

Fast convergence of Trimble CenterPoint RTX by regional augmentation

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Outline

- ▶ **Introduction CenterPoint RTX service**
- ▶ **Global Ionosphere Model**
- ▶ **Regional Ionosphere Model**
- ▶ **Performance of ionosphere models in terms of accuracy and convergence time**
- ▶ **Summary**

CenterPoint RTX Correction Service

- ▶ Real-time, ambiguity-fixing, PPP-like positioning service, static and kinematic mode
- ▶ Multi-GNSS service with worldwide coverage supporting GPS, GLONASS, QZSS, BeiDou (and Galileo)
- ▶ Orbit, clock and ionosphere corrections derived from global RTX reference station network
- ▶ Corrections are broadcasted via satellite (L-band) and IP (NTRIP) / mobile
- ▶ Open Post-Processing service ▶ <http://www.trimblertx.com/>

CenterPoint RTX Correction Service

Dual frequency specification

- 95% of the time
- Horizontal accuracy ≤ 4 cm
- After convergence time ≤ 30 min

v1.0
2011

Introduced in Sep. 2011
GPS /GLONASS

v2.0
2012

QZSS support

v3.0
2013

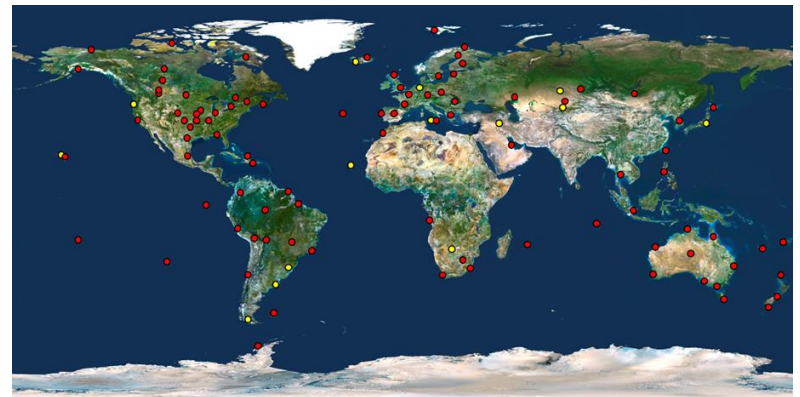
Global Ionosphere
Model

v5.0
2015

Regional Ionosphere
Model for Europe

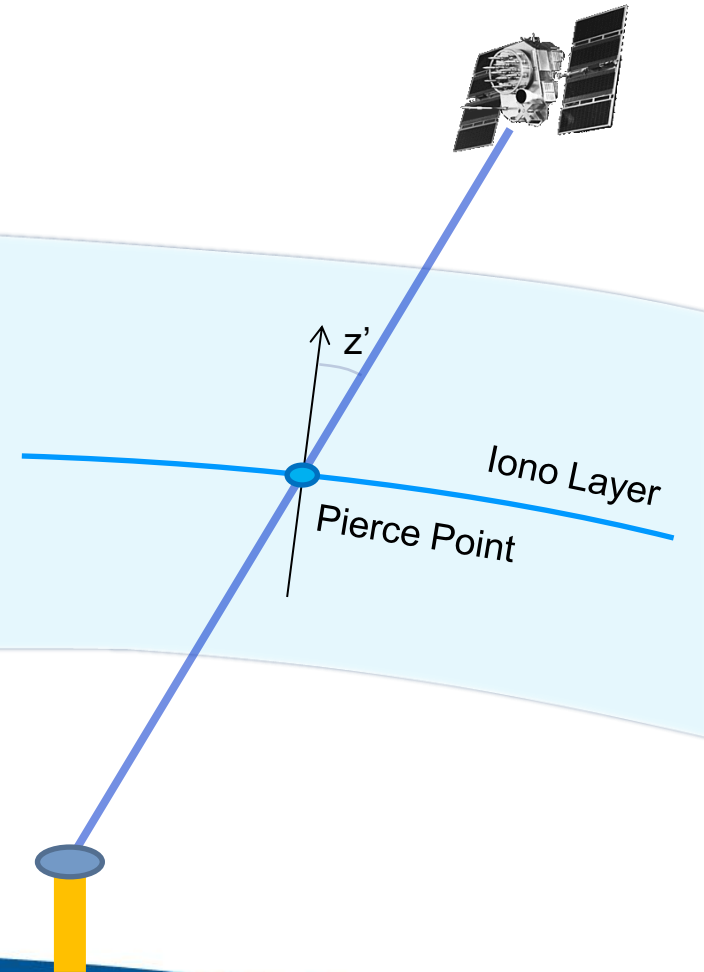
v4.0
2014

BeiDou MEO and IGSO support
Galileo support prepared



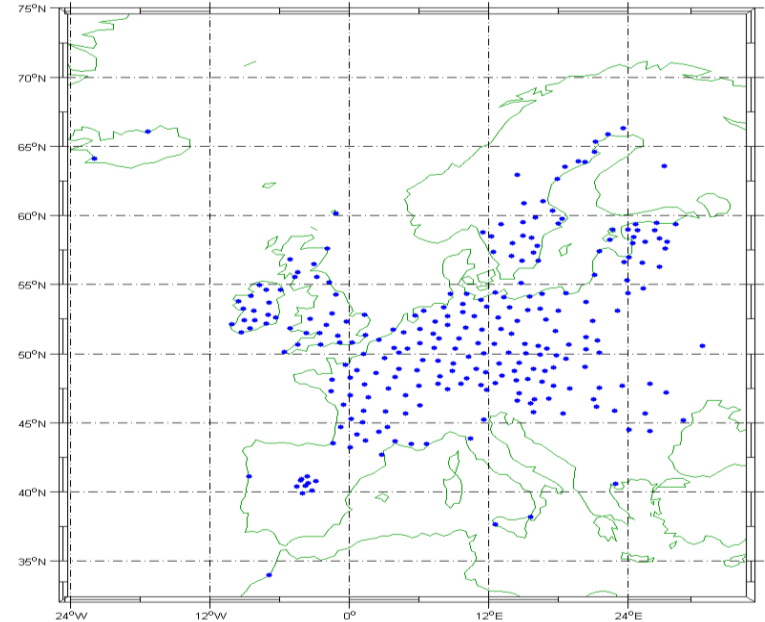
Global Ionosphere Model

- ▶ Based on global tracking network (~100 stations)
- ▶ Single layer model, pierce point and ionospheric mapping function:
Condense the total electron content (TEC) on a spherical ionosphere layer
- ▶ Vertical TEC represented by Spherical Harmonics
- ▶ Accuracy indicator, model best in Europe and USA



Regional Ionosphere Model

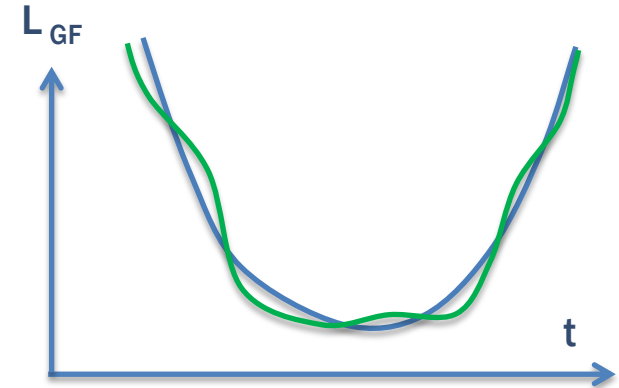
- ▶ Available in Europe, based on a regional tracking network
- ▶ 260 network stations, average spacing ~ 200 km
- ▶ Per-satellite model, providing slant delays, update rate 30 sec
- ▶ Accuracy indicator
- ▶ **Dual frequency specification**
 - ▶ 95% of the time
 - ▶ Horizontal accuracy ≤ 4 cm
 - ▶ **After ≤ 5 min**



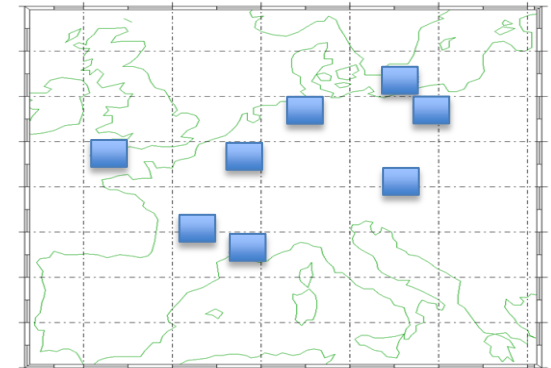
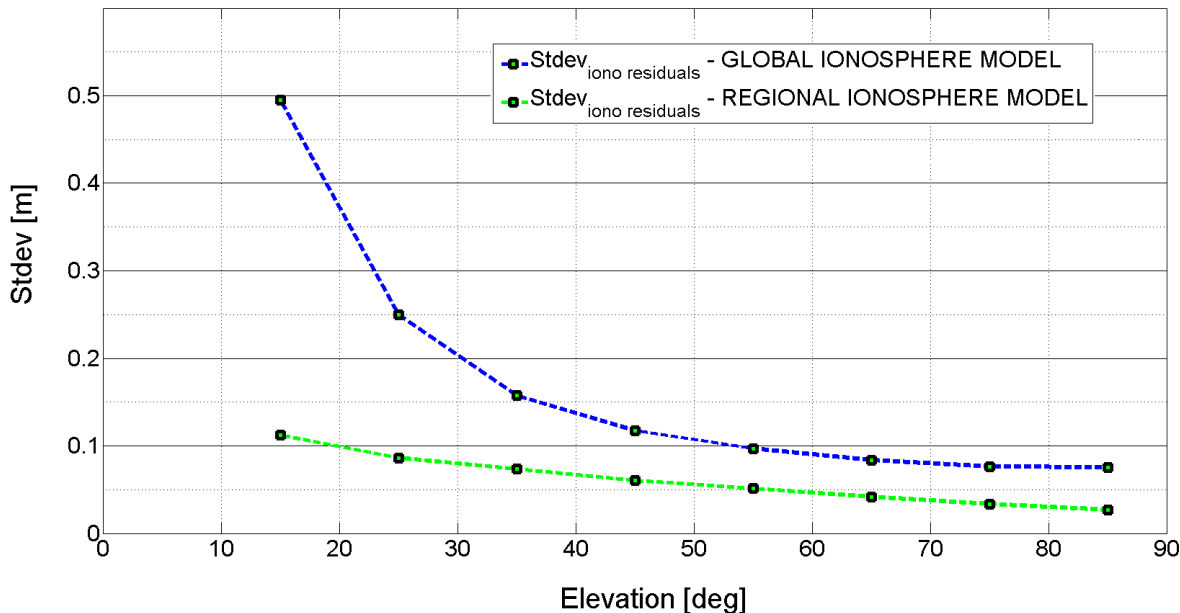
European tracking network (top) and service area (left)

Precision of RTX ionosphere models

- ▶ Comparison of satellite arcs in geometric-free linear combination
- ▶ Observation data vs. model
- ▶ Standard deviation of residuals



Standard deviation of ionospheric phase residuals in [m] w.r.t. GPS L1

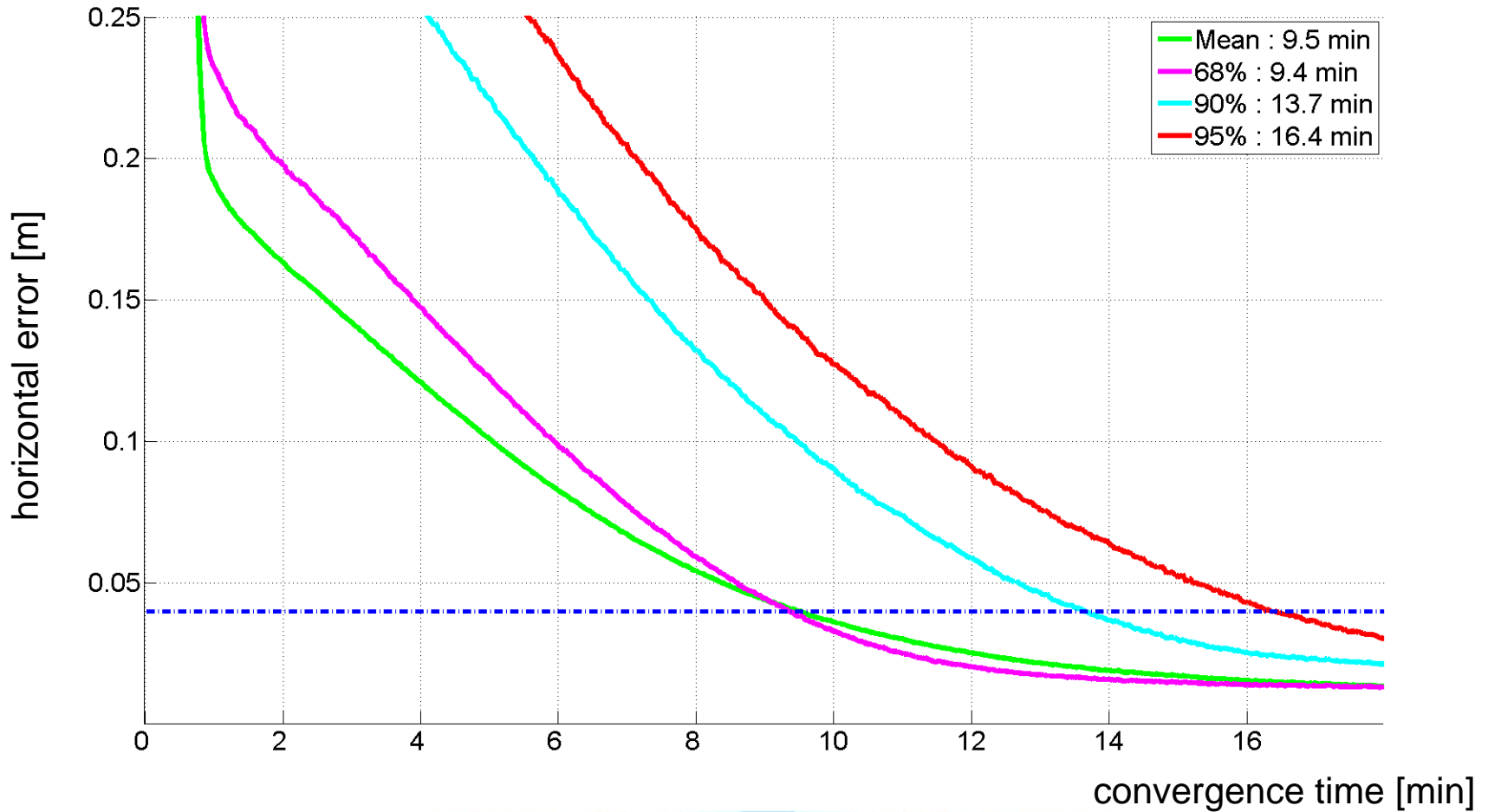


- 8 European Stations
- 24 hours (10th March 2015)
- Global and Regional model

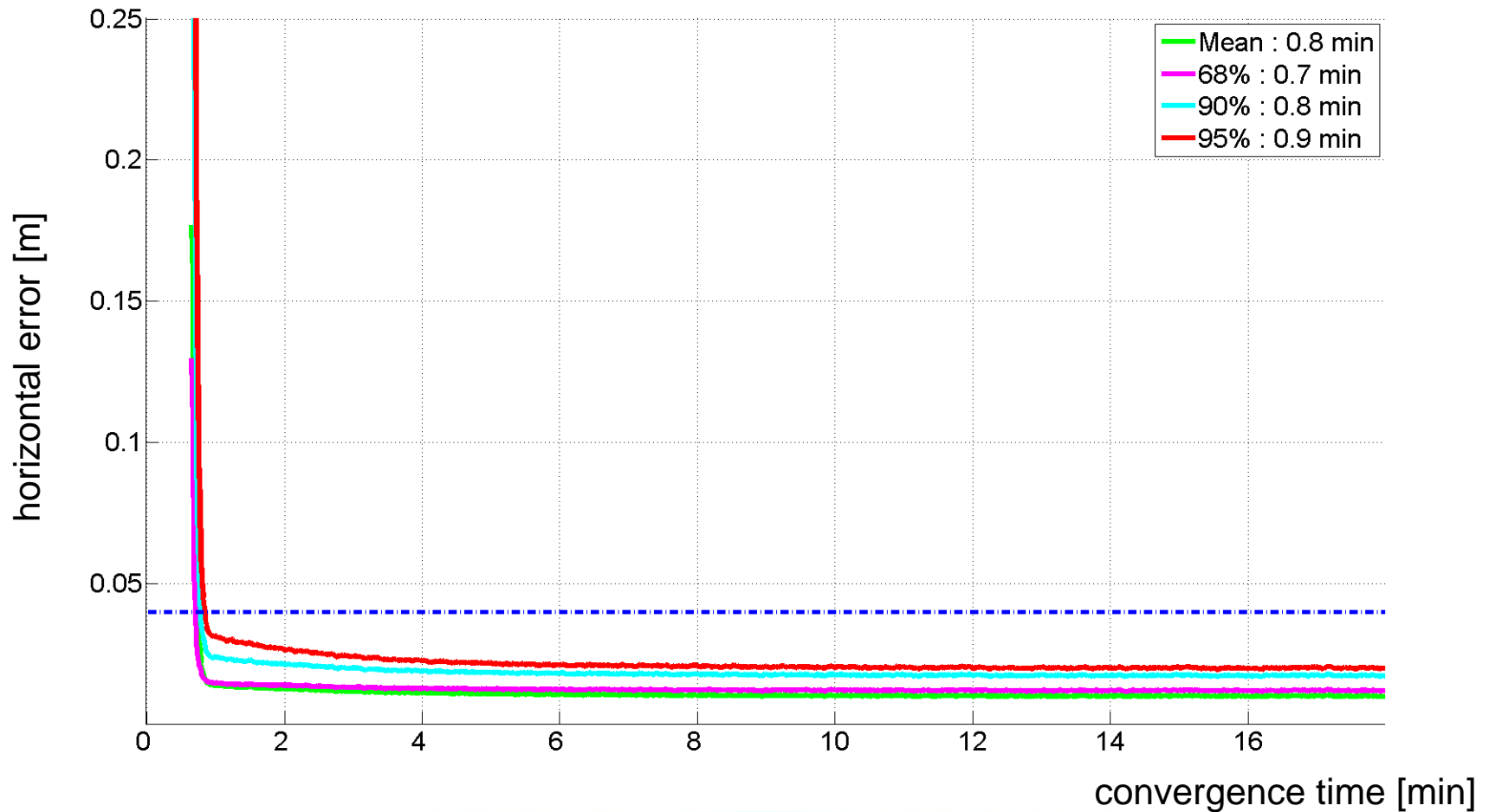
Dual frequency convergence

- ▶ Investigation of convergence time to ≤ 4 cm horizontal error for global and regional ionosphere model
- ▶ 14 days in March 2015 (2nd – 15th)
- ▶ 35 static test stations in Europe
- ▶ Kinematic processing in real time mode (i.e. no post processing)
- ▶ Restart every 30 minutes
- ▶ ~23,000 samples („convergence runs“)

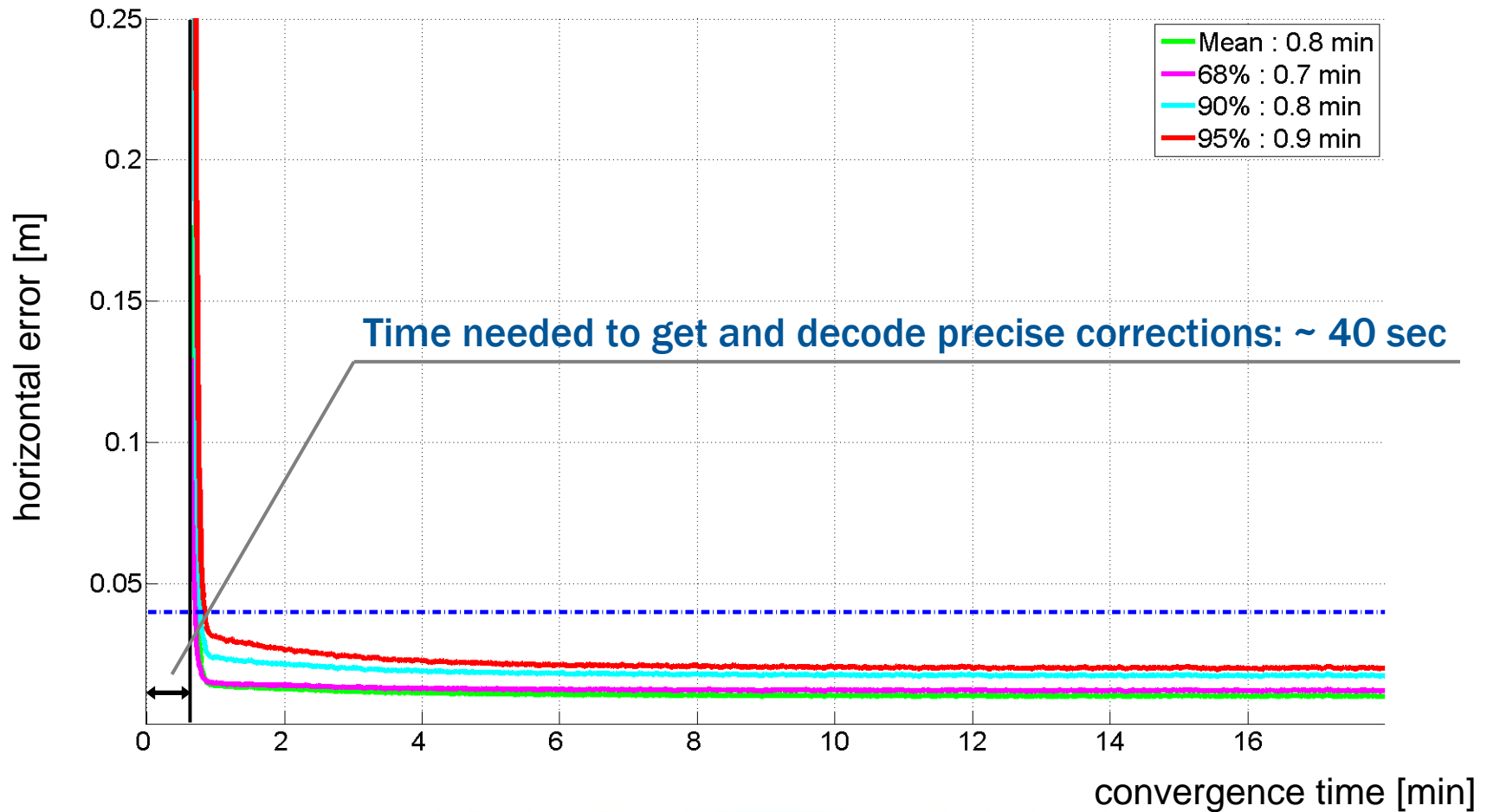
L1/L2 convergence: Global iono model



L1/L2 convergence: Regional iono model



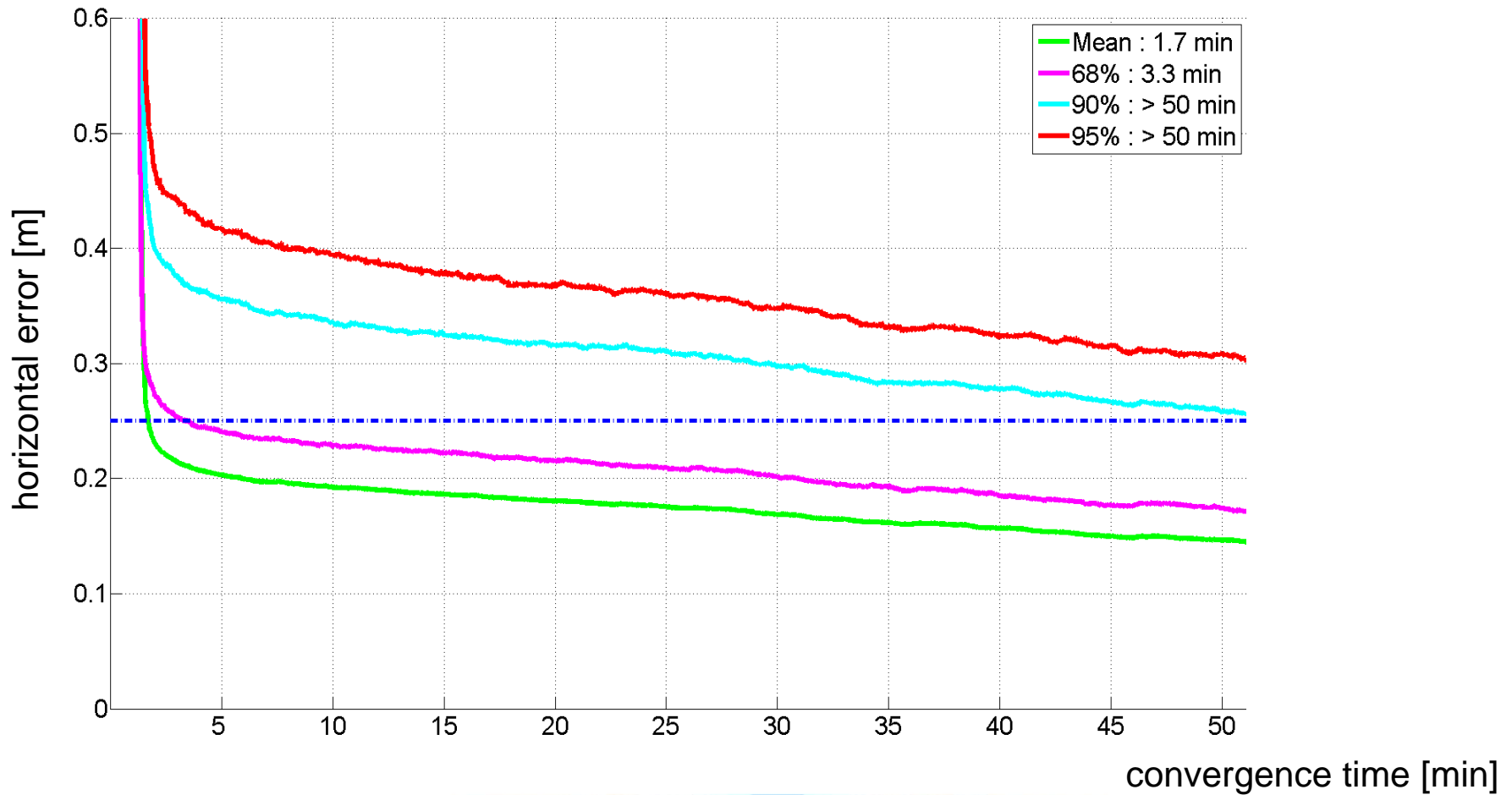
L1/L2 convergence: Regional iono model



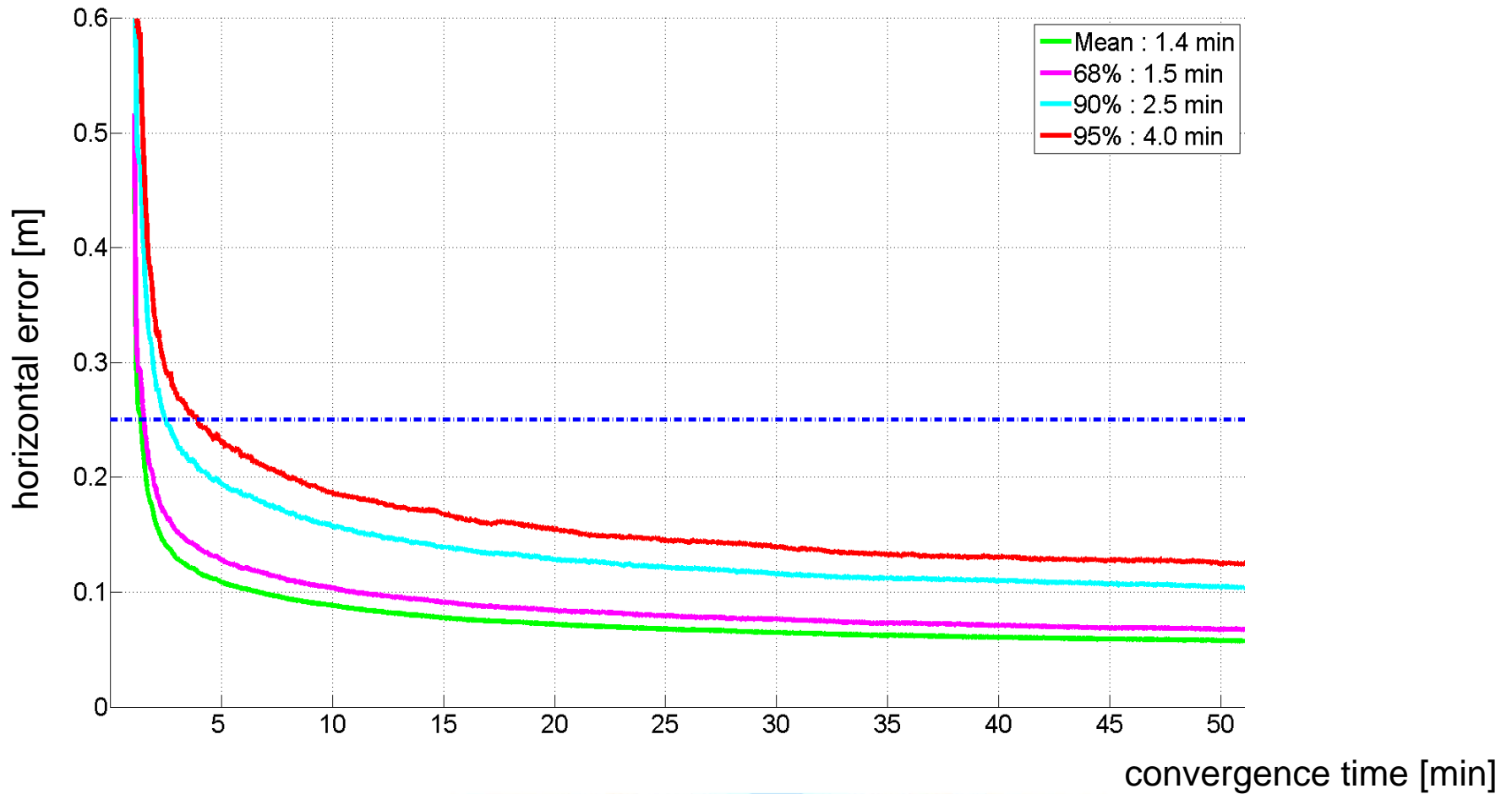
Single frequency convergence

- ▶ Investigation of convergence time to ≤ 25 cm horizontal error for global and regional ionosphere model
- ▶ 14 days in March 2015 (2nd – 15th)
- ▶ 27 static test stations in Europe
- ▶ Kinematic processing in real time mode (i.e. no post processing)
- ▶ Restart every 60 minutes
- ▶ ~8,000 samples („convergence runs“)

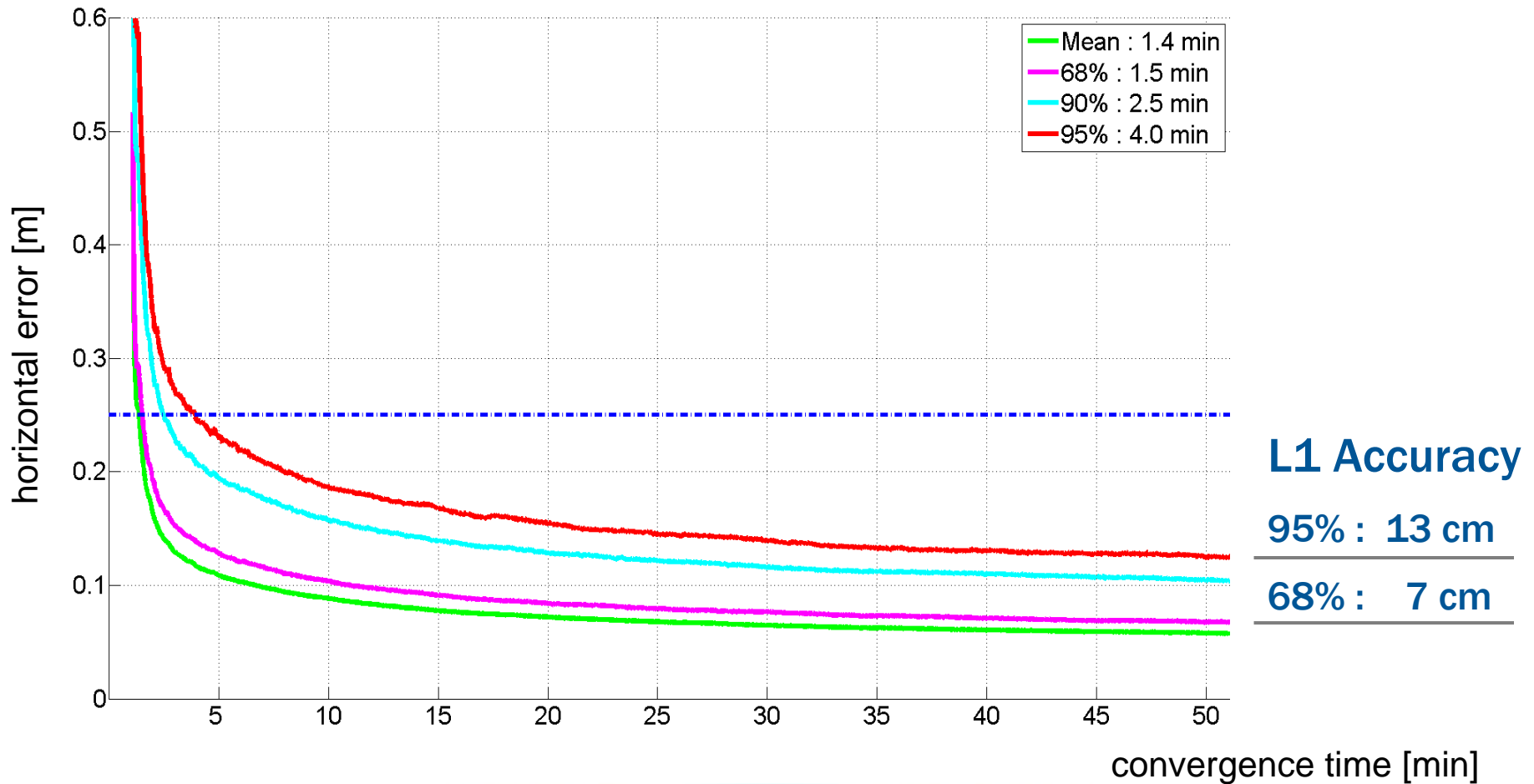
L1 convergence: Global iono model



L1 convergence: Regional iono model



L1 convergence: Regional iono model

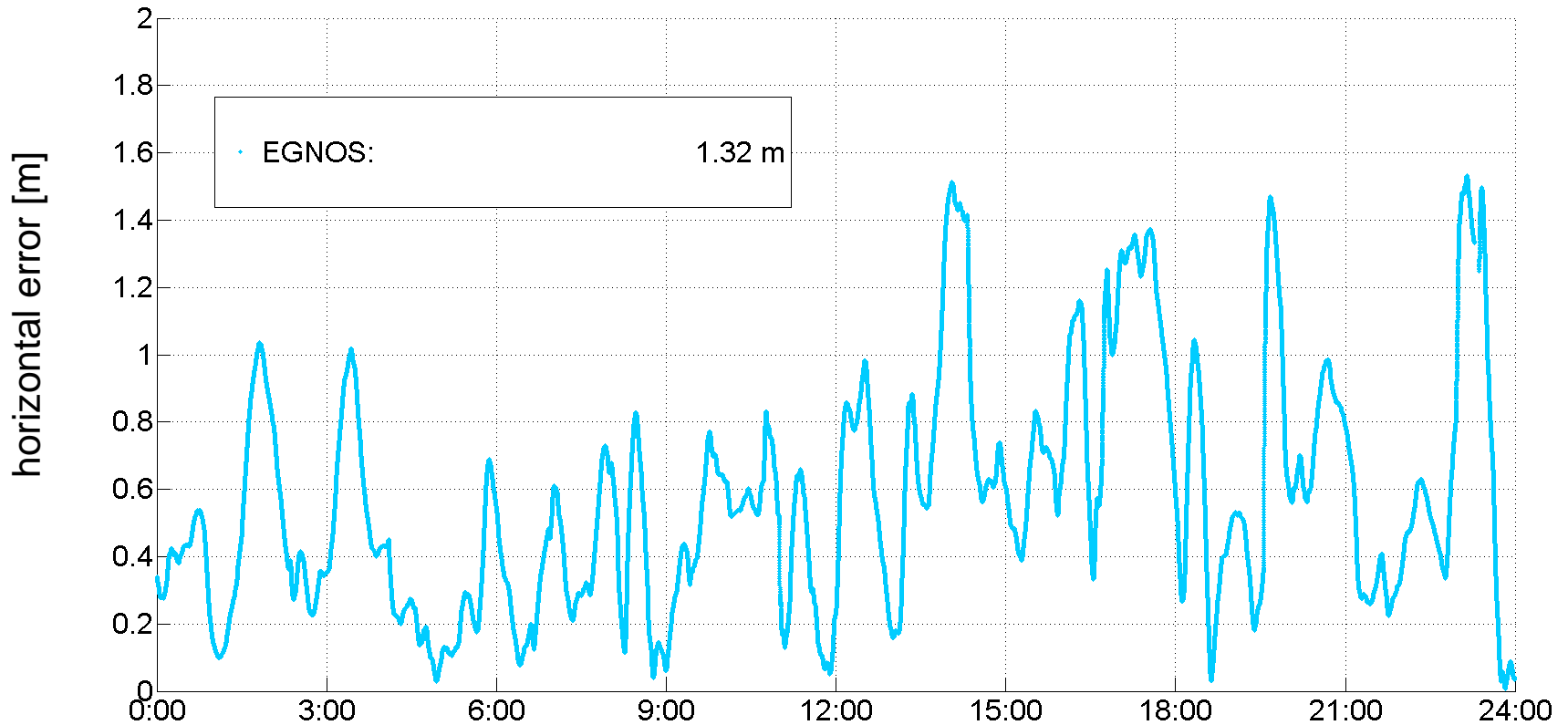


24h performance comparison

- ▶ 3 geodetic receivers connected to same geodetic antenna at Munich station
- ▶ Comparing EGNOS aided positioning to single and dual frequency RTX – converged solution
- ▶ 17th March 2015
- ▶ Global geomagnetic storm index (Kp-Index) indicates strongest event of current solar cycle at 12:00–24:00
- ▶ Ionosphere disturbances impacted the regional ionosphere model and are also obvious in the observation data of the Munich station

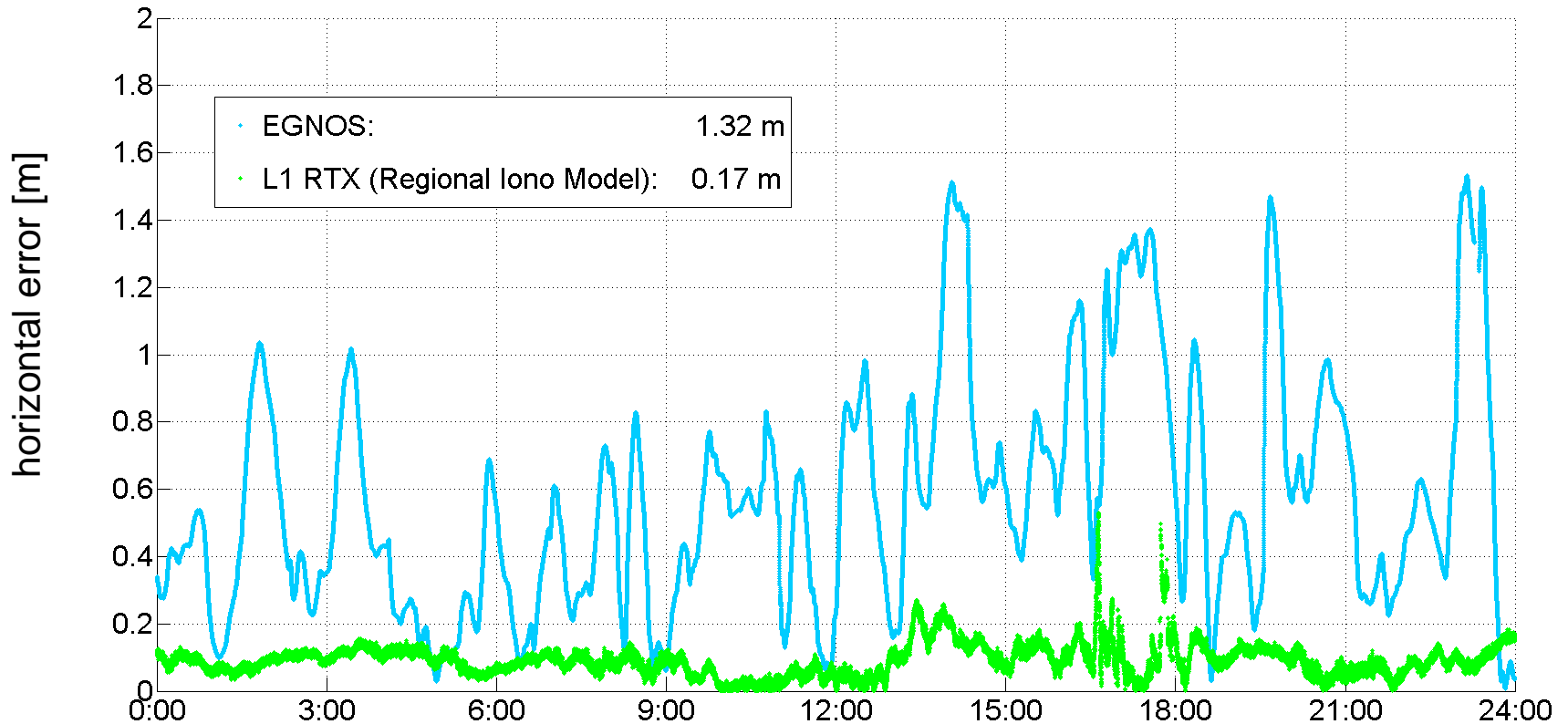
24h performance comparison

Time series of horizontal error and its 95% accuracy



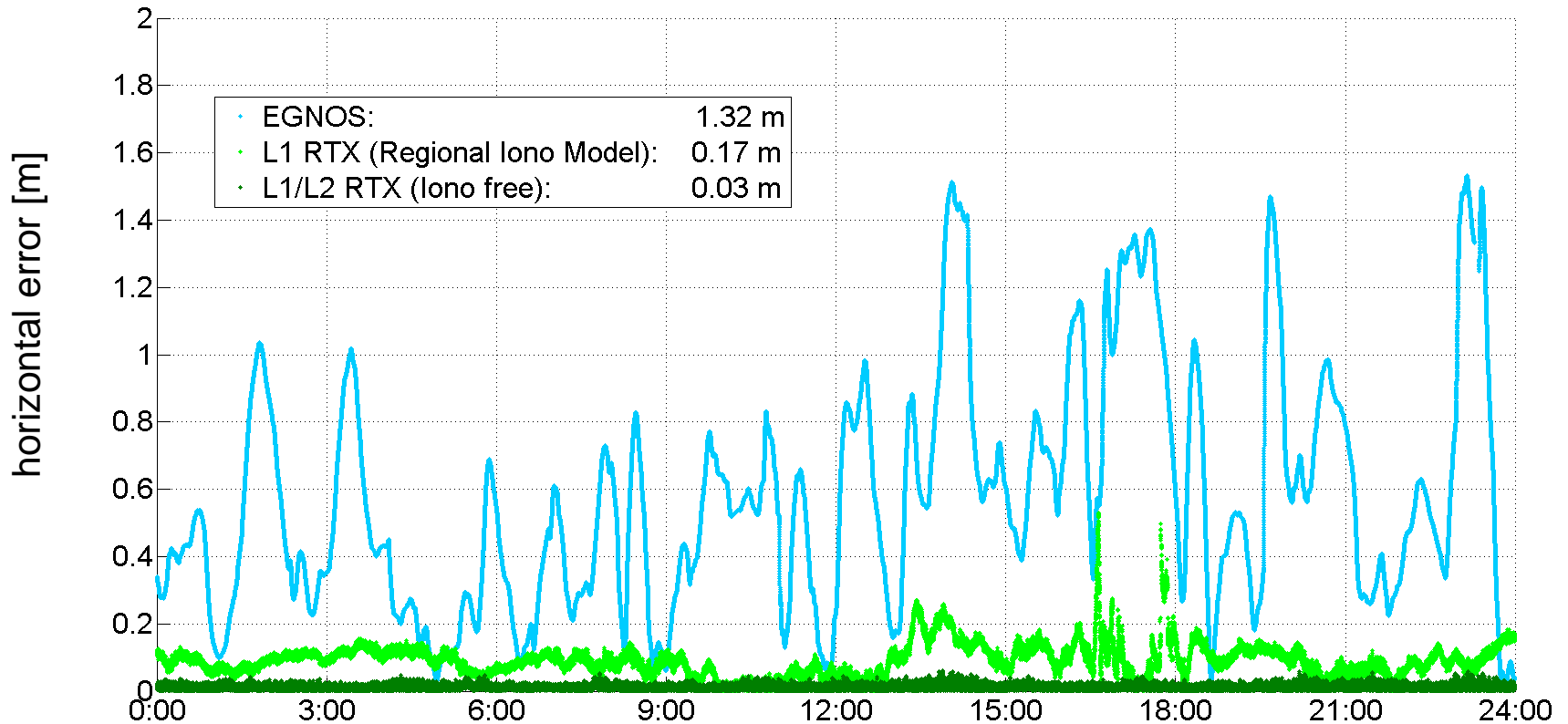
24h performance comparison

Time series of horizontal error and its 95% accuracy



24h performance comparison

Time series of horizontal error and its 95% accuracy



Summary

Trimble CenterPoint RTX ionosphere correction models

- ▶ Global model (since 2013)
- ▶ New regional, European model
- ▶ To reduce the PPP convergence time
- ▶ To improve the final PPP accuracy in single frequency mode

Summary

Performance of new regional, European model (95%)

- ▶ **Dual frequency convergence time (≤ 4 cm horizontal)**
 - ▶ Specified 5 minutes
 - ▶ 14 days test data < 1 minute
- ▶ **Single frequency convergence time (≤ 25 cm horizontal)**
 - ▶ 14 days test data 4 minutes
- ▶ **Single frequency accuracy (converged solution)**
 - ▶ 14 days test data 13 cm
 - ▶ 24 hours disturbed iono 17 cm