Potsdam, October 2014

CUBE timing errors introduced by long periods without GPS reception

The CUBE uses a low power consumption quartz oscillator. The drawback is that has a drift of up to +- 0.02 seconds per day. Please look at the observed drifts for 200 CUBEs from an actual field deployment (Fig. 2, top). This is generally not a problem at all! Since the CUBE periodically gets precise GPS timing information, i.e. individual data samples get an accurate GPS time, the necessary post-processing of the CUBE data (conversion to mini-SEED) considers these time tags and interpolates the time between these tags (assuming a linear time interpolation) produces a highly accurate (with respect to timing) data stream. The post-processing also does a "resampling" of the data points (by sinc interpolation) in a way that data from different CUBEs are synchronized, i.e. all digital samples from different CUBEs will have the same sampling time.

The overall timing accuracy assuming periodic GPS reception will be of the order of <50 microseconds (absolute time!).

If there is no GPS reception for longer time periods (CUBEs inside buildings, below subsurface, in an Ocean Bottom device, exceptional poor(!) GPS reception, etc.) the general assumption of a linear time drift versus the real (non-linear) time drift of the CUBE quartz oscillator might introduce some timing error.
The following figure (Fig. 1) shows schematically the potential deviation from an assumed linear drift when no GPS signals are received.

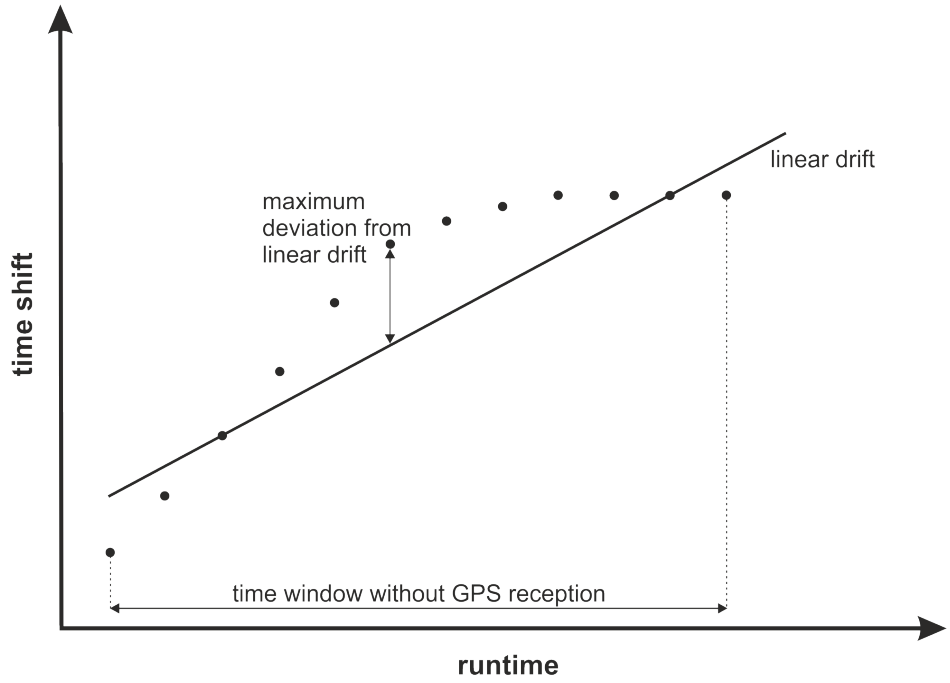


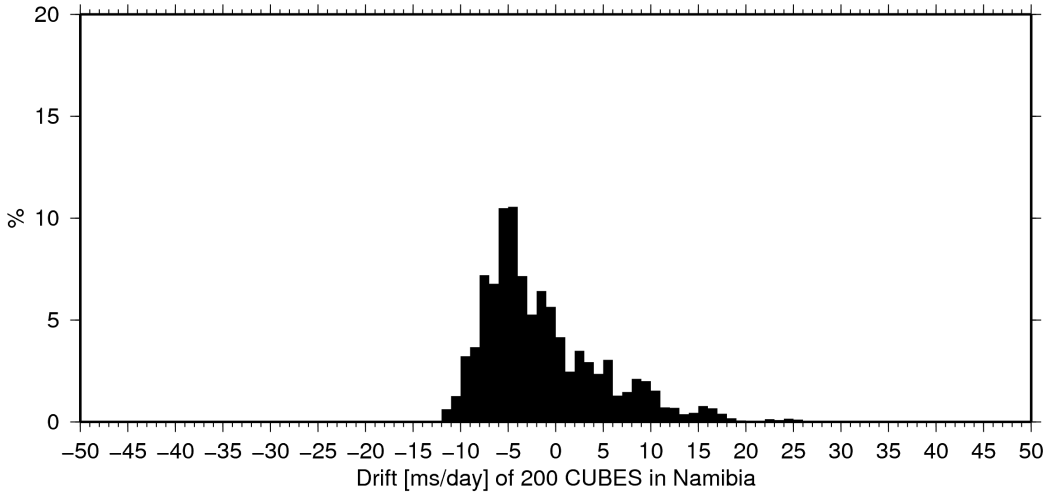
Fig. 1

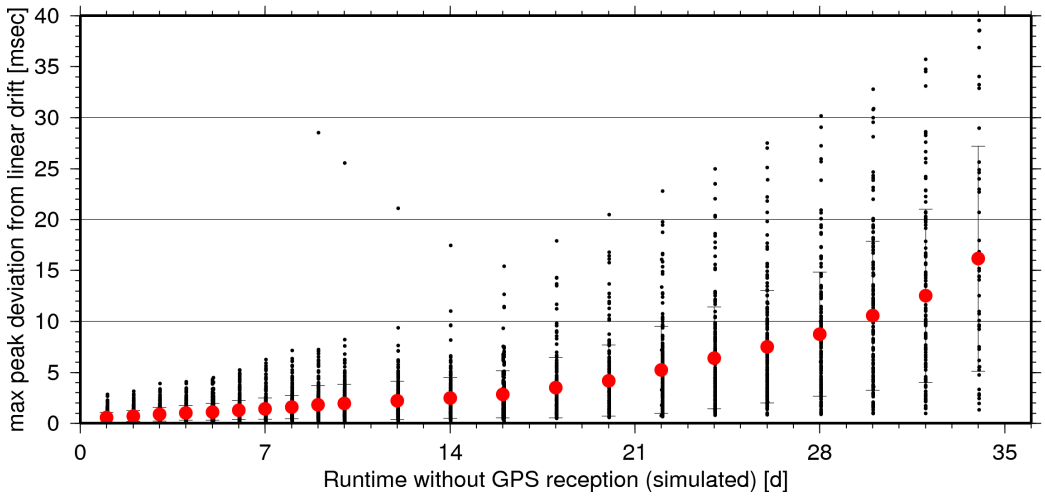
Extensive simulation of longer time periods without GPS reception had been carried out. The base for this investigations was a 7 week data set of 200 CUBEs deployed in the Namibian desert. There the daily temperature variations are the main reason for non-linear timing behaviour. Based on the data stream with +- continuous GPS reception I simulated (bootstrapping) periods of no-GPS reception and calculated the peak deviation from a linear behaviour, thus simulating periods of no GPS reception (schematics in Fig. 1).

Fig. 2 (bottom) shows the results of the peak deviations from linear time drift for a given time period (1-34 days). The black dots show the individual peak deviations (in milliseconds) for 200 CUBEs, the red dots are the average of these peak values.
(Note that one CUBE had a general malfunction: outlier for a duration of 8 - 14 days).

Example1: if you have a CUBE which has no GPS reception for 7 days, it will introduce a absolute timing error of typically less then 2 milliseconds, extreme cases might reach 7 milliseconds.

Example2: if you have a CUBE which has no GPS reception for 4 weeks, it will introduce a absolute timing error of typically less then 10 milliseconds, extreme cases might reach 30 milliseconds.





Remark: Please note the the CUBE was not designed to operate without GPS reception for a long time, GPS reception is considered as an integral part of the CUBE operation!
Try to avoid to run a CUBE without GPS by all means (or live with the introduced timing errors...). Questions? email me: trond@gfz-potsdam.de (Trond Ryberg)