For estimation of stochastic parameters, i.e. zwd, gradients and clock, Herring et al. (1990) suggest to use optimal linear smoothing. An optimal linear smoother is a combination of two Kalman filters that run in opposite directions (forward running filter: FRF, backward running filter: BRF).

As within OCCAM, clock is estimated as deterministic offset plus random walk rate.

The FRF is initialized with zero values for the parameters to be estimated (zwd, grd, clk and coordinate residuals). A priori standard deviations are chosen as follows: 100 m for station position, 1e4 m for clock bias, 0.01 m/s for clock rate, 1 m for zenith wet delay and 0.1 m/s for gradients (these are values Zinovy told me he is using and which I believe Joerg is using for the OCCAM KF too). The BRF is started with the final parameter estimates of the FRF. Herring et al. suggested using a priori variances for the BRF that are 1000 times greater than the variances of the final FRF parameter estimates.

Tests have revealed that the estimates of the FRF are not influenced by much by the choice of a priori variances as long as the variances are not too small. For the BRF, however, significant differences could be observed for the clock estimate when using different a priori variances. With a priori variances as suggested by Herring et al., the clock estimate of the BRF shows a somewhat strange behaviour. Figure 1 shows results of an analysis where all parameters were estimated, but where zero white noise and zero zwd were used for generation of fake delay observables in order to be sure that the strange results are not due to the turbulent troposphere. In Figure 1a the simulated clock time series (black), the final clock estimates of FRF (blue) and BRF (red), and the smoothed solution (green) are shown. It can be seen, that the FRF solution is very close to the simulated time series, whereas the BRF solution is not at all good. It is interesting to notice, that the smoothed solution is still better than the FRF solution, even though the BRF estimate is that bad. Figure 1b presents clock rate estimates of FRF (blue), BRF (red) and smoothing (green). Figure 1c shows FRF (blue) and BRF (red) estimates of clock offset. The FRF offset estimate shows the behaviour one could expect from a deterministic parameter: it shows some variation at the beginning but approaches an almost constant value then. I had expected the BRF to show the same behaviour, which is obviously not the case.
Figure 2 shows the same plots as Figure 1 but for an analysis where the BRF was started with the variances of the final FRF estimates without multiplying it by 1000. It can be seen in Figure 2a that the BRF clock estimate is much closer to the simulated time series now. Also the rate estimates presented in Figure 2b and the offset estimates presented in Figure 2c look much more reasonable now. I'm still somewhat worried about the BRF estimate of clock offset. It looks as I would have expected at the beginning (BRF starts at t = 24 hrs), but starts diverging towards the end.

Table 1 shows mean rms of zwd residuals, mean rms of clk residuals, and hgt residuals for both analyses. It can be seen that the only value, that is significantly affected, is the mean rms of clk residuals of the BRF (this is only true when using zero zwd and zero white noise).

Table 1 mean rms of zwd residuals, mean rms of clk residuals and hgt residuals in mm

BRF started with 1000 times the variances at the end of the FRF			
[mm]	zwd	clk	hgt
FRF	0.99	1.91	-0.05
BRF	1.19	**25.27**	-0.06
S	0.27	0.46	X

BRF started with variances at the end of the FRF			
[mm]	zwd	clk	hgt
FRF	0.99	1.91	-0.05
BRF	1.22	**1.90**	-0.05
S	0.27	0.46	X

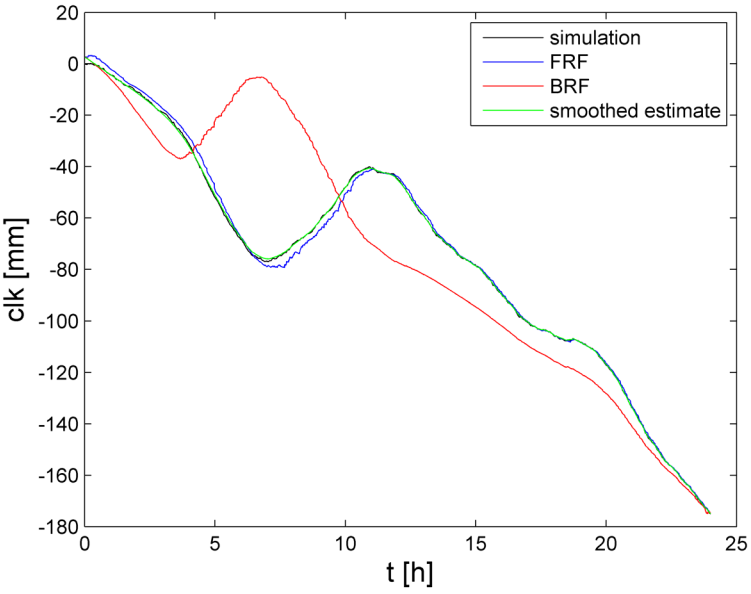

Figure 1a simulated clock time series (black), final clock estimates of FRF (blue) and BRF (red), and smoothed clock estimate (green). The BRF was started with a priori variances of 1000 times the variances of the parameter estimates at the end of the FRF.

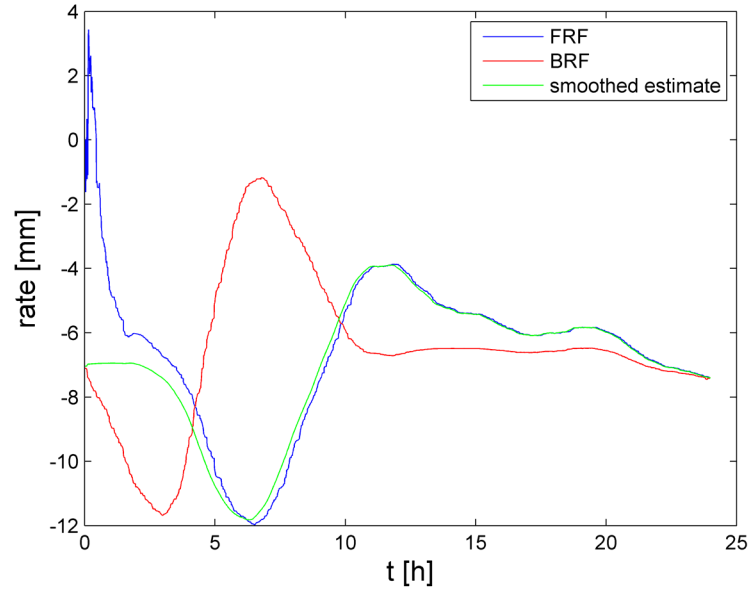

Figure 1b clock rate estimates of FRF (blue) and BRF (red), and smoothed rate estimate (green). The BRF was started with a priori variances of 1000 times the variances of the parameter estimates at the end of the FRF.

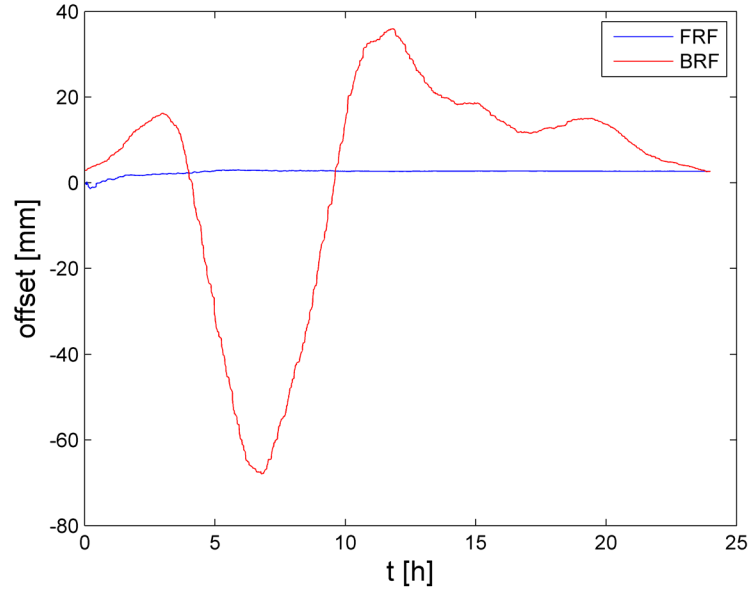

Figure 1c clock offset estimates of FRF (blue) and BRF (red). The BRF was started with a priori variances of 1000 times the variances of the parameter estimates at the end of the FRF.

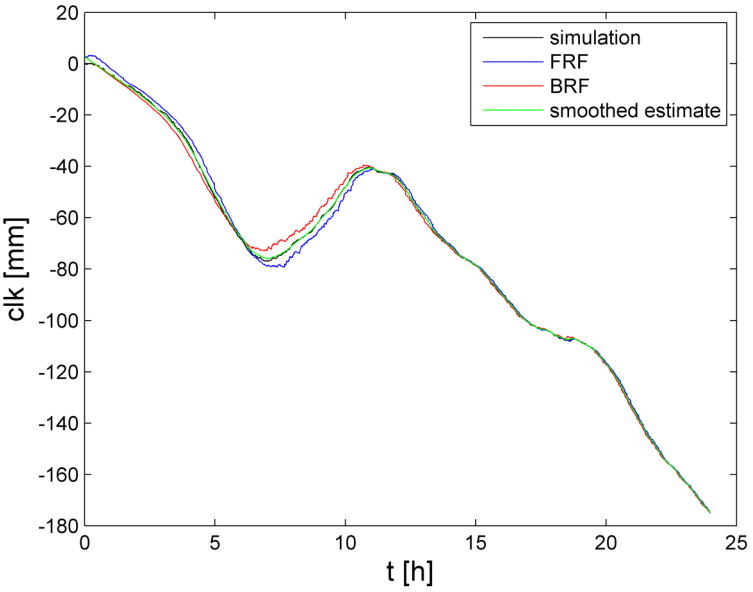

Figure 2a simulated clock time series (black), final clock estimates of FRF (blue) and BRF (red), and smoothed estimate (green). The BRF was started with the variances of the parameter estimates at the end of the FRF as a priori variances.

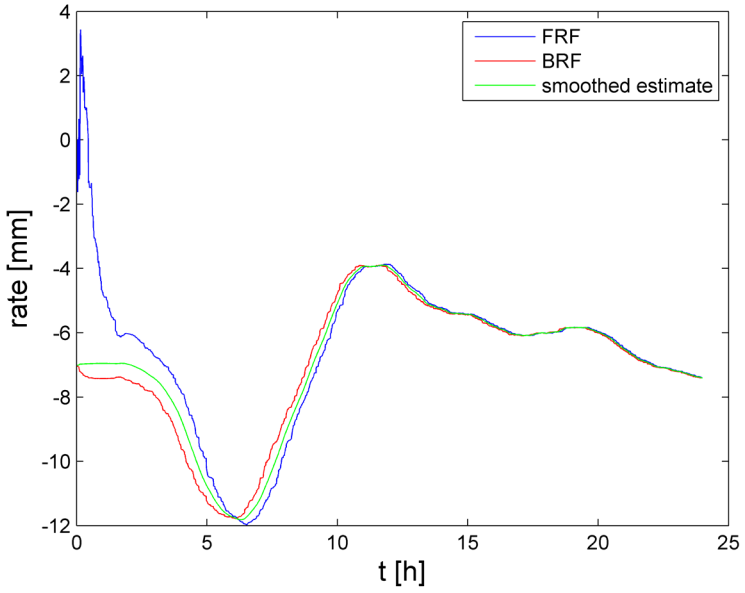

Figure 2b clock rate estimates of FRF (blue) and BRF (red), and smoothed estimate (green). The BRF was started with the variances of the parameter estimates at the end of the FRF as a priori variances.

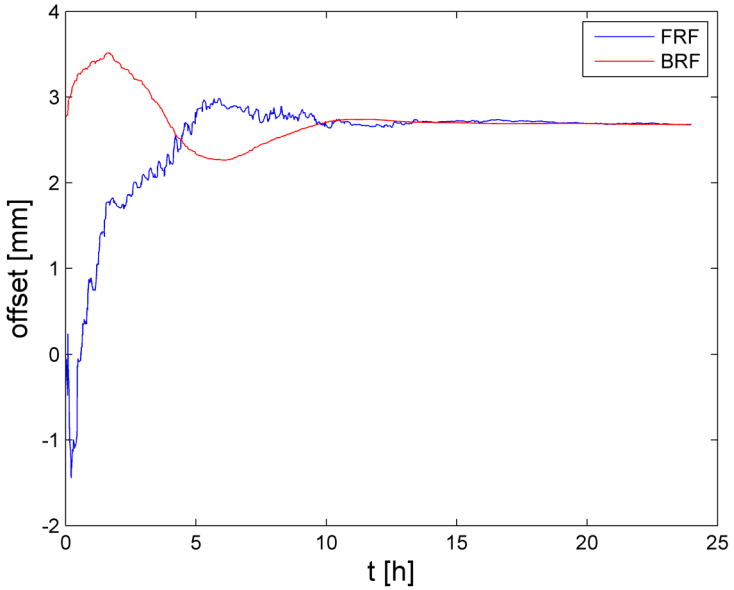

Figure 2c clock offset estimates of FRF (blue) and BRF (red). The BRF was started with the variances of the parameter estimates at the end of the FRF as a priori variances.