ION GNSS+ 2016

Galileo, an ace up in the sleeve for PPP techniques

September 15TH , 2016

Session D3: High Precision GNSS Positioning

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gmv INNOVATING SOLUTIONS

Outline

Introduction

- Precise Point Positioning Technique (PPP)
- GNSS Constellations Evolution

Multi-GNSS PPP Analyses

Galileo-only PPP Study

Conclusions

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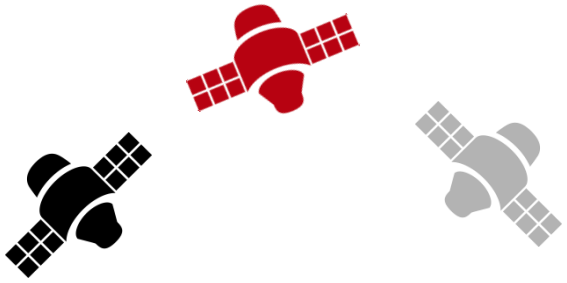
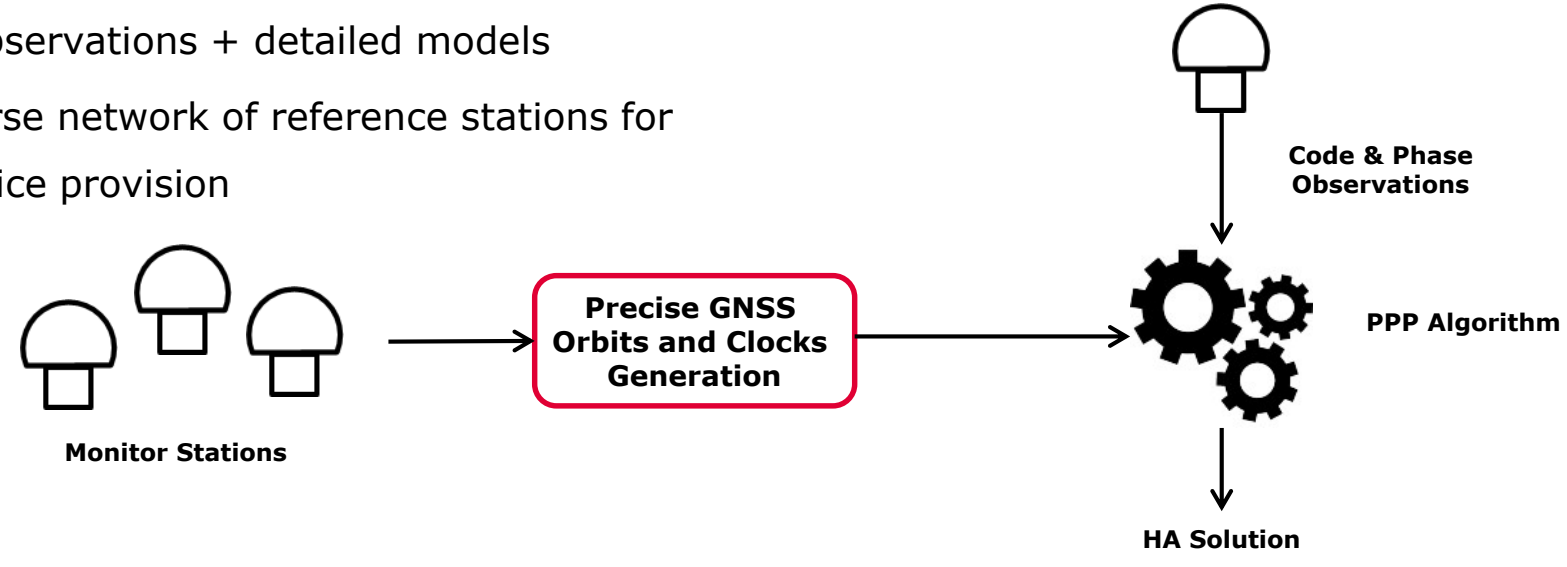
INTRODUCTION

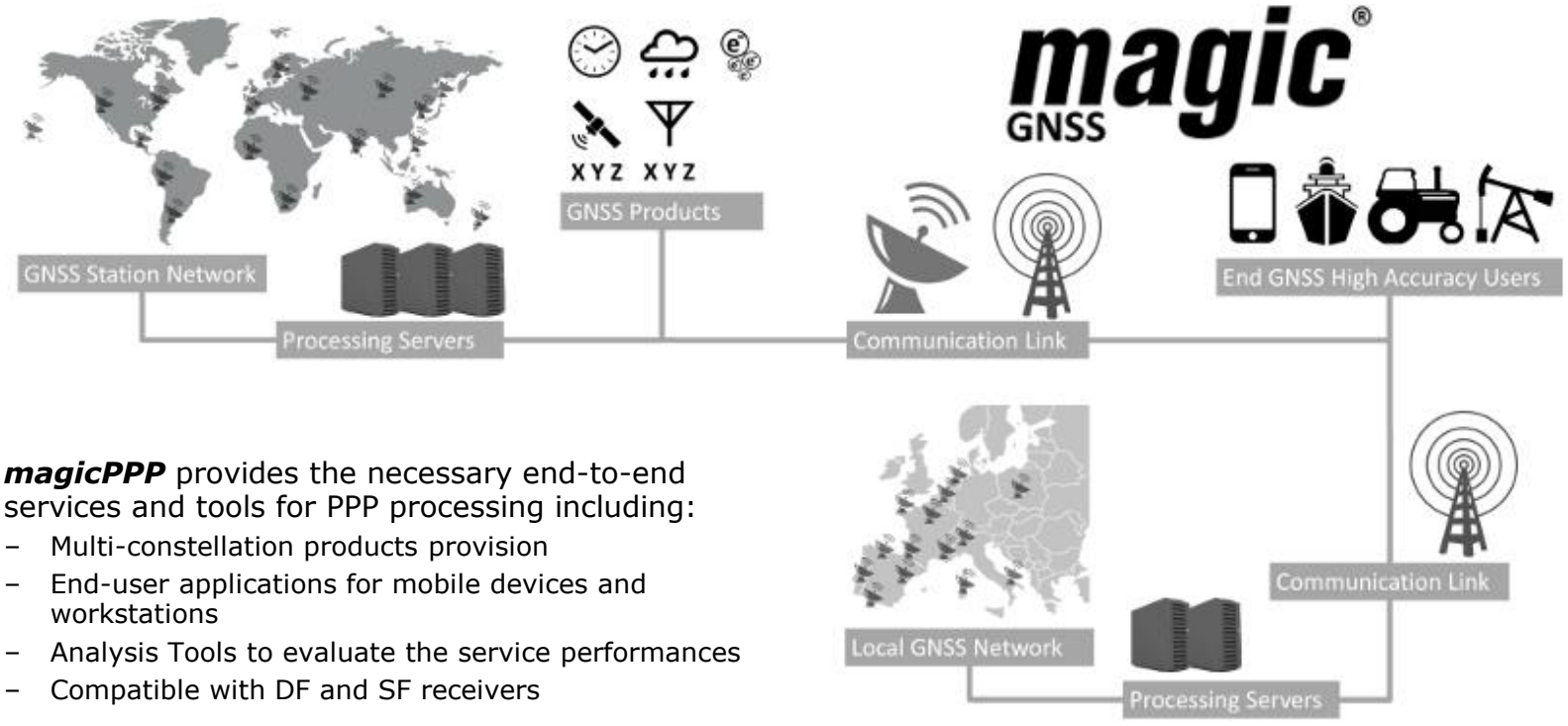
Precise Point Positioning

- Two HA Positioning solutions: PPP and RTK
- PPP is an absolute positioning technique
- Worldwide or Regional coverage
- Relies on the use of precise orbits & clocks + observations + detailed models
- Sparse network of reference stations for service provision



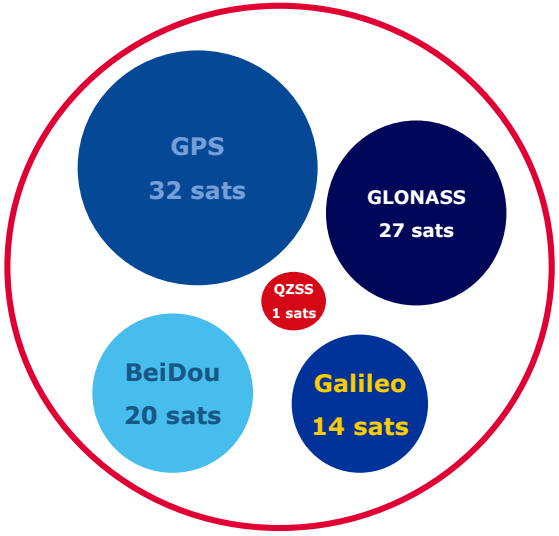


magicGNSS



- ***magicPPP*** provides the necessary end-to-end services and tools for PPP processing including:
  - Multi-constellation products provision
  - End-user applications for mobile devices and workstations
  - Analysis Tools to evaluate the service performances
  - Compatible with DF and SF receivers

GNSS Today



94 Satellites

Full Operation Capability
30 fully operational satellites and ground segment
2020

Full Operation Capability
22 fully operational satellites and ground segment
2017

Full Operation Capability
12 fully operational satellites and ground segment
2016

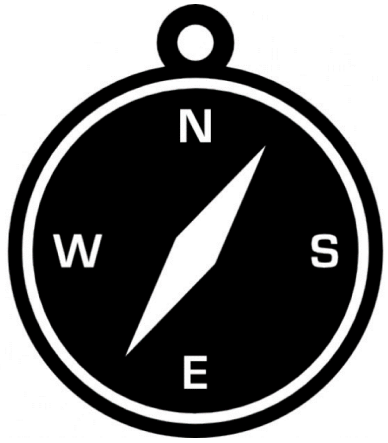
Initial Operation Capability
Early services for OS, SAR, PRS and demonstrator for CS
2015

In-Orbit Validation
4 fully operational satellites and ground segment
2014

Galileo System Testbed v1
Validation of critical algorithms
2013

source: GSA

On-going GNSS Evolutions



- GPS and GLONASS modernization
  - IIF satellites transmitting L2C and L5 signal→ +Robustness
  - Better on-board clocks
  - Future CDMA GLONASS
- Galileo Deployment and Initial Services
  - 4 New satellites deployed during 2016 and 4 more expected for next year
  - High performance on-board clocks will help to improve the PVT solutions at user level
  - Initial Services Declaration
- IGS and Analysis Centers are also moving in the multi-constellation direction.

Objective

Demonstrate the benefits of using Galileo for Precise Point Positioning Techniques

- Two types of analysis have been performed:
  1) Multi-constellation PPP ⇨ Benefits of introducing Galileo
  2) Galileo-only PPP ⇨ Achievable performances

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MULTI-GNSS PPP ANALYSES

Static-user Scenarios

- Stations
  - Continental Europe → WTZZ
  - North America → UCAL
  - Latitude > 60º → HOFN
  - Latitude < -4º → SEYG

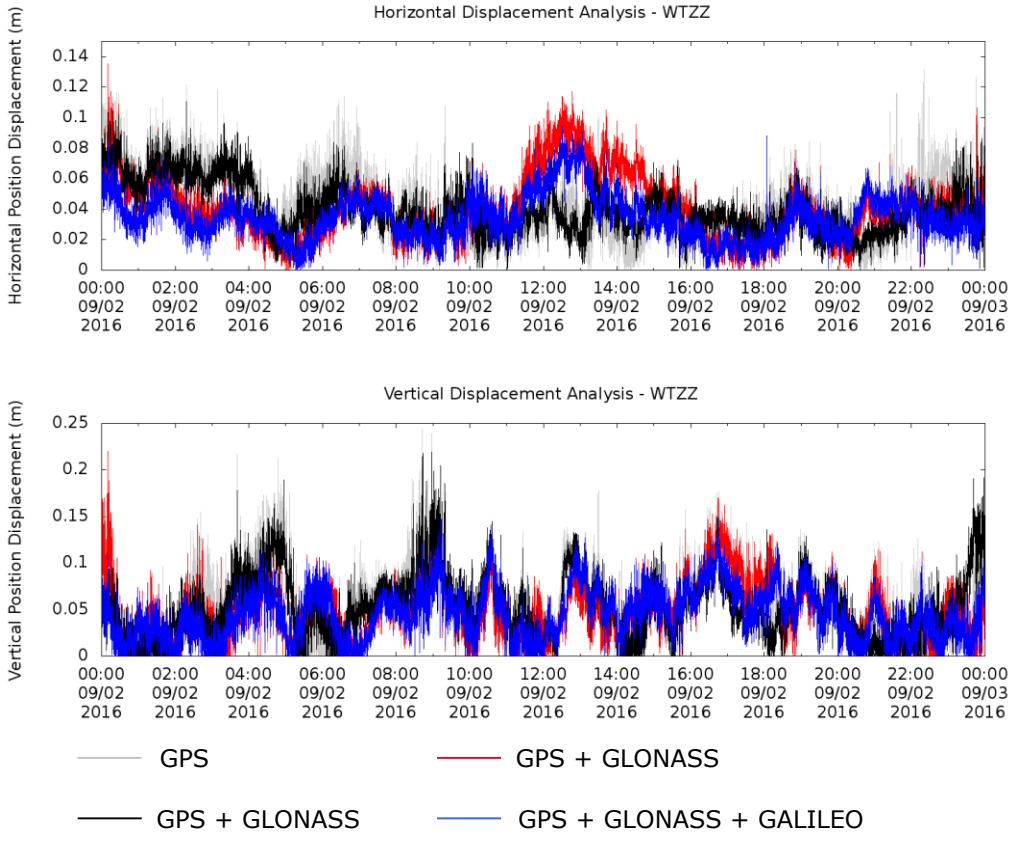
- Configurations
  - GPS only
  - GPS + GLONASS
  - GPS + GALILEO
  - GPS + GLONASS + GALILEO

- Open sky scenarios

WTZZ UCAL

HOFN SEYG

Continental Europe - WTZZ (Germany)

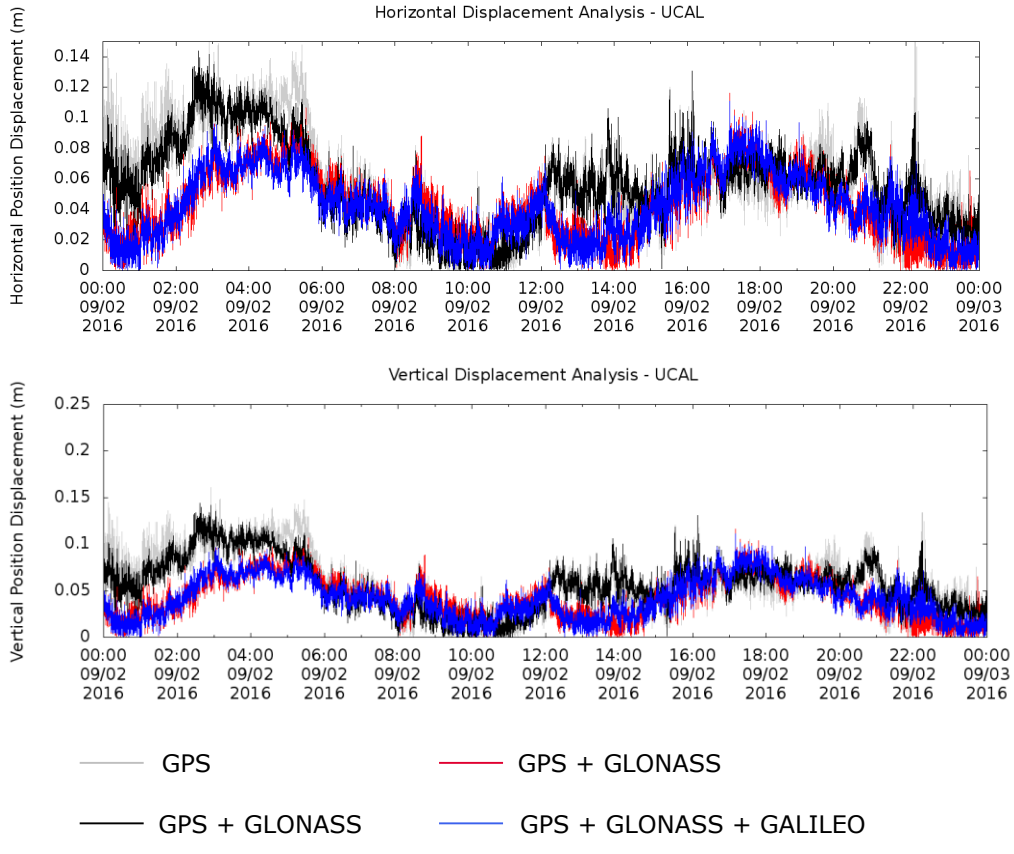


Receiver: *JAVAD TRE_G3TH DELTA*

	G	GR	GE	GRE
H (RMS, m)	0.05	0.05	0.04	0.04
V (RMS, m)	0.07	0.06	0.06	0.05

Improvement: 20-30%

North America - UCAL (Canada)

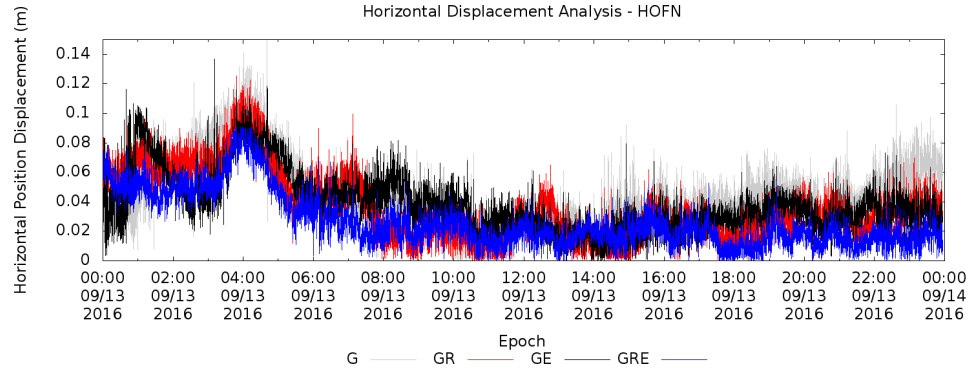


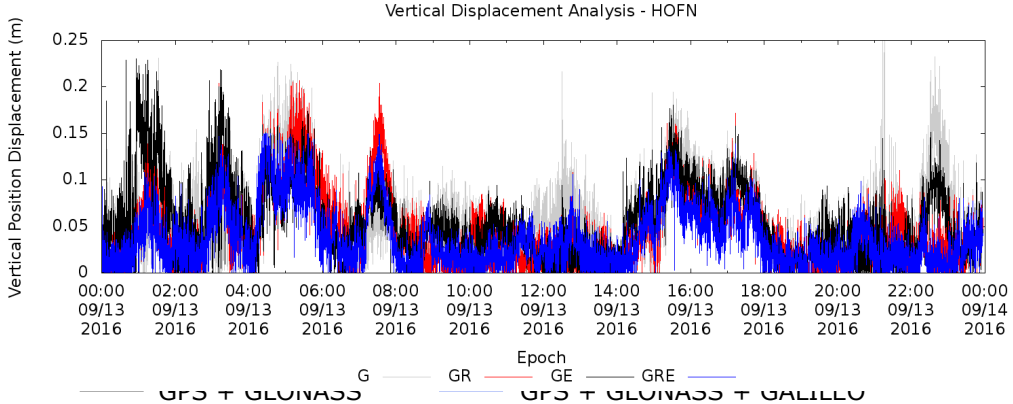
Receiver: *TRIMBLE NETR9*

	G	GR	GE	GRE
H (RMS, m)	0.07	0.05	0.06	0.06
V (RMS, m)	0.05	0.05	0.05	0.05

Improvement: 0-15%

High Latitudes - HOFN (Iceland)



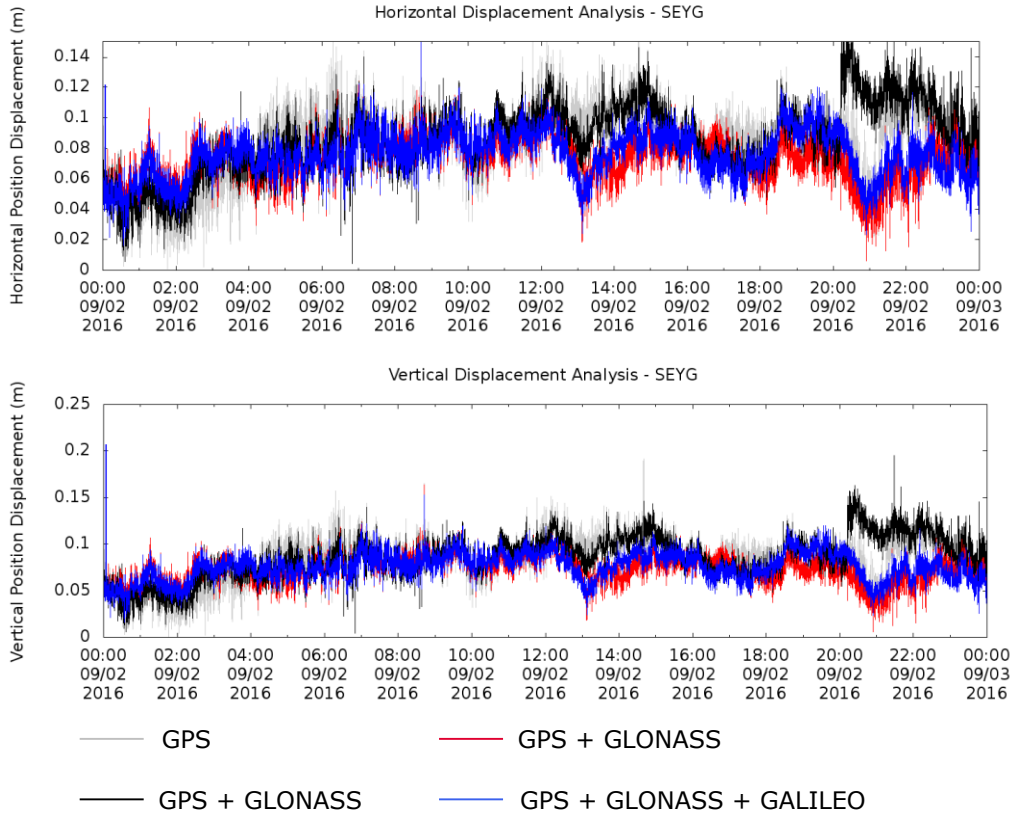


Receiver: *LEICA GR25*

	G	GR	GE	GRE
H (RMS, m)	0.05	0.03	0.04	0.03
V (RMS, m)	0.07	0.06	0.06	0.05

Improvement: 25-30%

Low Latitudes - SEYG (Seychelles Islands)



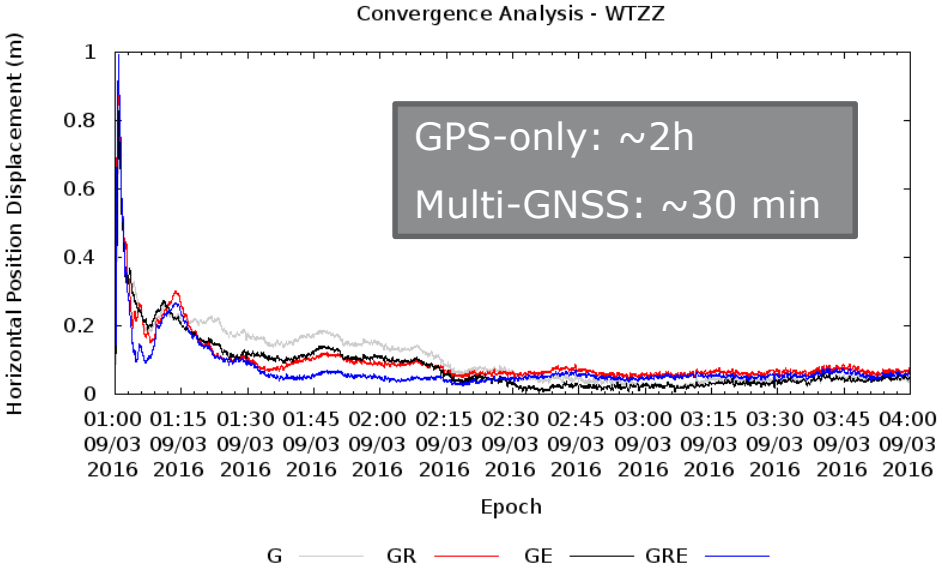
Receiver: *TRIMBLE NETR9*

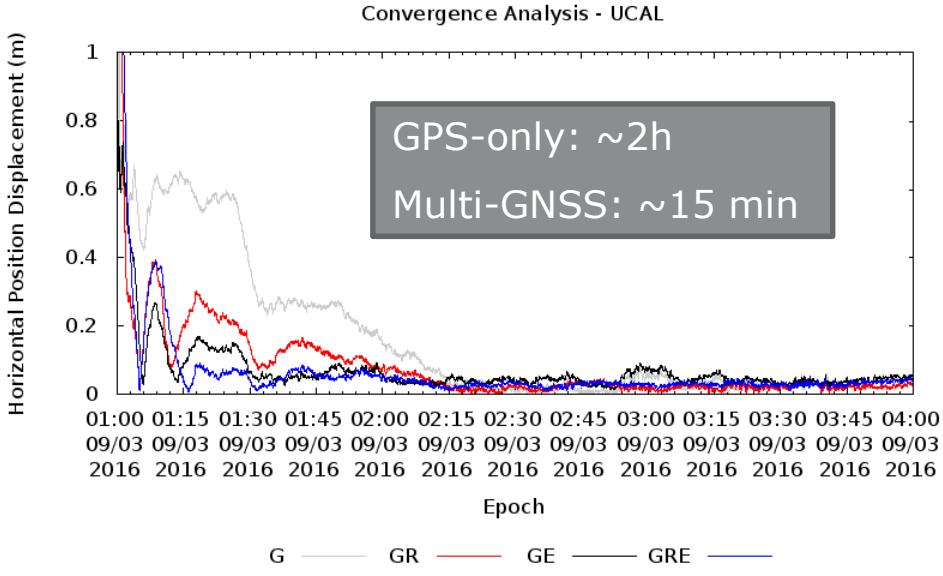
	G	GR	GE	GRE
H (RMS, m)	0.09	0.07	0.09	0.08
V (RMS, m)	0.06	0.05	0.05	0.04

Improvement: 10-30%

Convergence Analysis

- Horizontal Converge is analyzed with different constellation combinations (G-only, G+R, G+E, G+R+E)





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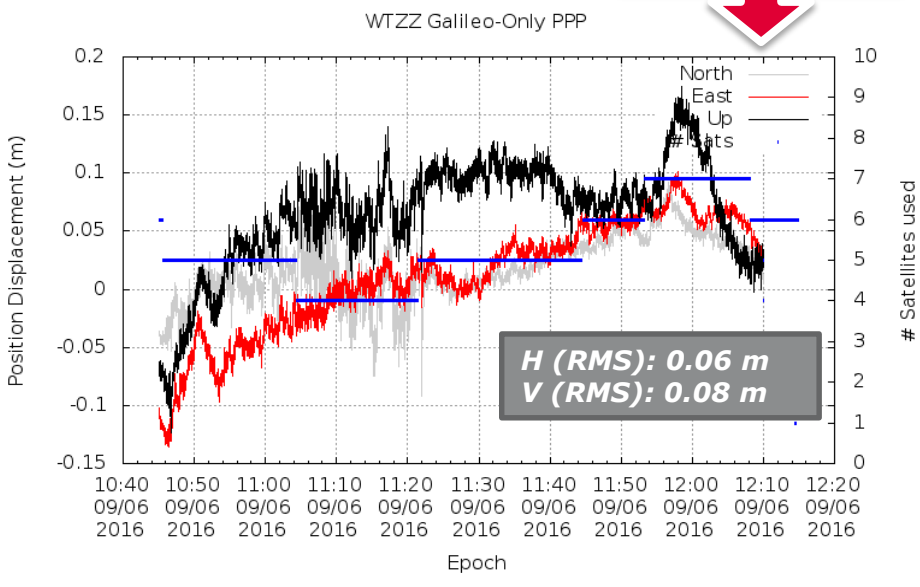
GALILEO-ONLY PPP STUDY

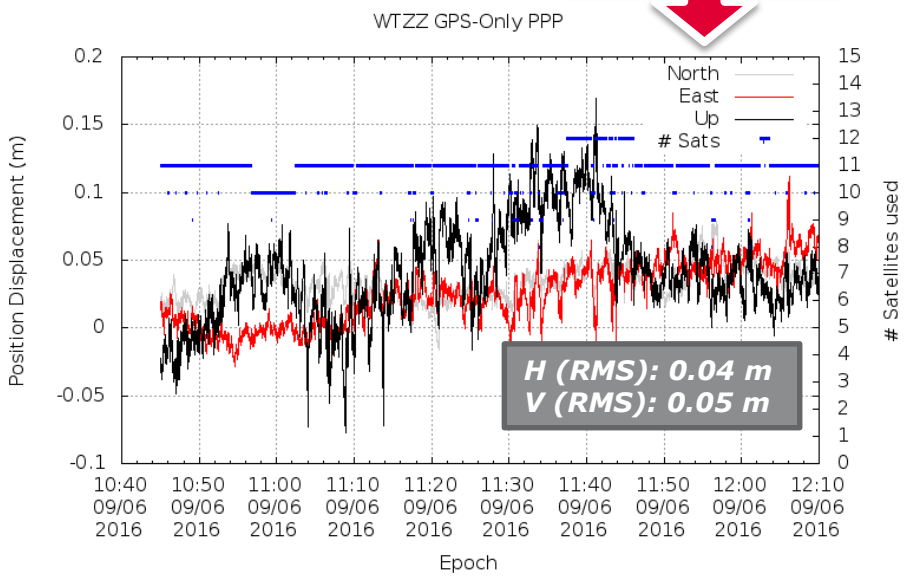
Static-user Scenario

- WTZZ station → Wetzel (Germany)
- Date: 06/09/2016
- 4-7 Galileo Satellites available

4-7 satellites



>10 satellites



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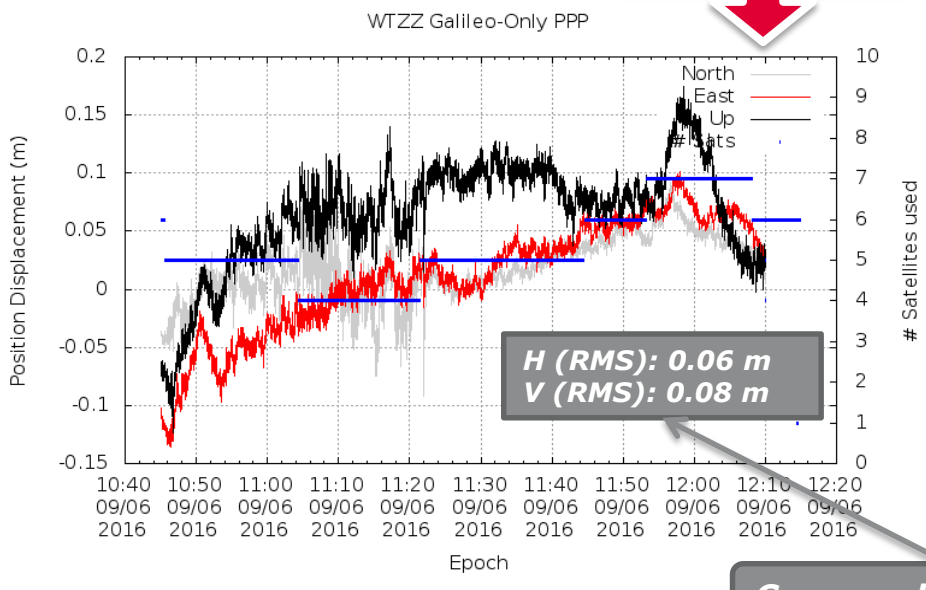
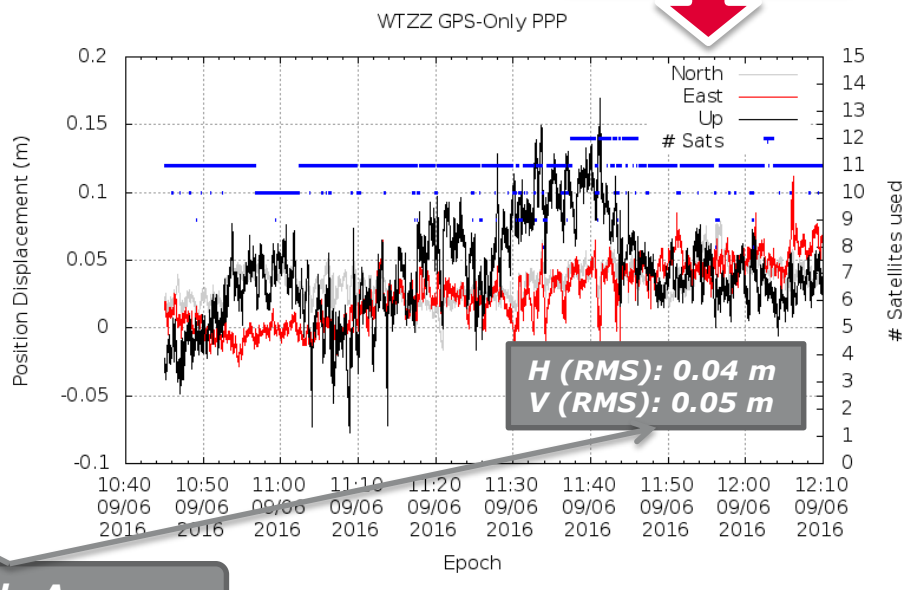


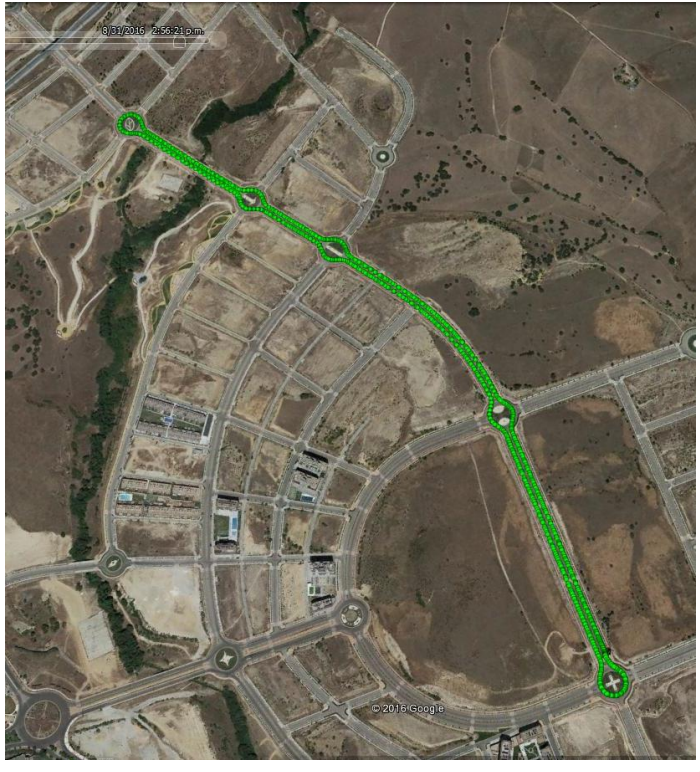
>10 satellites



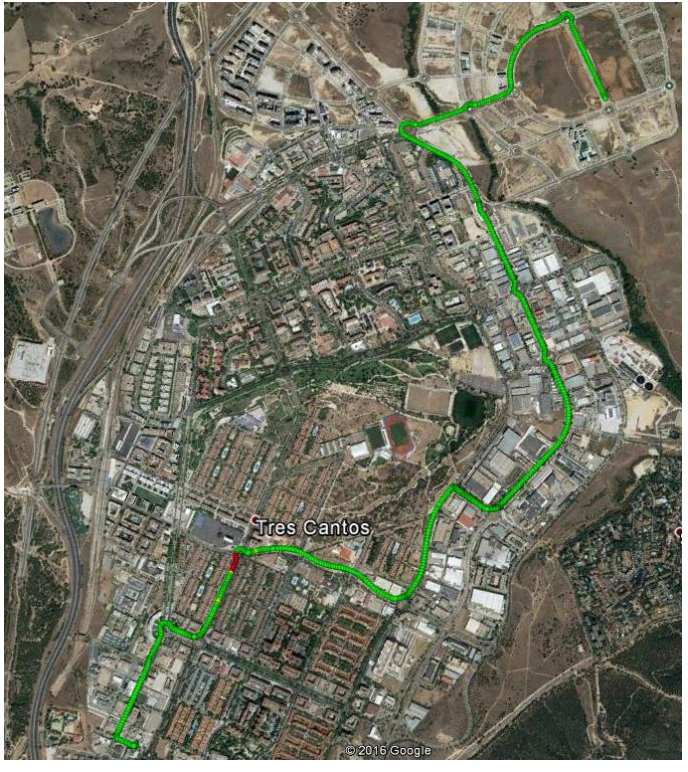
Comparable Accuracy

Kinematic-User Scenario

- Open-sky scenario



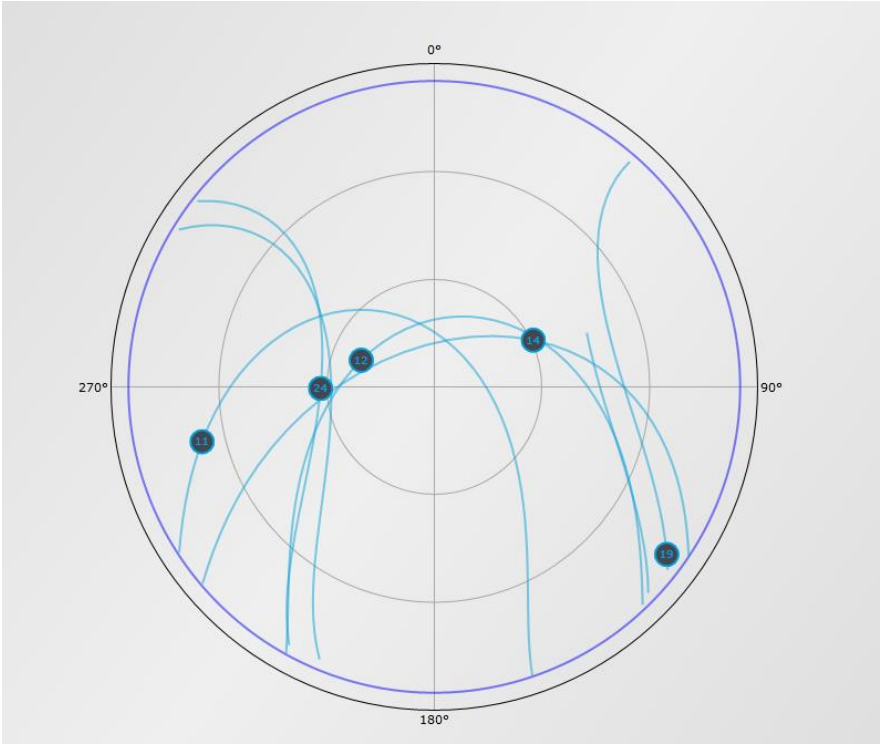
- Urban scenario



Kinematic-User Scenario

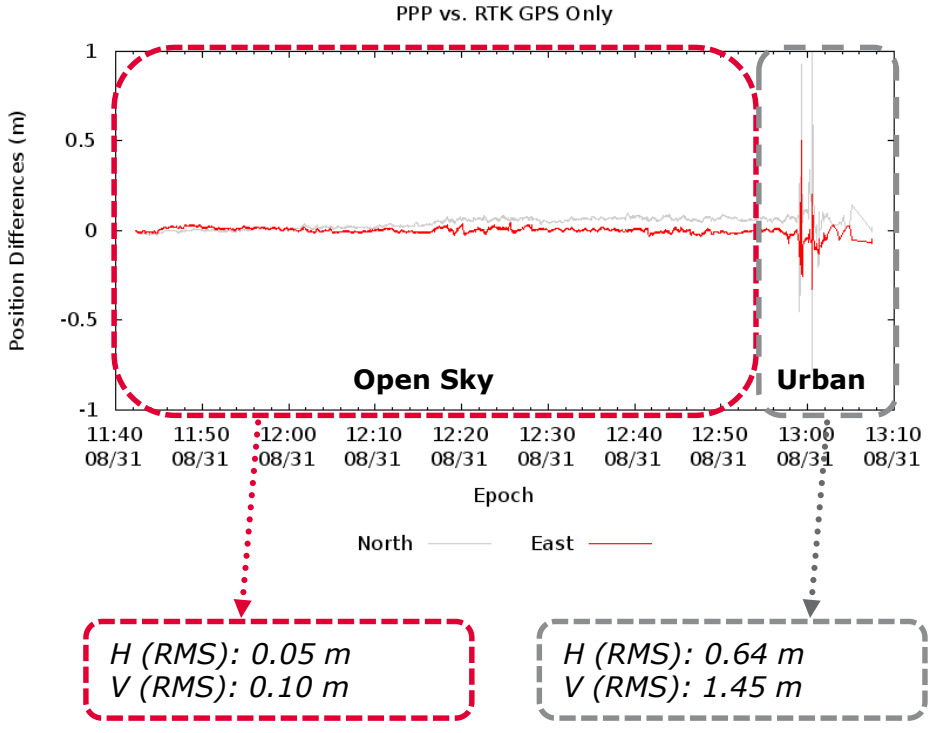
- Used receiver: Trimble R10
  - Multi-GNSS receiver
  - Not able to track Galileo Eccentric satellites (E14 and E18)

- Both open-sky and urban conditions are considered



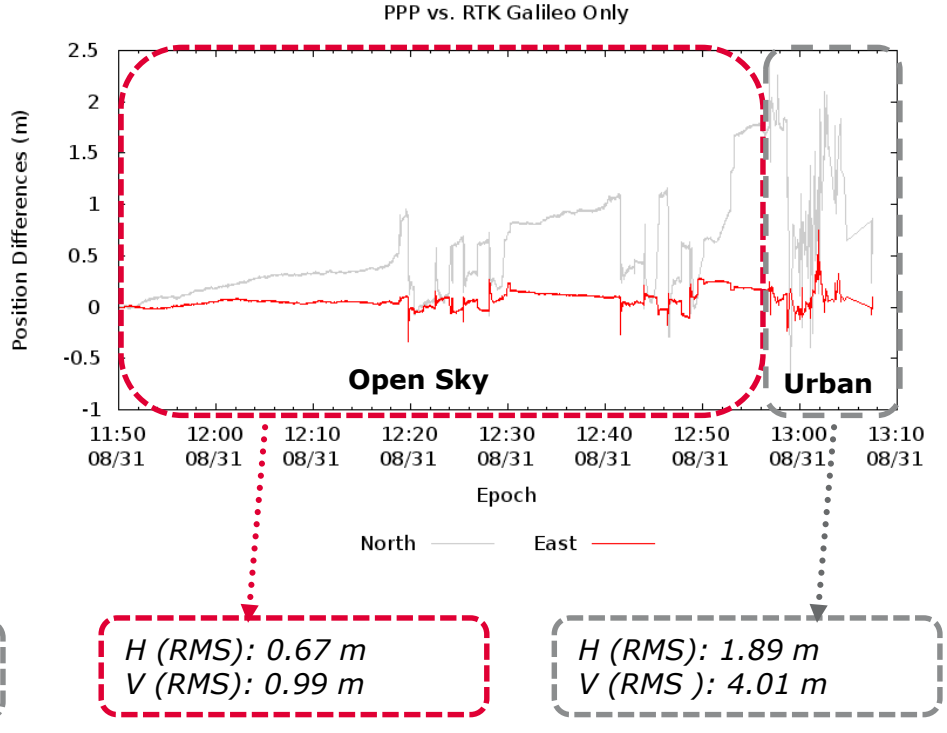
Galileo-only PPP

- Results Galileo-only (E11, E12, E19, E24) vs GPS-Only



H (RMS): 0.05 m
V (RMS): 0.10 m

H (RMS): 0.64 m
V (RMS): 1.45 m

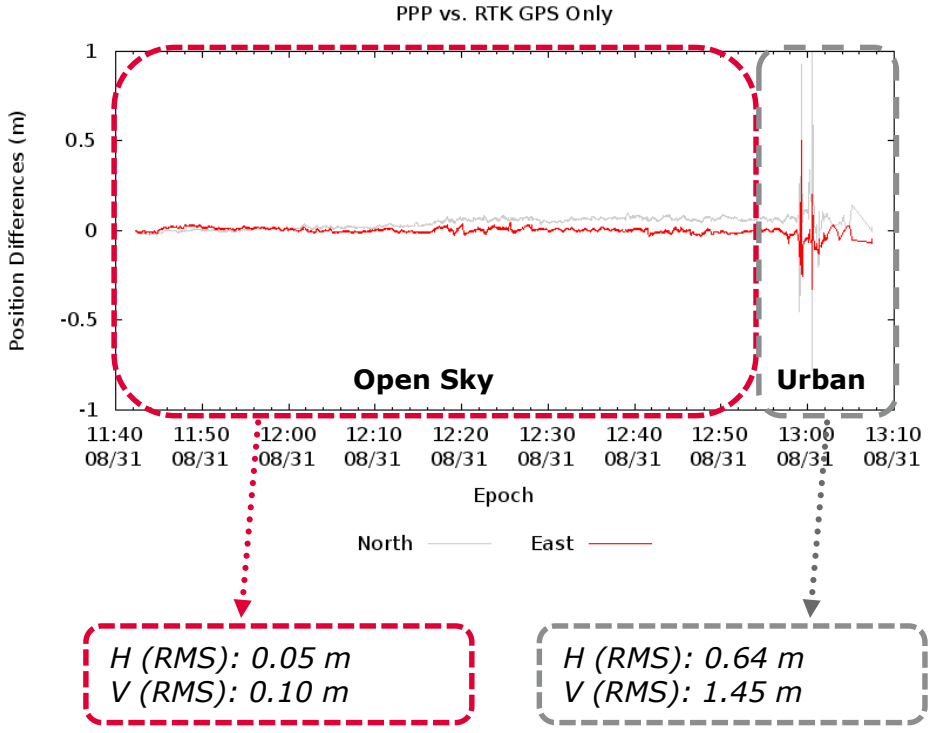


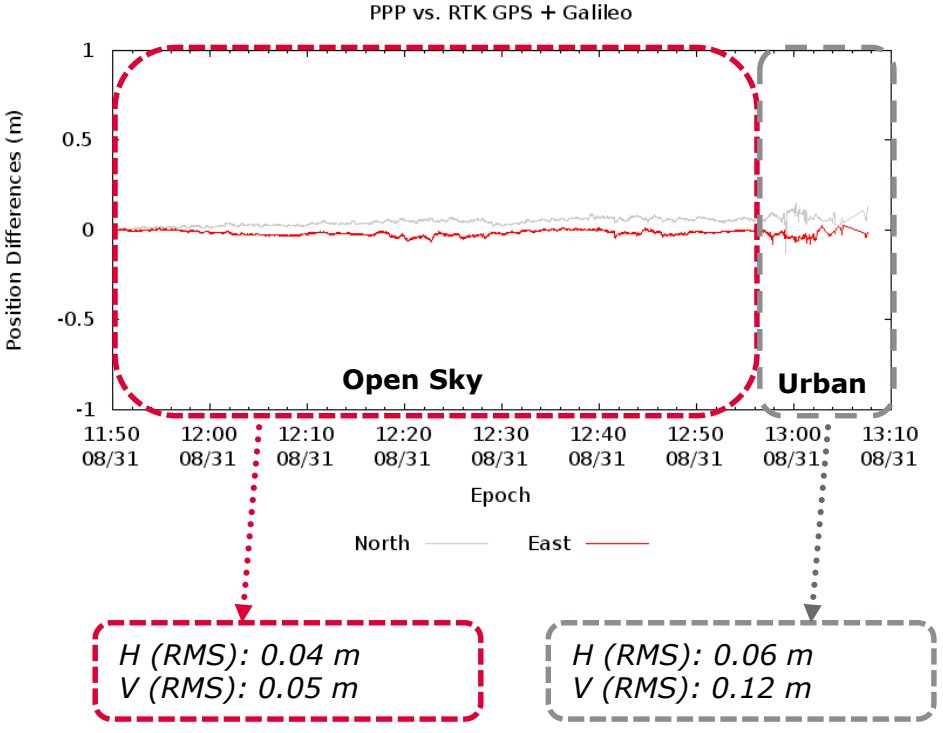
H (RMS): 0.67 m
V (RMS): 0.99 m

H (RMS): 1.89 m
V (RMS): 4.01 m

Galileo-only PPP

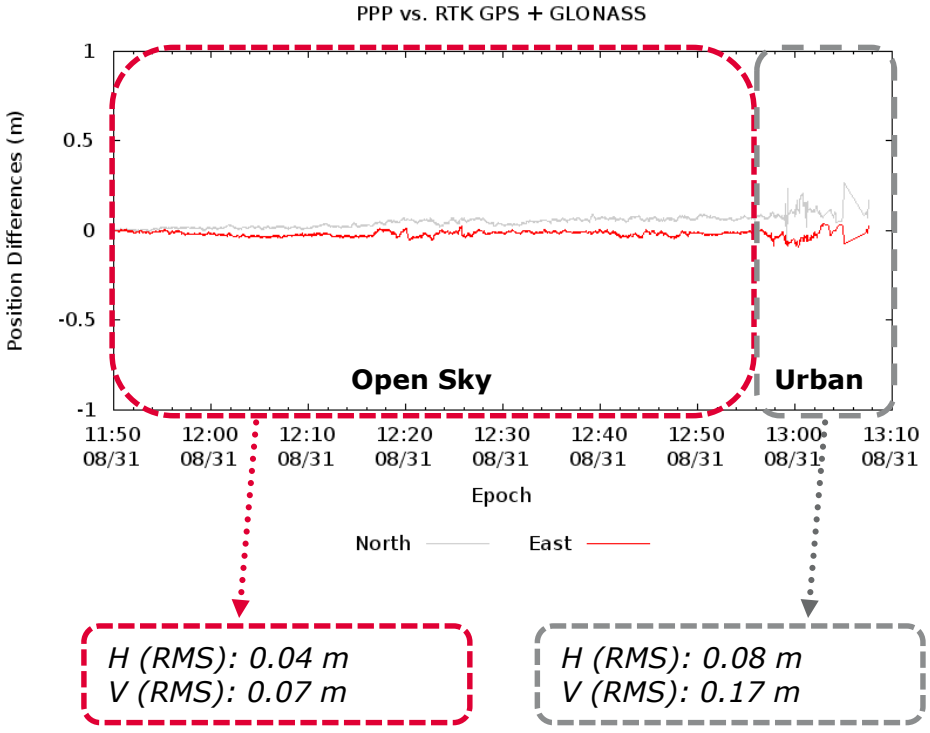
- Results GPS+Galileo vs GPS-Only

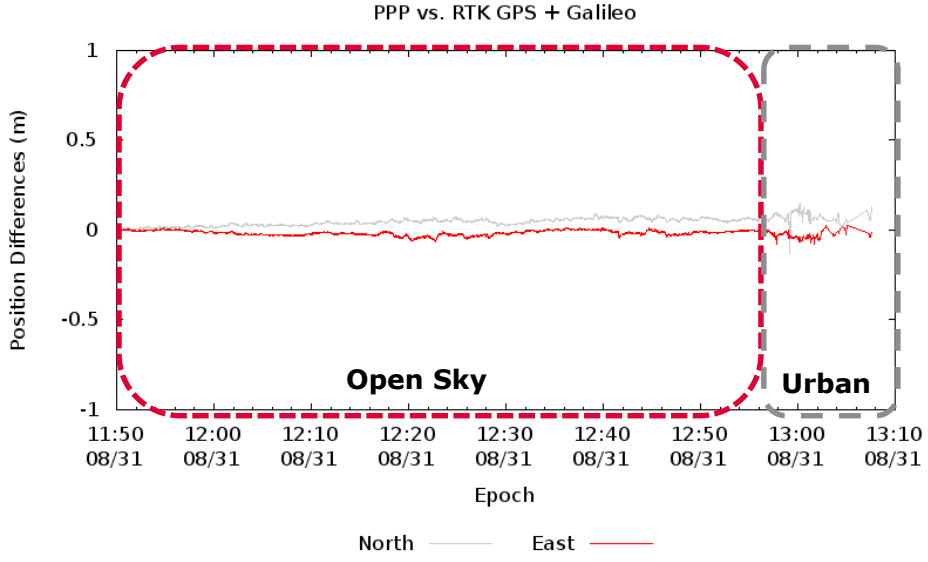




Galileo-only PPP

- Results GPS+GLONASS vs GPS+Galileo





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CONCLUSIONS

CONCLUSIONS

- Galileo is becoming a reality!!

- The introduction of Galileo satellites in the PPP solution significantly improves the performances:
  - Around 20% in open-sky scenarios
  - Dramatic in urban environments

- The performances of Galileo-only PPP solutions are comparable to GPS-only solutions in open-sky scenarios. It is expected to be the same for kinematic scenarios once more Galileo satellites are available.

- In late 2017, it is foreseen to have 22 Galileo satellites orbiting which will represent a major step-forward for PPP.

More about *magicPPP*

Tomorrow at 10:35:

D5b: Next Generation Sensors in Phones, Tablets and Wearables

Moving forward to the Future Low-Cost PPP Paradigm

Demos at booth 508!!!

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