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## Motivation

According to the IERS Conventions 2010, the instantaneous station position  $X(t)$  is the sum of a regularized (residual) position  $X_R(t)$  and  $n$  conventional reduction terms (see Figure 1).  $X_R(t)$  is parameterized as a position at a reference epoch  $t_0$  and a constant velocity. The modeled reduction terms  $\sum_n \Delta X(t)$  describe the non-linear station movement which is caused by instrumental or by various geophysical effects (e.g. Earth tides, ocean loading). Errors or uncertainties in the used reduction models and so far neglected effects (e.g. atmospheric and hydrologic loading) are in conflict with the common linear parameterization of the residual station motion and therefore could falsify consistently estimated parameters, in particular epoch parameter like the Earth orientation parameter (EOP). To overcome this lack of parameterization, the regularized station position could be estimated frequently in epoch reference frames (ERFs).

## Station parameterization

The regularized station positions are estimated and published usually every three to five years in the International Terrestrial Reference Frame (latest publication: ITRF2008 and DTRF2008). In these frames, the constant velocity is used to extrapolate the station position to any epoch in time. Therefore, this parameterization is called in the following multi-year reference frame (MRF).

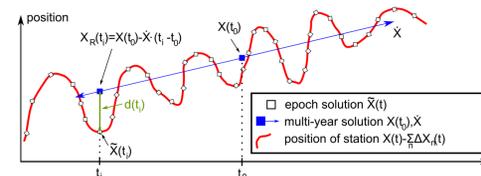


Figure 1: Parameterization of the station motion of a multi-year and an epoch reference frame.

In contrast to the MRF, the residual station positions in the ERFs are estimated more frequently in a weekly time interval (Figure 1). This kind of parameterization allows a more accurate approximation of the residual station motion than the MRF:

$$X_R(t) + \epsilon_1(t) = X(t) + \sum_n \Delta X(t) = \tilde{X}(t) + \epsilon_2(t) \quad (1)$$

with  $\epsilon_1(t) \gg \epsilon_2(t)$  being the approximation errors of the two parameterizations. All reference system realizations discussed on this poster are combinations of the geodetic space techniques GPS, SLR and VLBI and are based on identical input data.

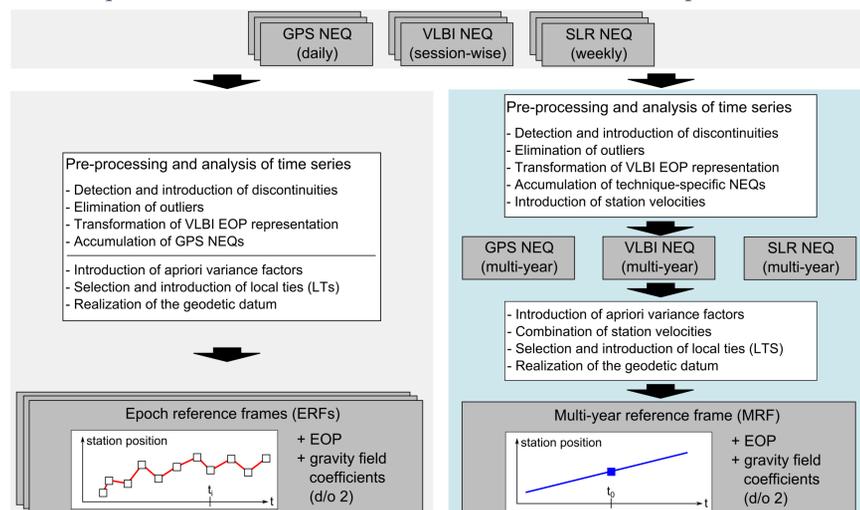


Figure 2: Processing scheme for MRF and ERF.

## Network orientation vs. EOP

As shown in Figure 2, the last step in the processing chain is the realization of the geodetic datum. In the combined solution, the orientation of the station network is realized with a 'No-Net-Rotation' (NNR) condition over a subset of GPS station coordinates. NNR means that the selected station sub-network is not allowed to show any rotations w.r.t. the apriori coordinates.

Not reduced geophysical effects in the station coordinates of the GPS sub-network could cause a common rotation of the whole station network w.r.t. the apriori coordinates and therefore could propagate into the EOP.

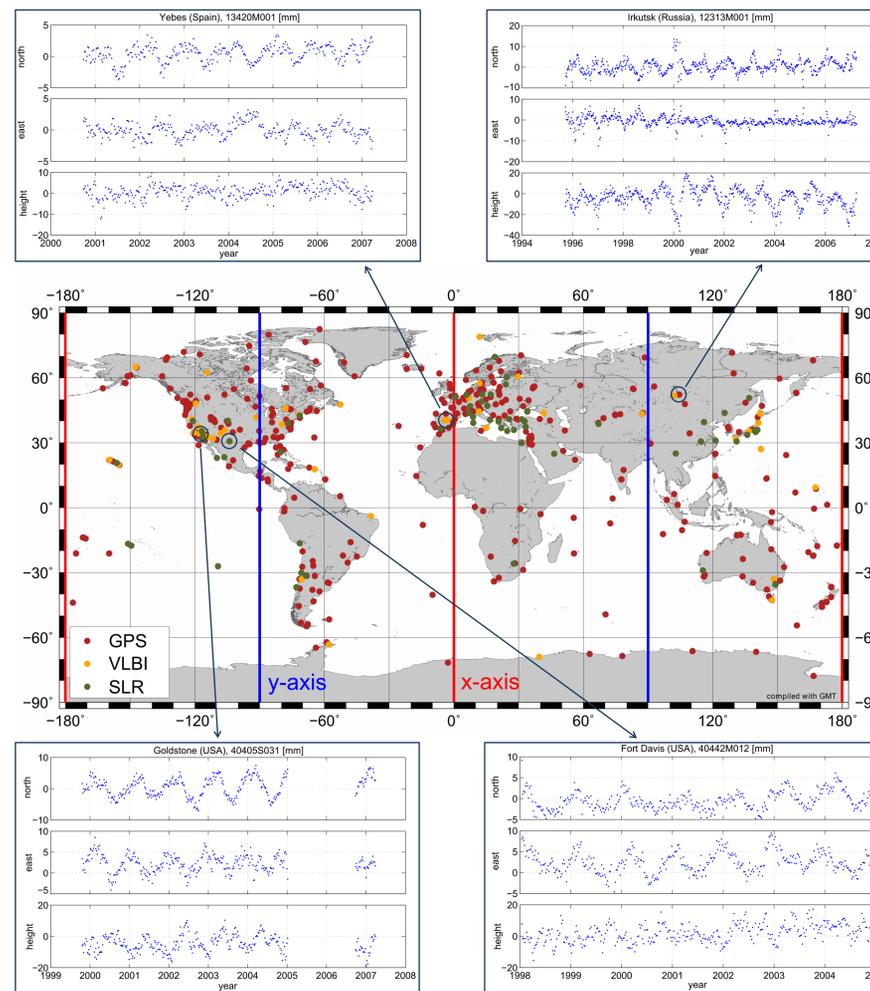


Figure 3: Global station distribution (middle) and position differences between the MRF and the ERFs for the four GPS stations Irkutsk (Russia), Yebees (Spain), Goldstone (USA) and Fort Davis (USA). These stations are used, amongst others, for the datum realization of the GPS only and the combined solution.

The terrestrial pole coordinates are complement parameter to the network orientation in the xy-plane of the Earth-fixed reference frame. The x-coordinate of the terrestrial pole (x-pole) describes the orientation of the network w.r.t. the y-axis and the y-coordinate (y-pole) describes the orientation of the network w.r.t. the x-axis, respectively. The stations, exemplarily shown in Figure 3, are used, amongst others, for the NNR condition. The position differences between the MRF and the ERFs force the whole network to a common rotation which propagates into the terrestrial pole coordinates.

## Results

The computed time series of terrestrial pole coordinates obtained from the ERF solutions are compared with those from the MRF solutions. First, the single technique EOP series are analyzed. The difference time series (MRF-ERFs) of the techniques GPS and SLR are shown in the spectral domain in Figure 4. In the GPS time series, the y-pole contains an annual signal with an amplitude of  $0.37 \pm 0.06$  mm whereas in the SLR differential time series, the x-pole contains an annual signal with an amplitude of  $2.10 \pm 0.19$  mm. The fact that the annual signal appears in different components of the terrestrial pole might be explained with the station distribution around the coordinate axes (see Figure 3, Table 1). The VLBI only solution is not discussed in detail, because its terrestrial pole coordinates show a high scattering due to the session-wise varying station network.

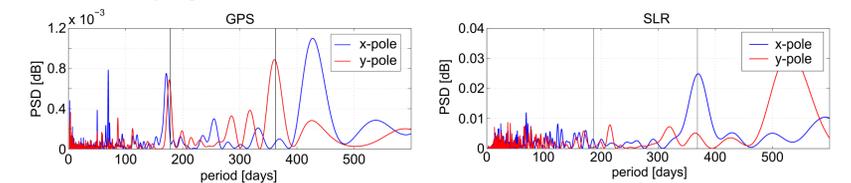


Figure 4: Power density spectra of the difference time series (MRF-ERFs) of the terrestrial pole coordinates. The left plot shows the GPS only solutions, the right plot shows the SLR only solutions.

The difference time series of the combined solutions in the temporal and in the spectral domain are shown in Figure 5. Both components of the terrestrial pole contain an annual signal (see Table 1).

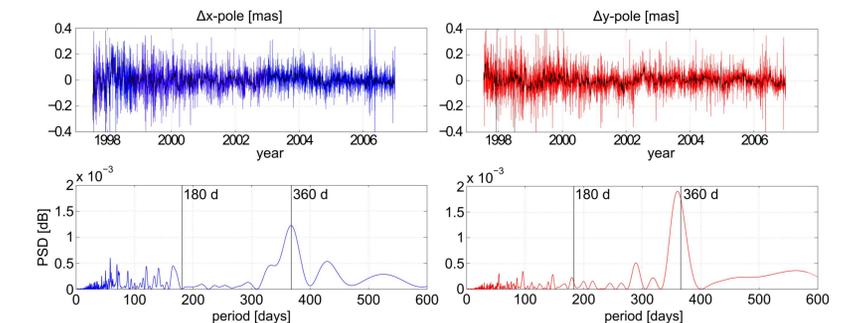


Figure 5: Difference time series of the terrestrial pole coordinates (MRF-ERFs) of the combined solution in the temporal (upper part; filtered with moving median: black) and in the spectral (lower part) domain.

Table 1: Most significant amplitudes of the single technique (GPS, SLR) and of the combined solutions.

technique	x-pole		y-pole	
	period [days]	amplitude [mm]	period [days]	amplitude [mm]
GPS	427.74	$0.43 \pm 0.06$	360.56	$0.37 \pm 0.06$
	170.84	$0.35 \pm 0.04$	176.37	$0.34 \pm 0.01$
	69.72	$0.37 \pm 0.02$		
	50.39	$0.25 \pm 0.06$		
SLR	369.41	$2.10 \pm 0.19$	528.38	$2.52 \pm 0.17$
	173.32	$1.05 \pm 0.00$	171.07	$1.19 \pm 0.11$
combination	367.55	$0.44 \pm 0.03$	360.31	$0.53 \pm 0.02$

## Conclusion

If terrestrial pole coordinates of a MRF solution are compared with those from ERF solutions, annual signals with amplitudes up to 0.53 mm are found. These signals are caused by non-linear station motions, which are approximated in ERF only solutions.