Inst. für Astronomische und Physikalische Geodäsie
Technische Universität München
Prof. Urs Hugentobler
Tel. 089 – 289 23195, Room 3618
`urs.hugentobler@bv.tu-muenchen.de`

Wintersemester 2014/2015

Labs in Precise GNSS

Exercise 2: **Positioning with Pseudoranges – Part A**

The simplified pseudorange observation equation for the for receiver i and satellite k reads as

$$P_i^k = |\mathbf{r}^k - \mathbf{r}_i| + c \cdot \delta t_i - c \cdot \delta t^k + T_i^k + I_i^k + E_i^k \tag{1}$$

with

$\mathbf{r^k}$	position of satellite k
$\mathbf{r_i}$	position of receiver i
δt^k	satellite clock correction
δt_i	receiver clock correction
T_i^k	tropospheric correction for receiver i tracking satellite k
T_i^k	ionospheric correction for receiver i tracking satellite k
E_i^k	observation errors

In part A of this exercise, atmospheric effects will be neglected. L1 code observations as well as the satellite positions and satellite clock corrections for the stations Wank and Zugspitze are given in separate files. For details see the `readme.txt` file of the zip archive.

2.1 L_1 Pseudorange Solution

Compute epoch-wise L1 coordinate and receiver clock solutions for station Wank. Start with a priori station coordinates given below and receiver clock correction equal to zero. Due to numerical reasons, express the receiver clock correction in meters. Estimate for each epoch the station position and clock correction linearizing the observation equation and using the method of least squares from L_1 code observations. I.e., write a MATLAB script that performs more or less the following:

1. Read the satellite positions and observations you need
2. Loop over all observation epochs

3. For a given epoch:
   (a) Correct satellite positions for Earth rotation during light travel time
   (b) Compute the derivatives of the observation equation w.r.t. the estimated parameters
   (c) Set up the grand design matrix $\mathbf{A}$ and the observation vector $\mathbf{l}$ for all observations of the epoch
   (d) Compute the normal equation matrix and solve it
   (e) Compute the formal errors of the parameters
   (f) Store the results and the formal errors and go to the next epoch

Constants

$c = 299\,792\,458\,\frac{\mathrm{m}}{\mathrm{s}}$	vacuum speed of light
$\omega_E = 7.292\,115\,146\,7 \cdot 10^{-5}\,\frac{\mathrm{rad}}{\mathrm{s}}$	Earth rotation rate

A priori coordinates

Wank:	$x_r = 4235956.688$ m,	$y_r = 834342.467$ m,	$z_r = 4681540.682$ m
Zugspitze:	$x_r = 4246098.549$ m,	$y_r = 824269.097$ m,	$z_r = 4675790.018$ m

2.2 Interpretation of the results

1. Plot the time series of station coordinates and receiver clock corrections together with their formal errors. Give numerical values for station coordinates and receiver clock corrections of the first epoch in your report.

2. Assuming that the a priori coordinates are the true position: which accuracy and which precision have you achieved with this simple positioning algorithm?

3. Which effects have been neglected and which order of magnitude do they have?

Submission deadline for joint lab report on part A and B: 01 December 2014