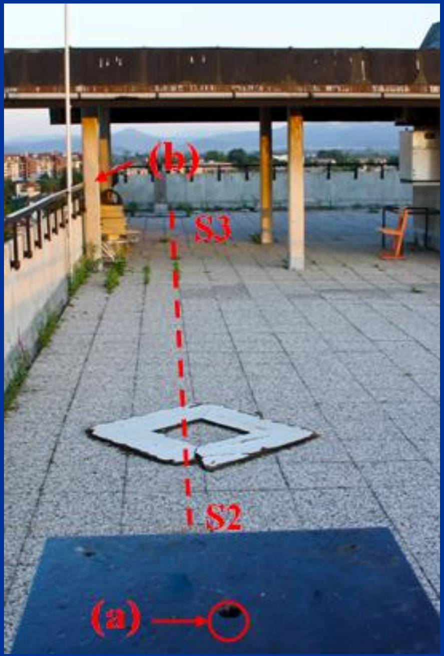
Use of DGPS when all the conditions are met. If not, the custom autonomous positioning is used.

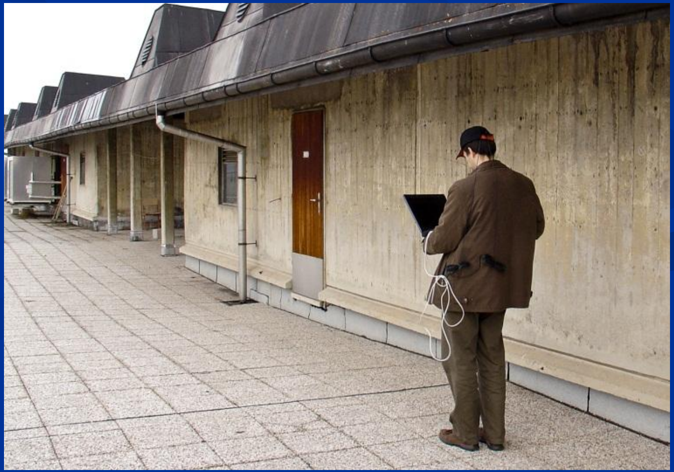
4. Examples

Different conditions:

- unobstructed - normal
- obstructed
- indoors
- mixed conditions – kinematic surveys

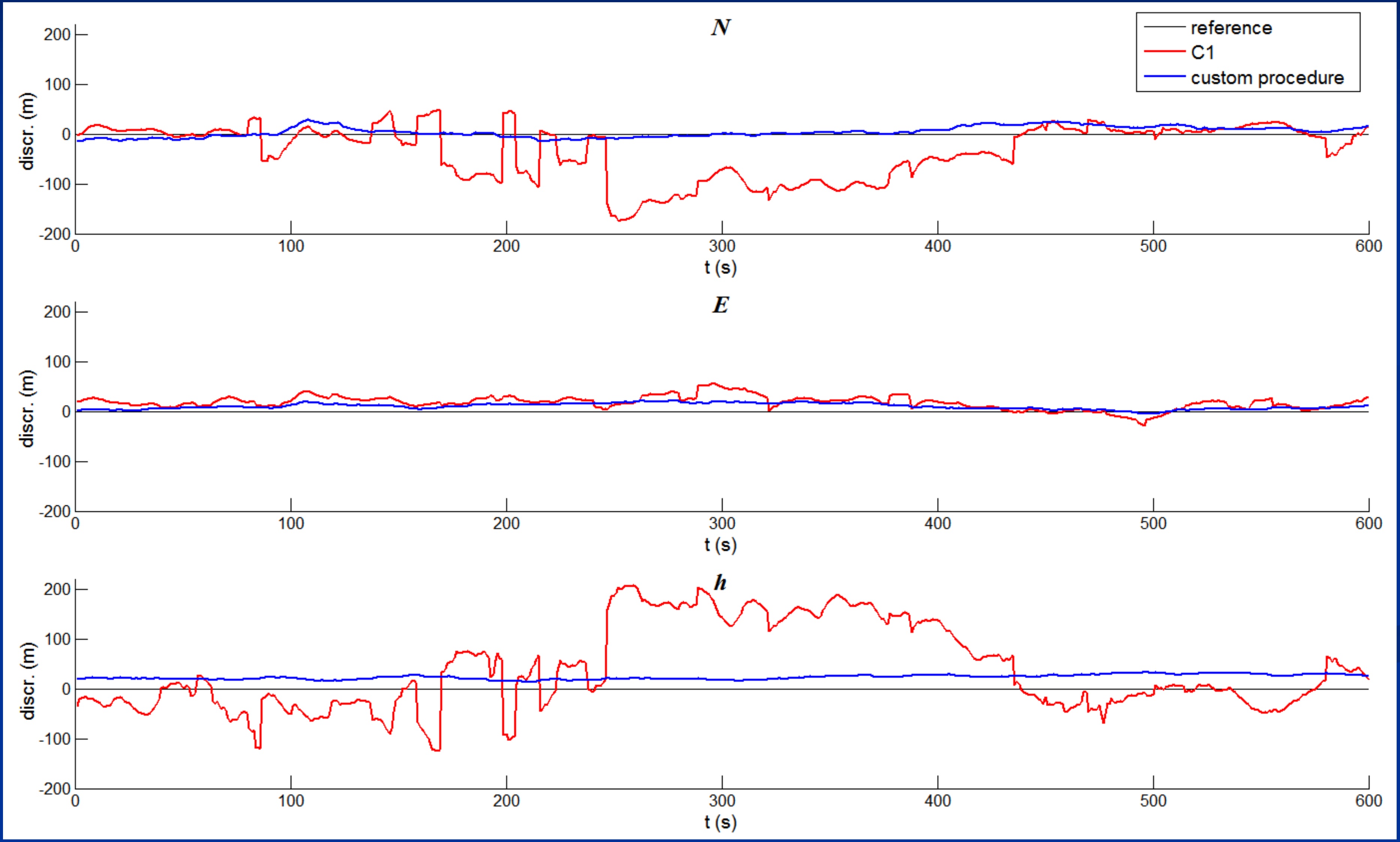






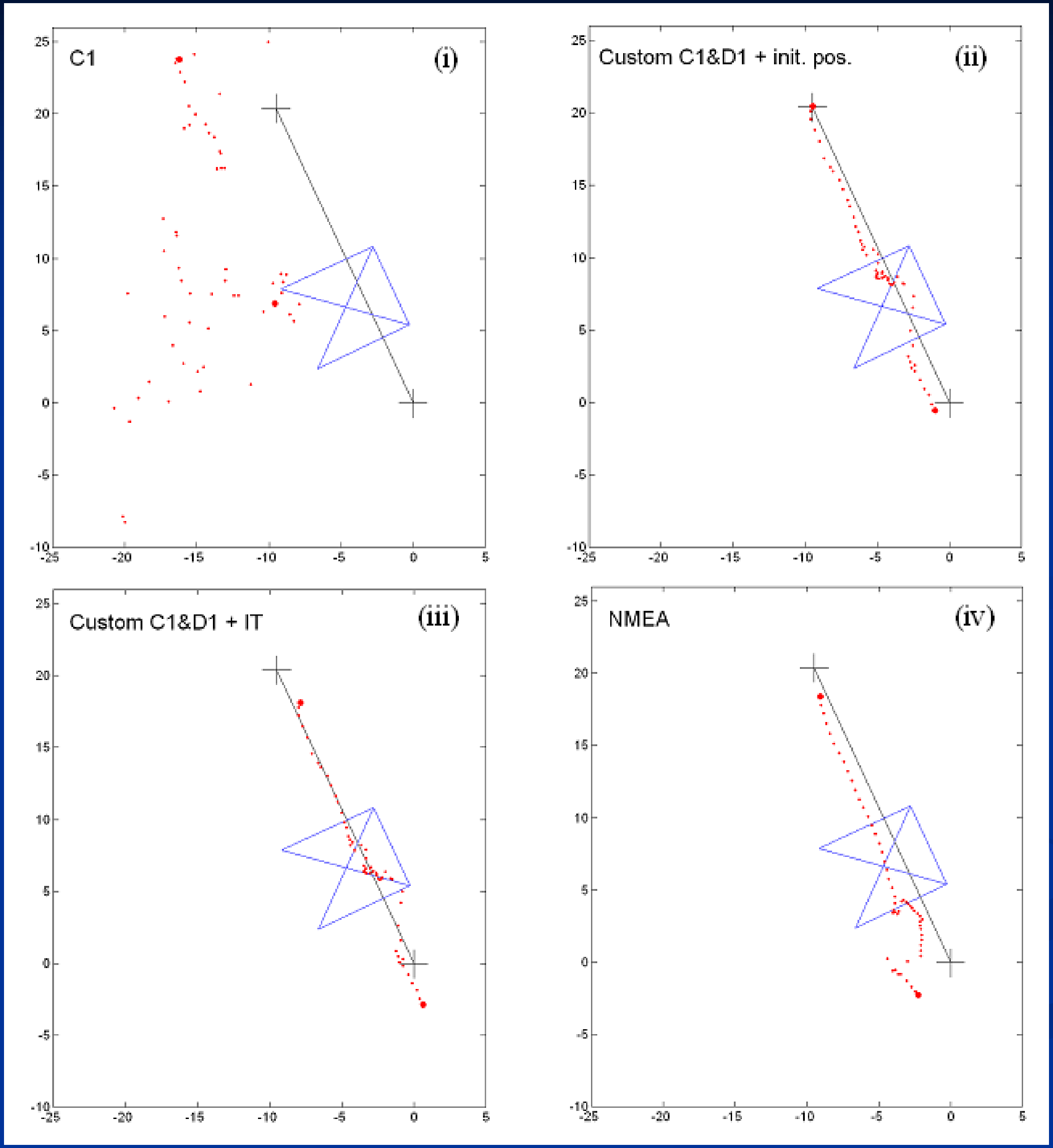
4.1. Static indoor situation

Red – basic code-based positioning, blue – custom procedure

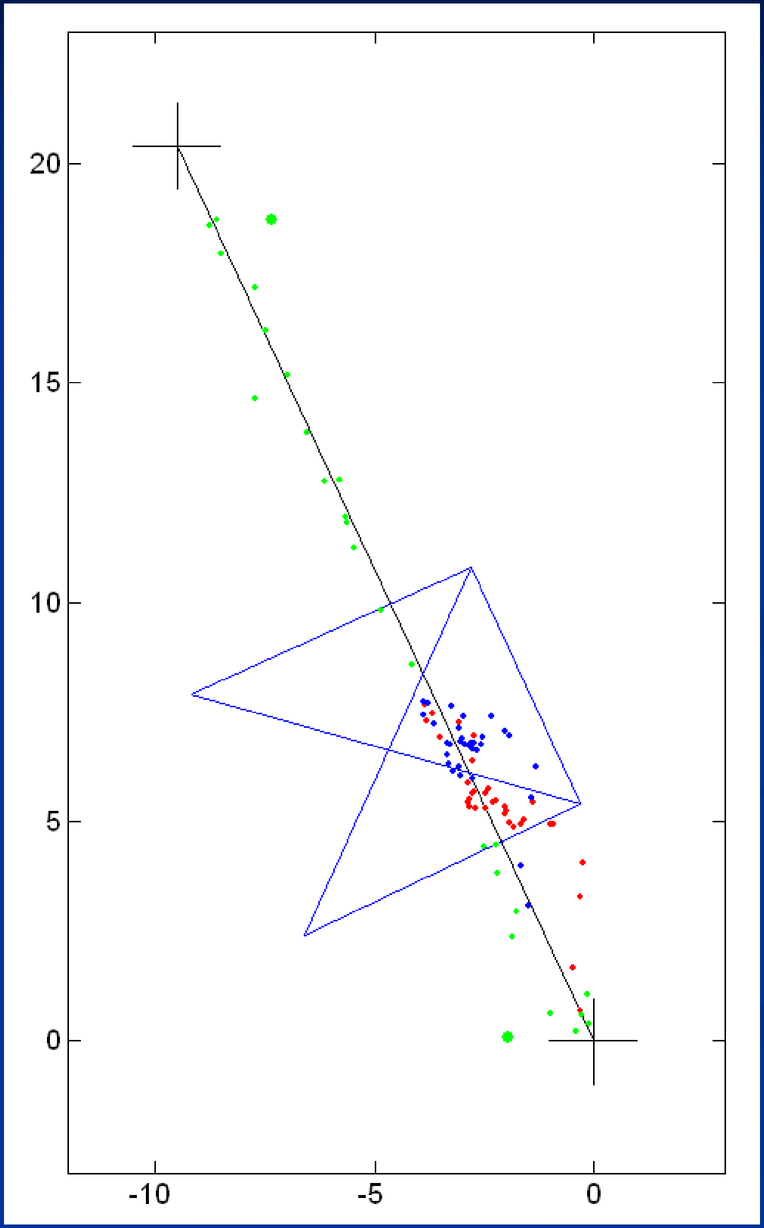


4.2. Kinematic case

Autonomous solutions



Conditional DGPS



- cDGPS
- custom auton.
- corr. custom

Conclusions

Final – the best solution

- Custom procedure using code-based and Doppler observations
- Use of ionosphere and troposphere models

If possible, use conditional DGPS

HS GPS doesn‘t work just everywhere!
Even when it works, the results are not always reliable.

In order to achieve seamless (uninterrupted) navigation, GPS has to be combined with other positioning systems, for instance:

- Inertial navigation system (INS); MEMS
- UWB positioning
- Wi-Fi positioning

Thank you for your attention !

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