The International Terrestrial Reference Frame (ITRF) combines microwave (MW) based observations to Global Navigation Satellite Systems (GNSS) satellites and Satellite Laser Ranging (SLR) observations to the pairs of LAGEOS satellites using a level at the stations. Experiments using SLR observations to GNSS satellites that are equipped with both techniques (mainly GLONASS) as space tires for the combination were studied in the past [3, 5]. The goal is to prevent GNSS-diascoric signals into the center of mass of the Earth as determined by the spherical SLR satellites. At the same time the quality of the ERP series should not be degraded by the considerably noisier SLR measurements. We concluded that the effect of including SLR in a combination solution was insignificant as the combined solution remained within the same standard deviations as the SLR-only solution. (8) concluded that co-locations in space are more effective in terms of the scale information than the larger noise in the SLR observations and the better ERP estimation capability of the MW observations. The simulation approach allows to distinguish between the effect of the observation noise and the effect of the geographical distribution of the observations in space. At this weighting the GECs match the solution derived from SLR observations to LAGEOS on the level of 0.05 mas and the ERPs remain ± 0.02 mas within the solution obtained from the MW observations.

Combination of SLR and MW observations

We created daily combined NEQ (NEQcomb) by stacking the individual NEQ from MW data to GLONASS (NEQGL) satellites provided by REPRO 15 and the NEQ generated from SLR observations to GLONASS (NEQSL). The common parameters are ERPs, GCCs and the satellite orbit parameters. All SLR observations were replaced by simulated NEQ (3) using the consistent set of stations coordinates and satellite orbits from REPRO 15. Therefore the truth is known and we can distinguish between the influence of the observation noise and the effect of the SLR observation distribution in the solution. We used a weight of $\omega = \frac{1}{\sigma_{MW}^2} \approx 12$ and again $\omega$ needs to be at least 50 to significantly differ from solution with $\omega = 1$. The scatter between the days remains on the same level.

Influence of SLR observation noise

To assess the influence of the simulation noise on the scatter between the days in Fig. 2 we created a simulated scale and scatter of the different solutions. For $\omega = 4,000$ the scatter between the different solutions remains smaller than the one given by the variation in available observations. For weights of $\omega = 5,000$ the scatter between different realizations of the random simulation noise reaches the same level as the scatter given by the variation in the distribution of available observations. For higher weights the noise dominates the scatter.

Figure 2 shows the scale that is transferred onto the GNSS station coordinates for four different initializations of the simulation noise for a fixed weight $\omega = \frac{1}{\sigma_{MW}^2}$.

Combination with LAGEOS

The solutions of the combined SLR and MW observations to SN does not resemble the ratio of observations. We can see that more than 0.1% of the scale in Fig. 2 is now estimated as SAO-z and SAO-x. SAO-z is limited by the spherical SLR satellites. At the same time the quality of the ERP series should not be degraded by the considerably noisier SLR measurements. At the same time the quality of the ERP series should not be degraded by the considerably noisier SLR measurements. The different number of stations, SLR station only being able to track one target at a time and the MW station being able to track multiple satellites at once results in available observations. For weights of $\omega = 8,000$ the scatter between the days remains on the same level.