# Influence of global ionosphere model in static GPS surveying using commercial GPS processing software

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## Content

- Influence of global ionospheremodel in static GPS surveying?
- Test methodology
- Results

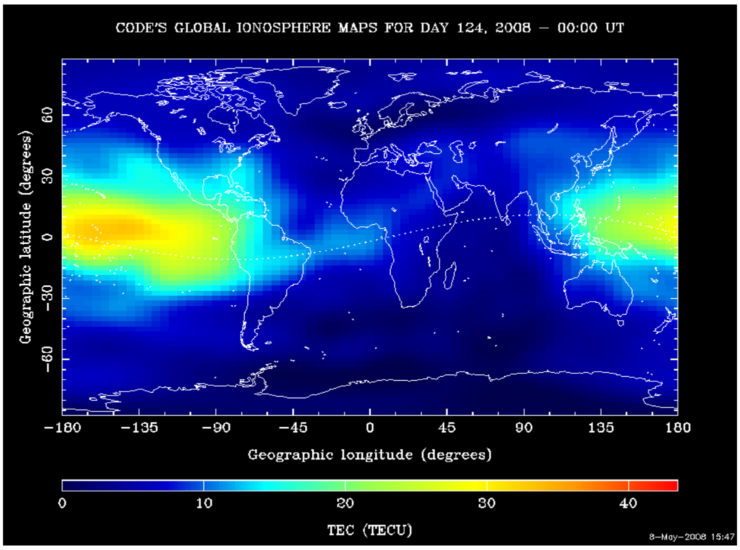
# Influence of ionosphere

- Ionosphere is from 50 up to 1000 km above ground
- Ionosphere is one of the biggest error sources in GPS processing
- Ionosphere is dispersive medium with respect to the GPS frequencies
- Influence of ionosphere depends on the electron density



# Influence of ionosphere

- Ionosphere has time dependent variation:
  - Solar activity has 11-year cycle with great influence for number of electrons
  - There is also significant seasonal and diurnal variation




Animation: CODE (Astronomical Institute, University of Berne)



# Elimination of influence of ionosphere

- Traditionally the ionosphere effects have been eliminated using dual frequence receivers and ionosphere-free linear combination in processing
- Possibility use global ionosphere maps

# Global ionosphere maps

- Generated from worldwide GPS observations
- We used CODE final ionosphere model in processing
  - CODE IONEX(IONosphere map EXhange) files
  - VTEC (Vertical total electron content)-information
  - Two hour interval
  - Free download from the web
  - Maintained by Astronomical Institute, University of Berne, Switzerland



# Test methods

- Process same GPS dataset with and without ionosphere model using broadcast and precise ephemerides
- Influence of ionosphere compared to influence of precise ephemerides
- Influence of ionosphere with different observation times and baseline lengths

# Test field




# Test field and test data

- Seven reference point forming a set of 18 baselines
- Baselines lengths vary from 1.8 to 32.5 km
- Reference coordinates were processed and adjusted from the whole five-day observation data with Trimble Total Control
- Test data was divided into 10min, 15min, 30min, 1h, 2h, 3h and 6h observing times

| observing times | 10 min | 15 min | 30 min | 1 hour | 2 hours | 3 hours | 6 hours |
|---|---|---|---|---|---|---|---|
| number of sessions | 20 | 20 | 20 | 20 | 15 | 10 | 5 |

# Processing the data

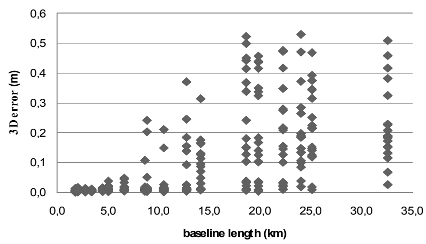
- Data was processed with Trimble Total Control (TTC) software
- Available for all surveyors
- Easy to download ionosphere model from the web



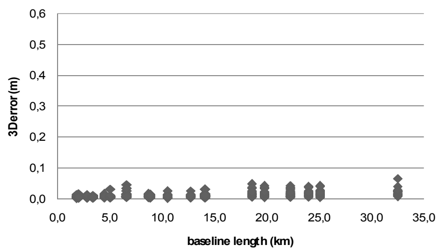
# Processing the data

- Processing interval was 30 seconds
- All vectors were processed individually without network adjustment
- Four combination
  - Processing data without ionosphere model using broadcast and precise orbits
  - Processing data with ionosphere model using broadcast and precise orbits
- Almost 8,000 baselines were processed

# Processing the data




Individual 3D errors for 10 minute sessions with broadcast ephemerides
(7 gross errors discarded)




Individual 3D errors for 10 minute sessions with broadcast ephemerides using ionosphere model
( 1 gross error discarded)

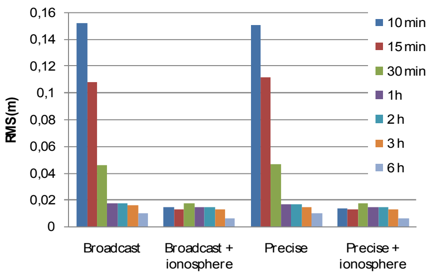


# Pre-processing of the results

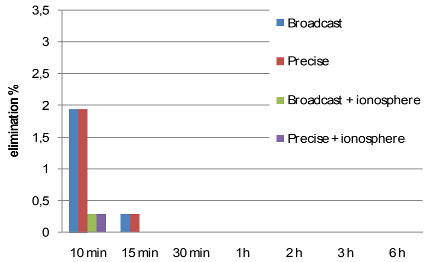
- Cleaning data from gross errors
- Accuracy and reliability
- Three methods to clean data

# Method 1:

- Eliminate gross errors that were bigger than one meter




Rms accuracy

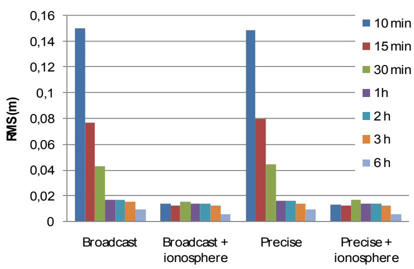



Percentage of discarded vectors

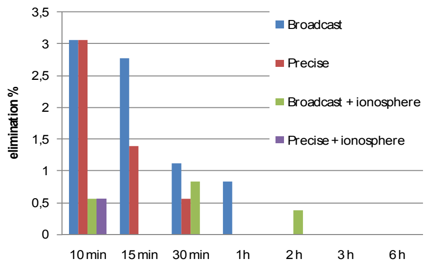


# Method 2:

- Errors larger than 3*rms were discarded



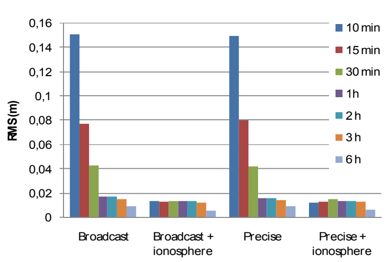

Rms accuracy



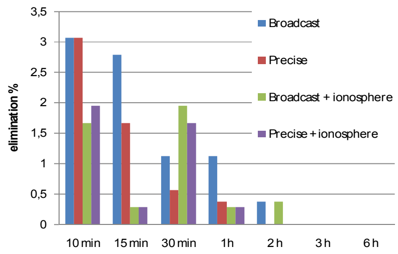

Percentage of discarded vectors

# Method 3:

- Data points that were outside the 3*σ were discarded




Rms accuracy




Percentage of discarded vectors

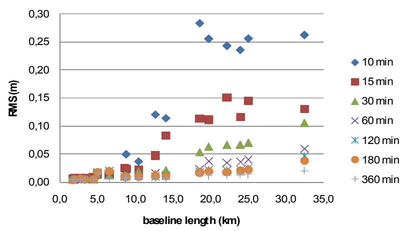


# Pre-processing of the results

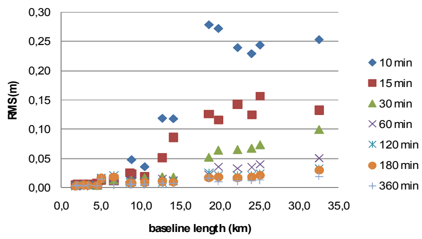
- Elimination method have only minor effects to the results
- Method 3 was chosen to eliminate gross errors
- Rms-value was chosen to accuracy measure

# Results

- Accuracy without ionosphere model using broadcast and precise orbits




Broadcast ephemerides

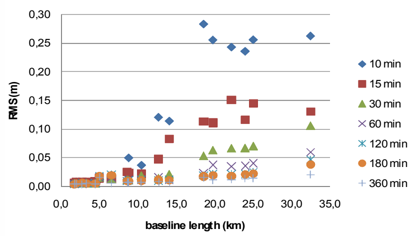



Precise ephemerides

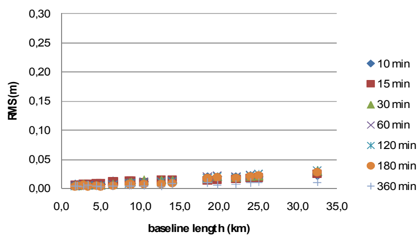


# Results

- Accuracy with and without ionosphere model using broadcast ephemerides



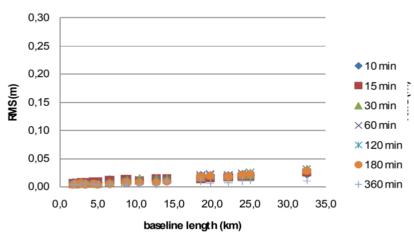

Without ionosphere model



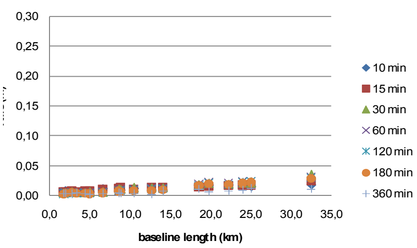

With ionosphere model

# Results

- Accuracy with and without ionosphere model using precise ephemerides




Broadcast ephemerides




Precise ephemerides



# Conclusions

- Ionosphere model improves accuracy of static GPS surveying
- With short observing time and long baselines accuracy improves from decimeter level to centimeter level
- With ionosphere model one may get similar results with drastically shorter observing times
- Use of precise orbits instead does not improve accuracy significantly

# Further study

- More data from larger area
- Larger seasonal and diurnal variation in data
- Different processing software's
- Finnish Geodetic Institute is continuing the study



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