7TH BELGIUM GEOGRAPHY DAY

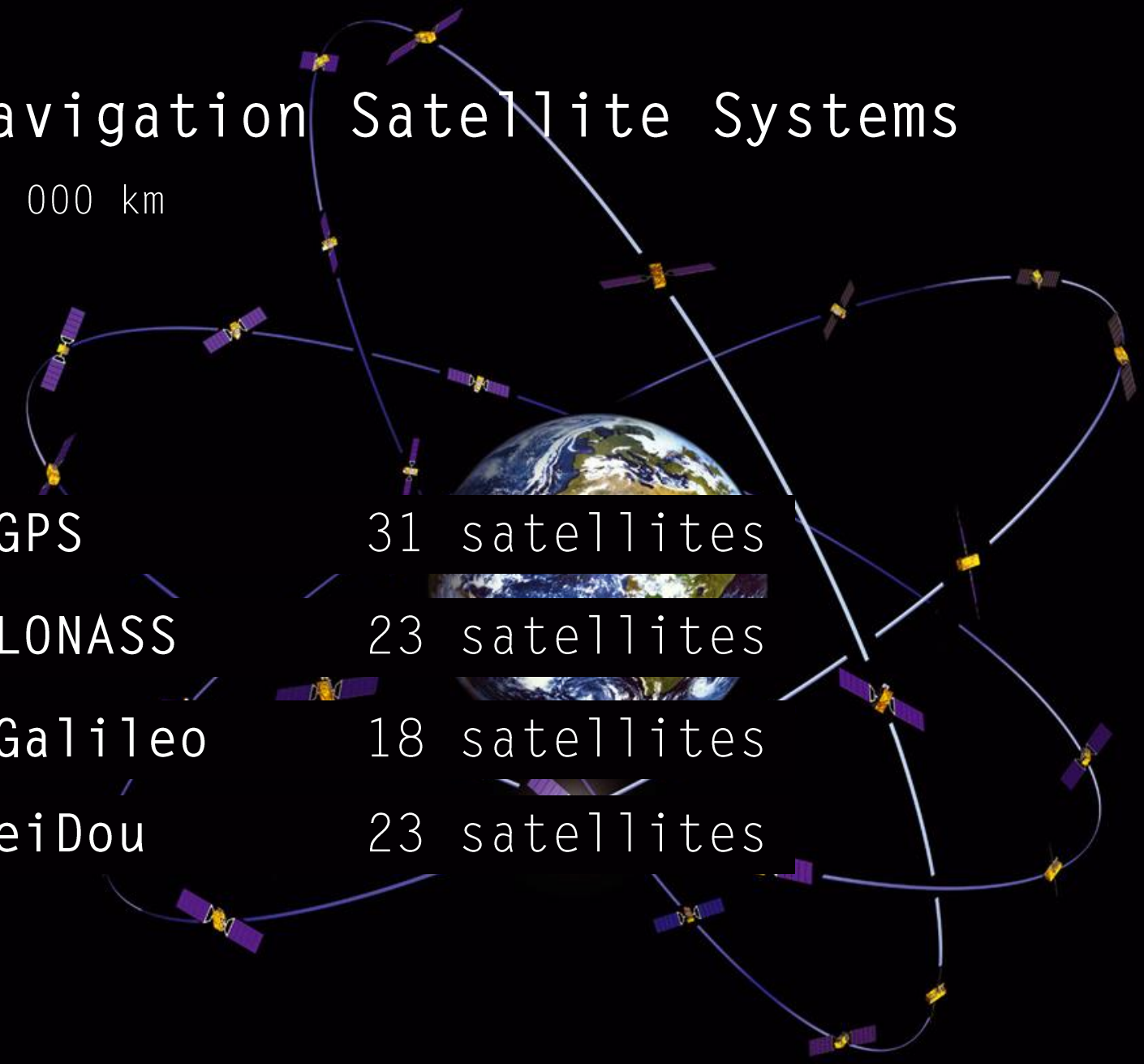
Precise positioning in multi-GNSS mode

Cécile Deprez & René Warnant

Novembre 2017

Global Navigation Satellite Systems

Altitude: ±20 000 km



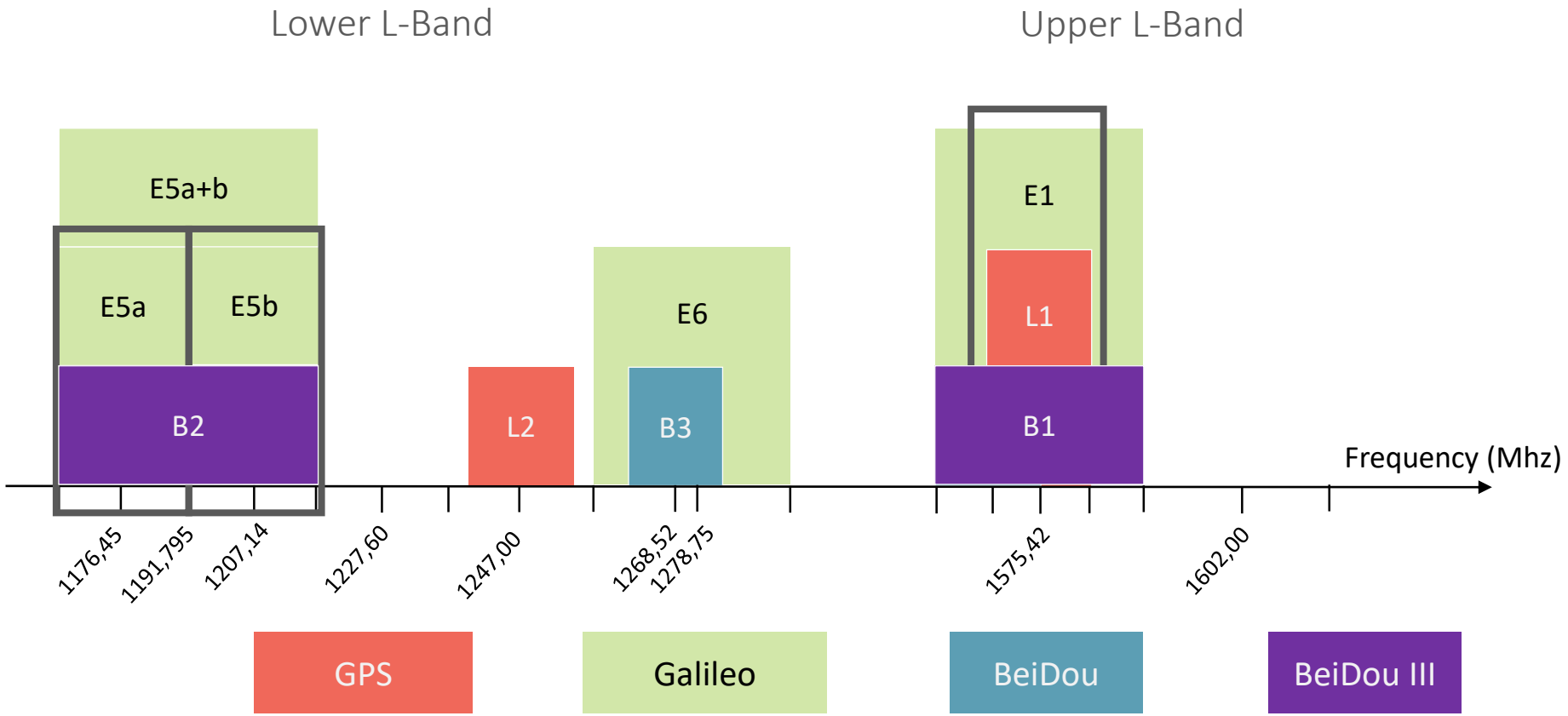
American: **GPS** 31 satellites

Russian: **GLONASS** 23 satellites

European: **Galileo** 18 satellites

Chinese: **BeiDou** 23 satellites

Compatibilities between GNSS

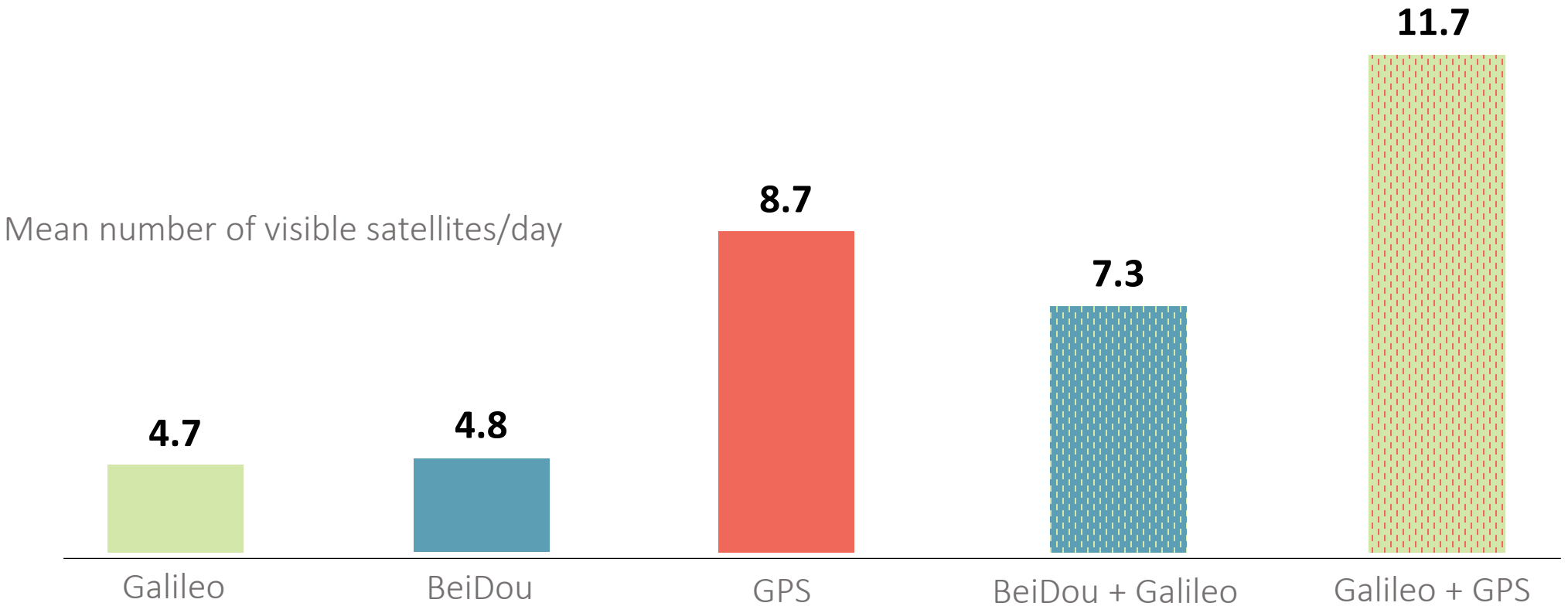


Benefits of multi-GNSS

- More satellites available
  - Satellites visible anywhere anytime

Addition of GNSS

rises the number of visible satellites



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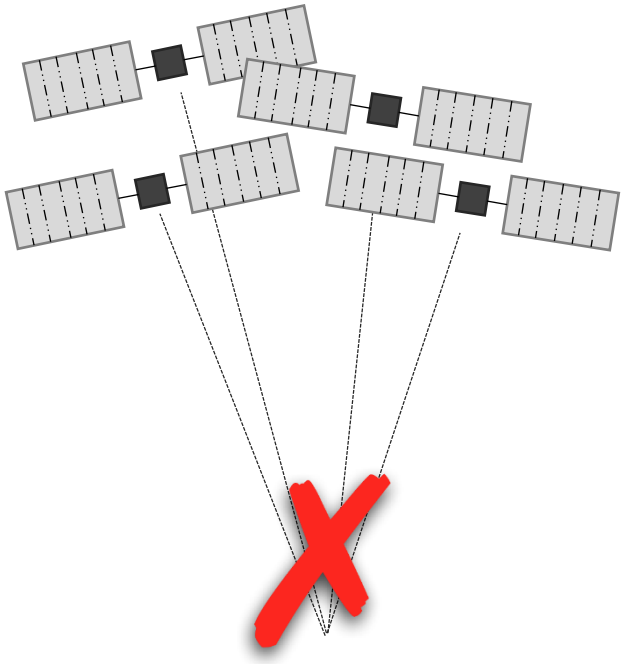
Benefits of multi-GNSS

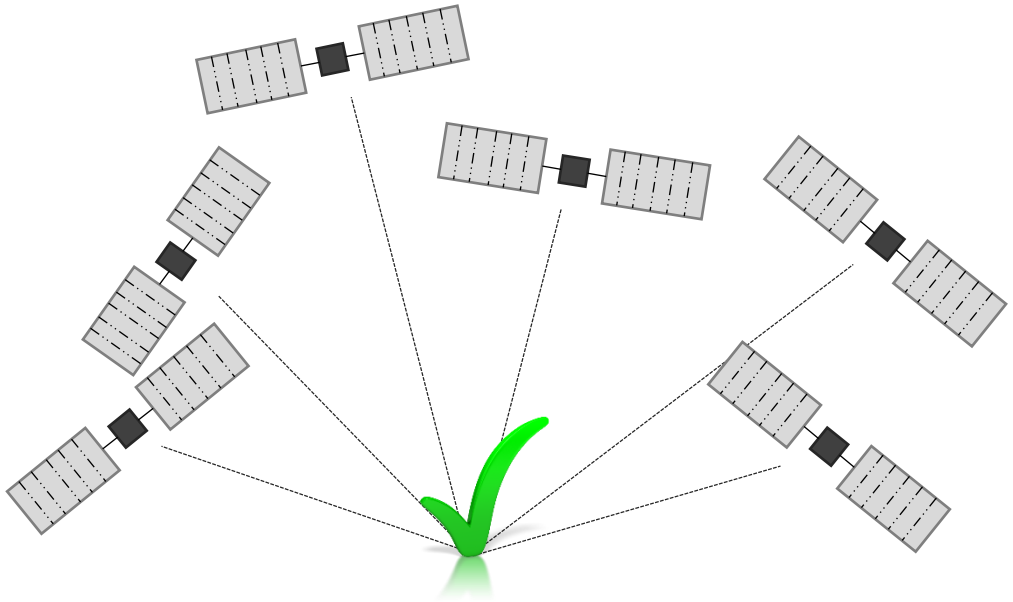
- More satellites available
  - Satellites visible anywhere anytime
  - Improved satellite geometry

The **geometry** of the satellites affects the position precision :

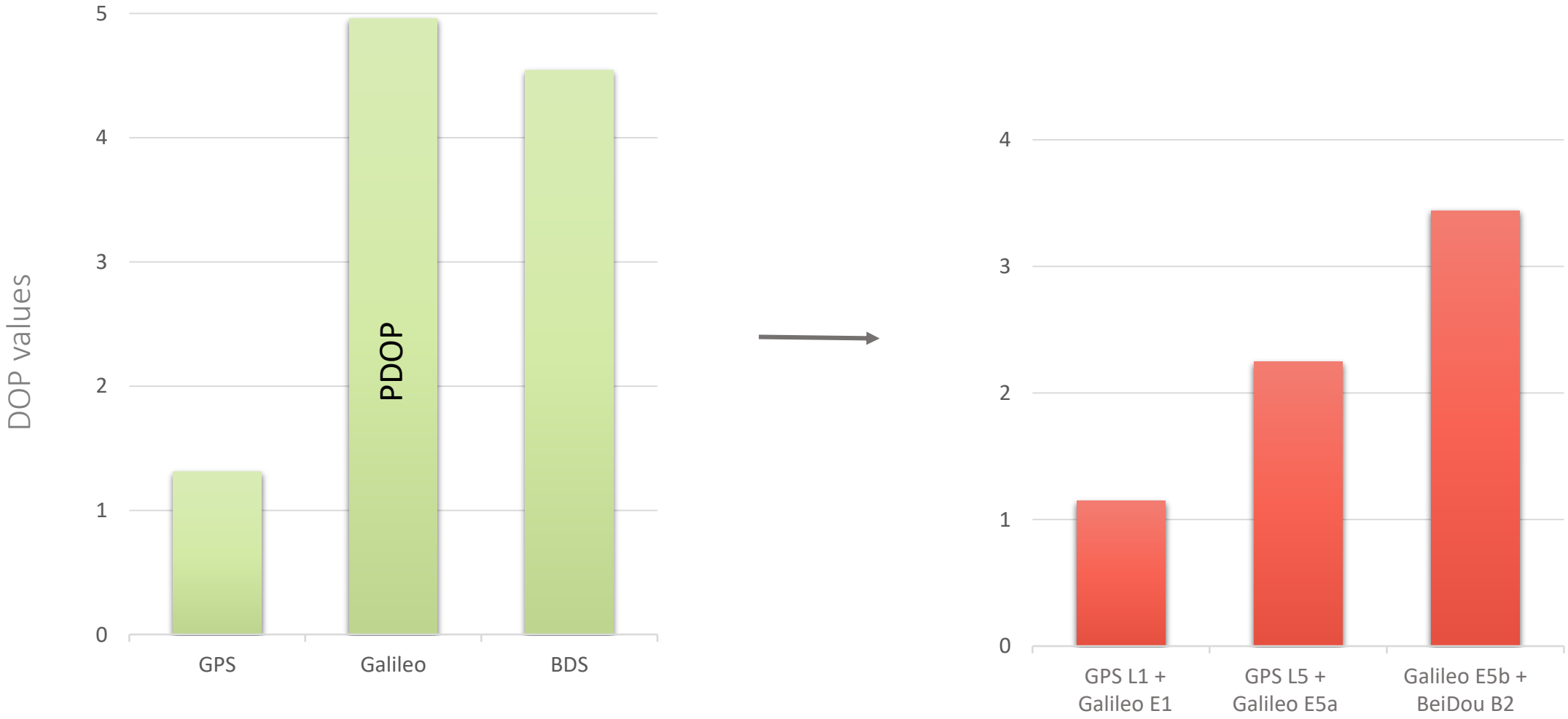
$$\sigma_{POS} = DOP.\sigma_{OBS}$$

Position **D**ilution **O**f **P**recision





Multi-GNSS solution improves geometry



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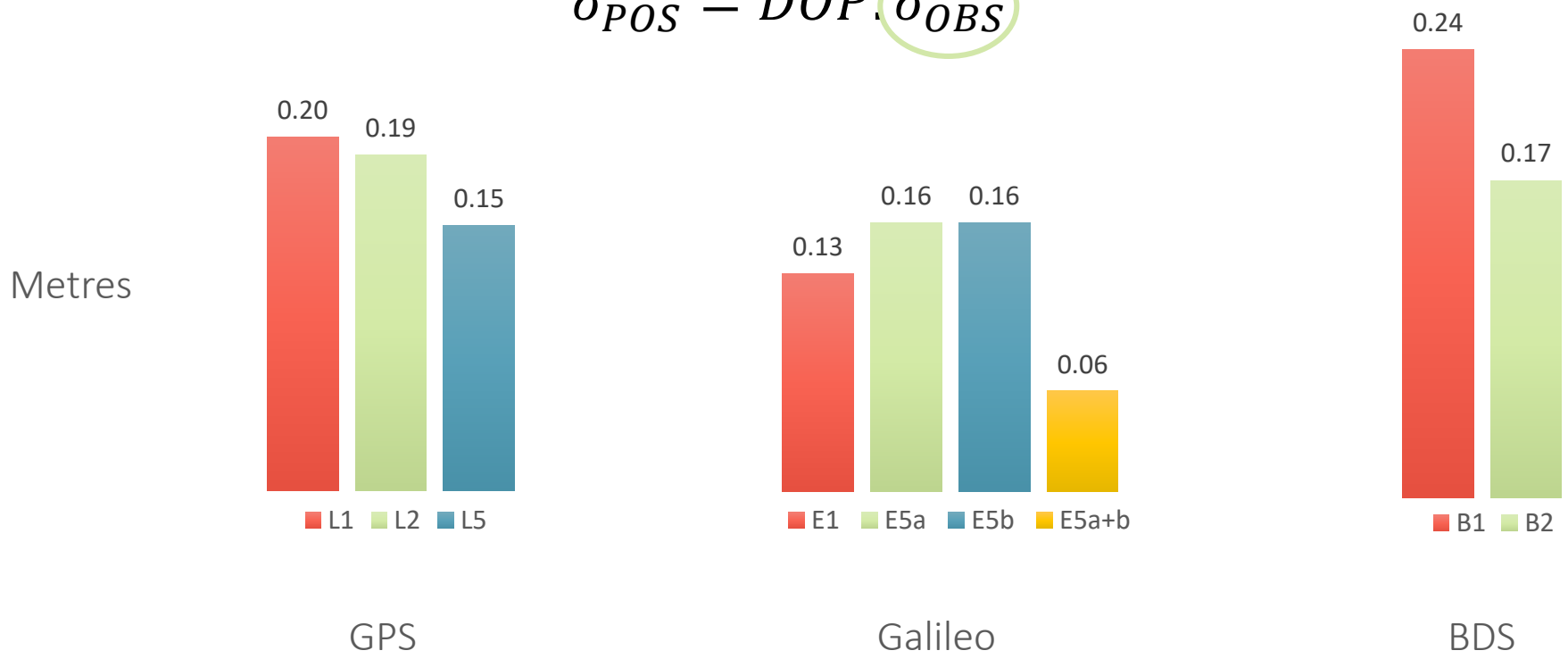
Benefits of multi-GNSS

- ❑ More satellites available
  - Satellites visible anywhere anytime
  - Improved satellite geometry
- ❑ New frequencies available

Best precisions with Galileo code signals

New signals = more robust

$$\sigma_{POS} = DOP . \sigma_{OBS}$$

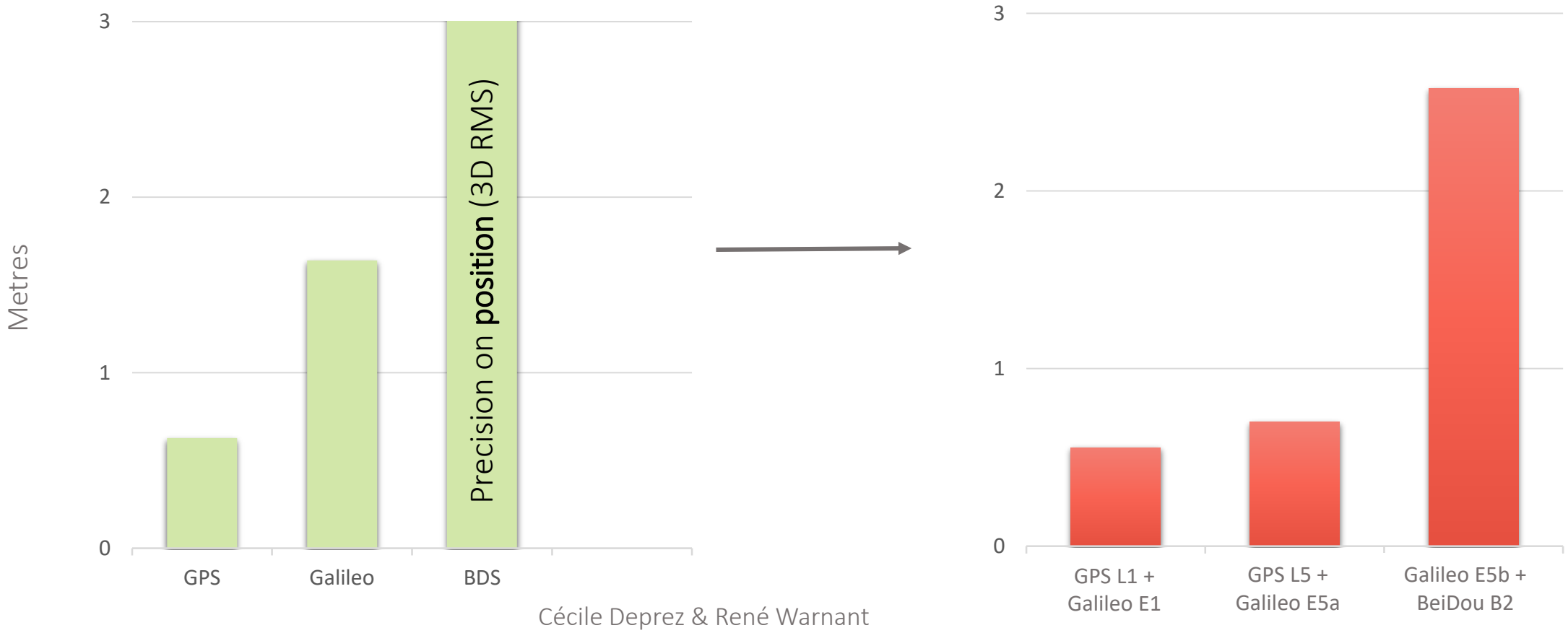


Benefits of multi-GNSS

- ❑ More satellites available
  - Satellites visible anywhere anytime
  - Improved satellite geometry
- ❑ New frequencies available
- ❑ Improved precision on position

Multi-GNSS solution leads to more precise positions

regardless of the type of receiver used



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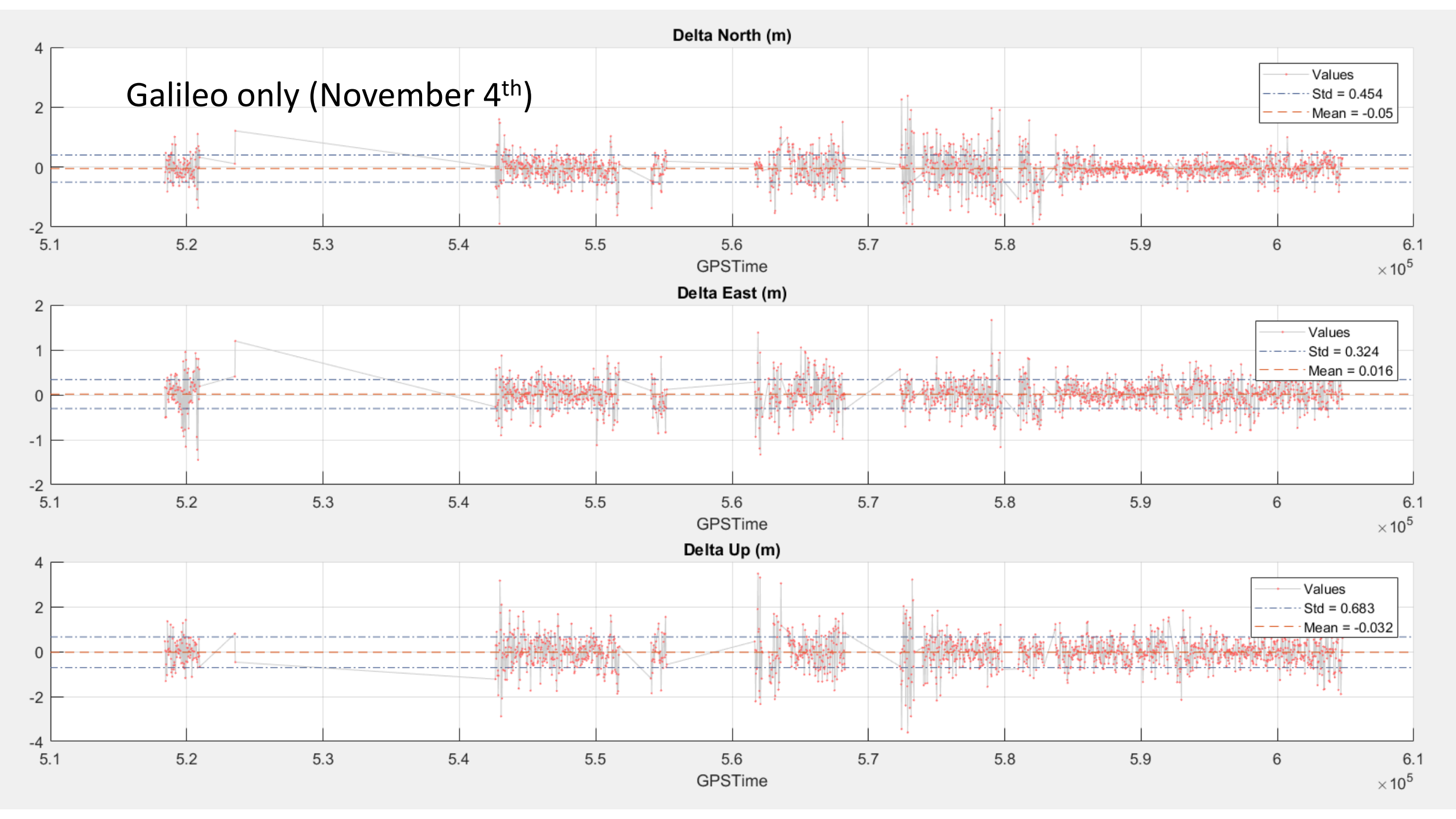
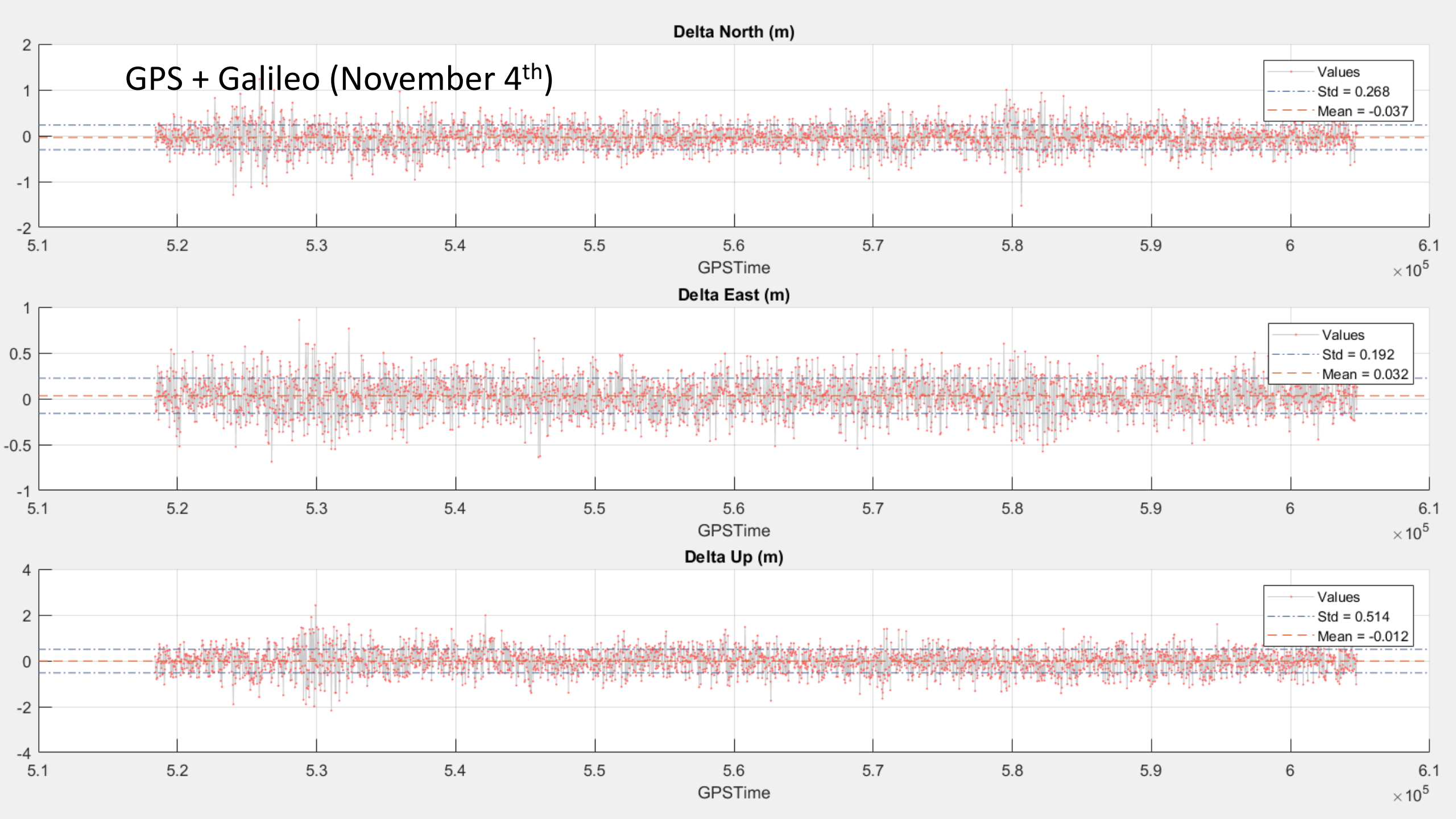
Benefits of multi-GNSS

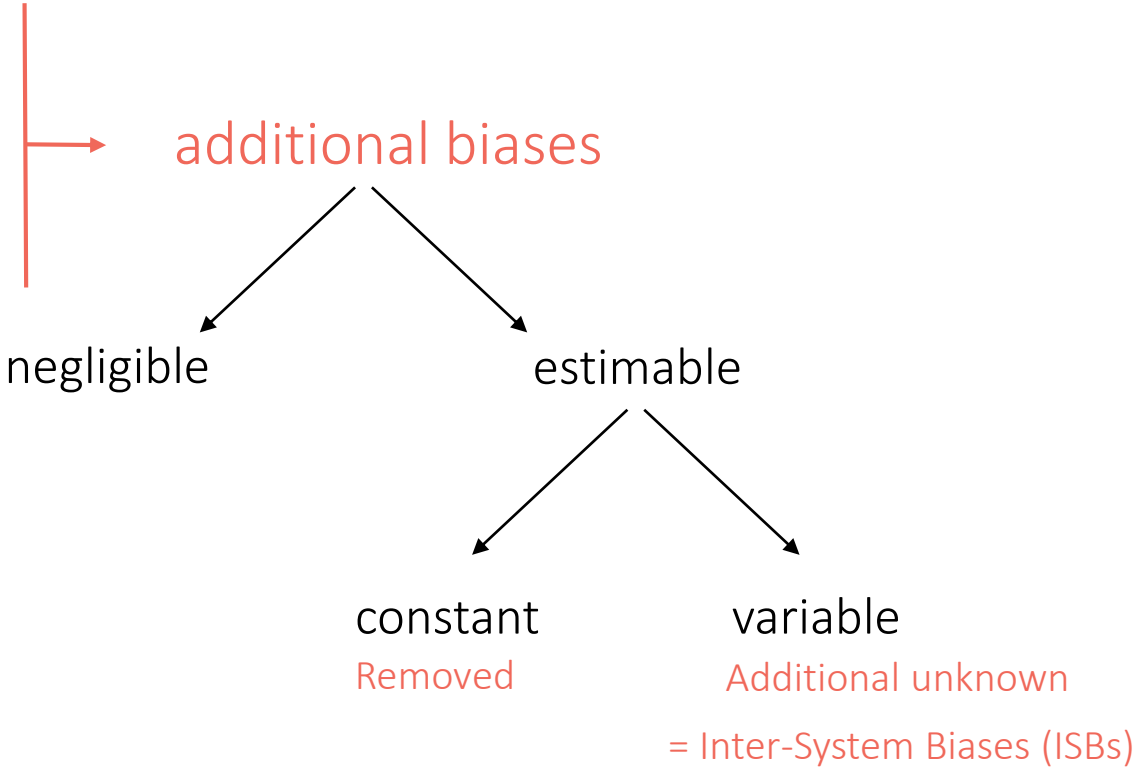
- ❑ More satellites available
  - Satellites visible anywhere anytime
  - Improved satellite geometry
- ❑ New frequencies available
- ❑ Improved precision on position
- ❑ Improved reliability


Galileo only (November 4th)
Delta North (m)
Values
Std = 0.454
Mean = -0.05
GPSTime
×10^5
Delta East (m)
Values
Std = 0.324
Mean = 0.016
GPSTime
×10^5
Delta Up (m)
Values
Std = 0.683
Mean = -0.032
GPSTime
×10^5


GPS + Galileo (November 4th)
Delta North (m)
Values
Std = 0.268
Mean = -0.037
GPSTime
×10^5
Delta East (m)
Values
Std = 0.192
Mean = 0.032
GPSTime
×10^5
Delta Up (m)
Values
Std = 0.514
Mean = -0.012
GPSTime
×10^5

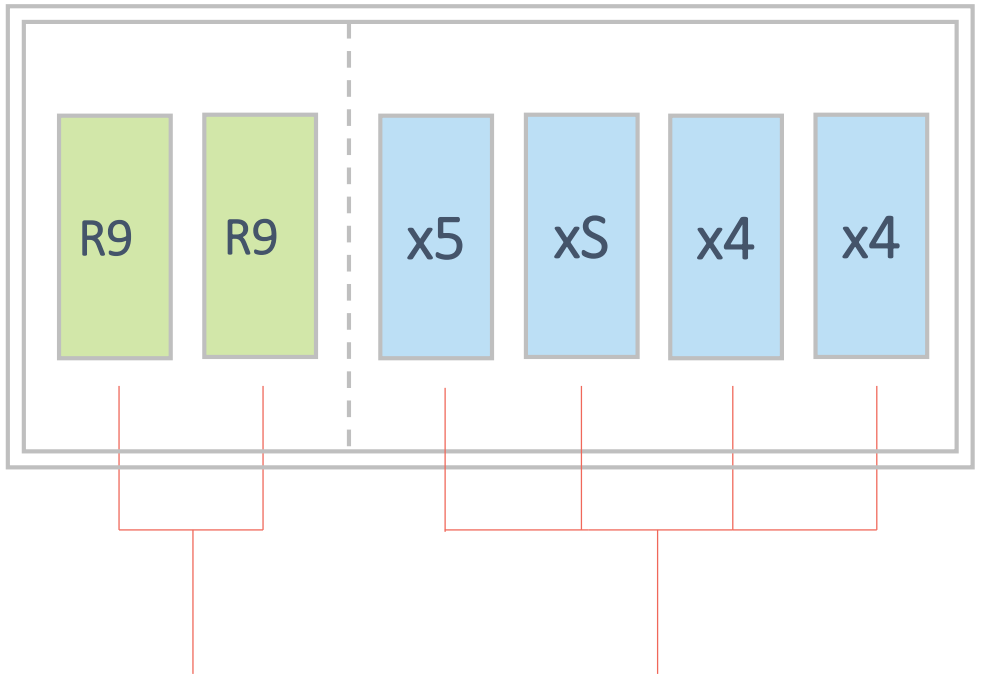
Drawbacks of multi-GNSS

- Differences between GNSS
  - Coordinate systems
  - Time systems
  - Hardware delays

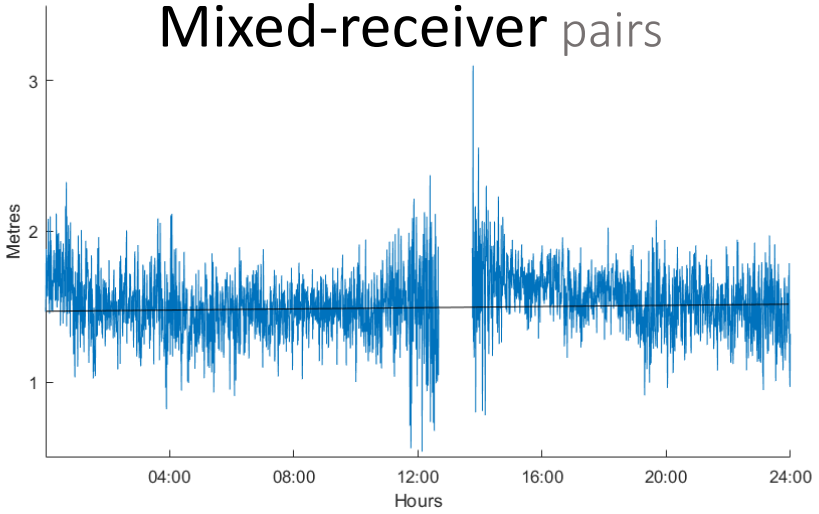


ISBs are receiver-dependent

University of Liège

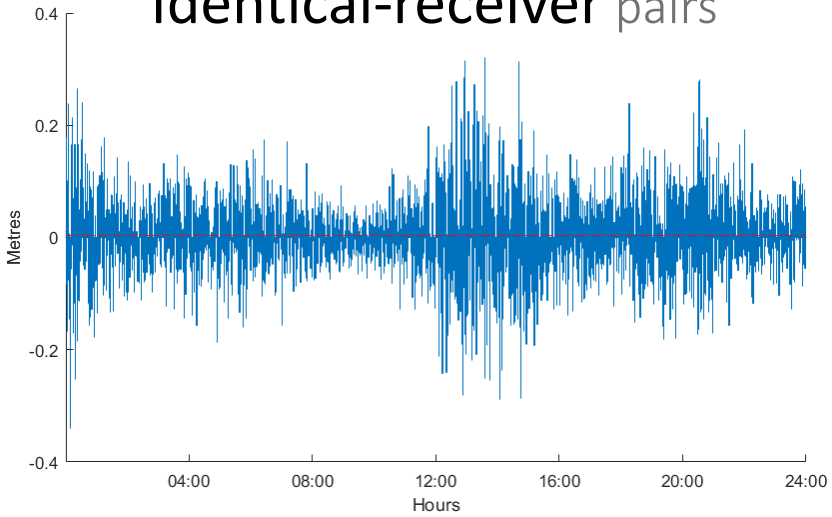


Mixed-receiver pairs



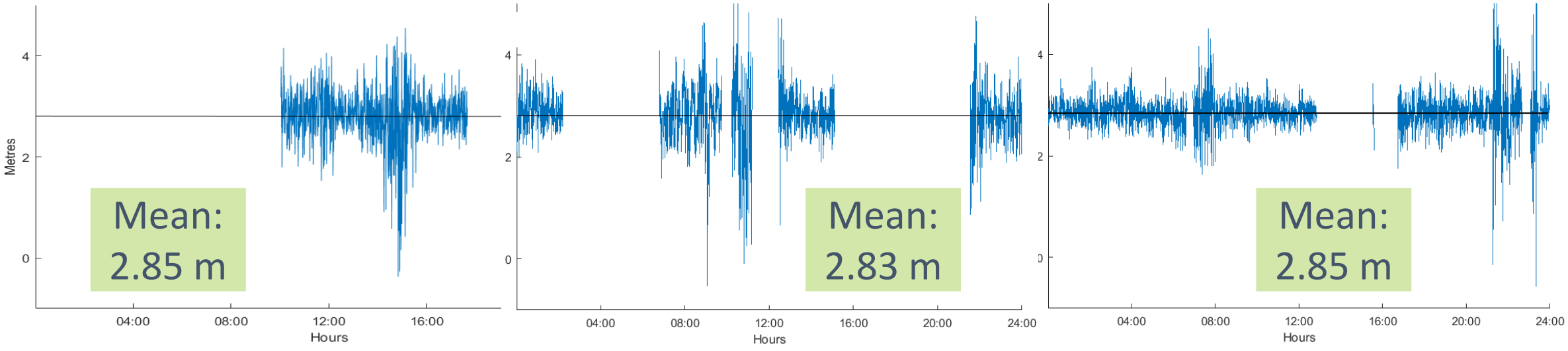
Mean: 1.52 m

Identical-receiver pairs



Mean: 0.00 m

ISBs are stable across years



2014 2015 2016

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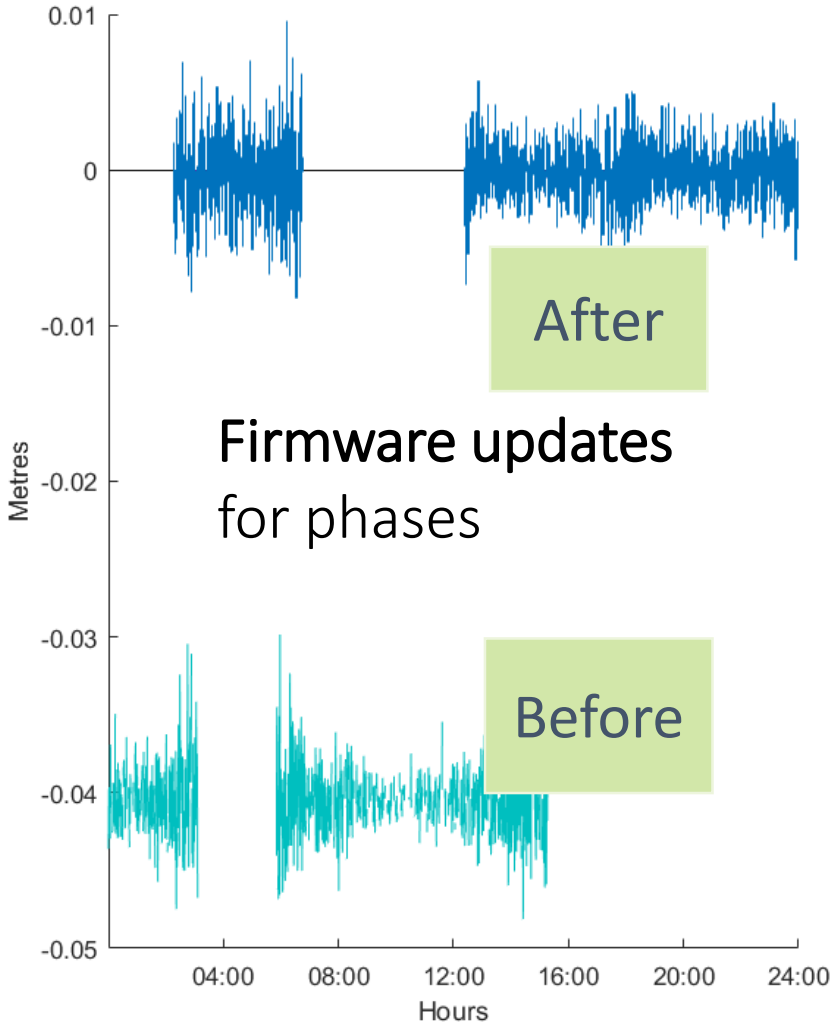
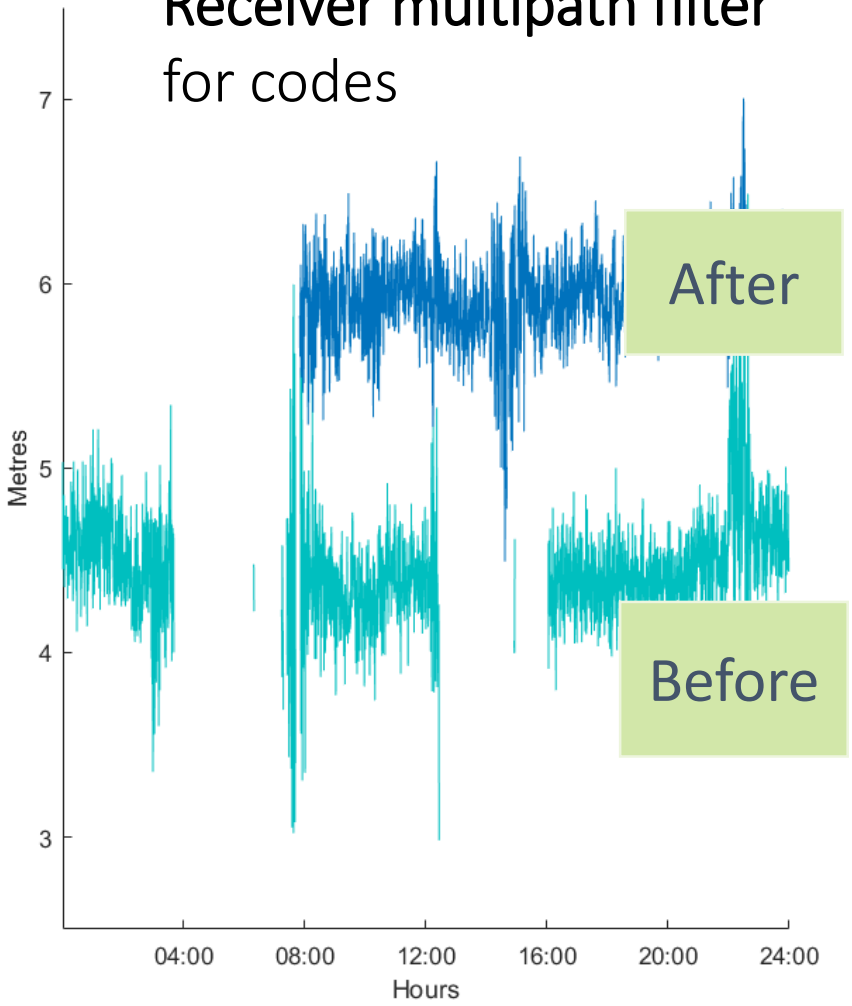
ISBs might be affected by



Firmware updates
for phases

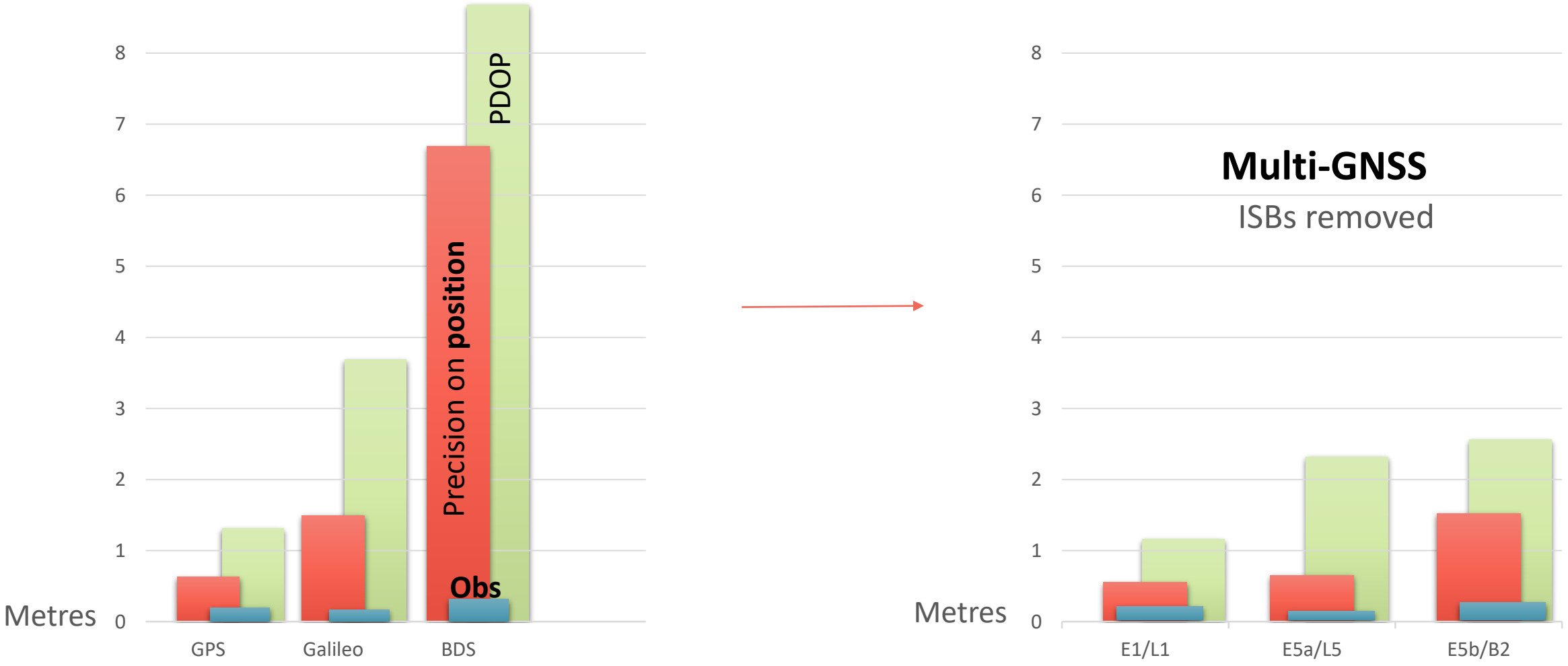
Receiver multipath filter
for codes



Conclusion

- ❑ Drawbacks of multi-GNSS
  - Coordinate systems — Negligible
  - Time systems — Constant – given in the ephemeris data
  - Hardware delays — Constant - Receiver and frequency dependent
- ❑ Benefits of multi-GNSS
  - Availability
  - Position precision improvement
  - Reliability

Multi-GNSS **improves** positioning results



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FREEDOM TO RESEARCH

Under the supervision of WARNANT René (rene.warnant@uliege.be)