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Critical inspection of the terrestrial reference frame as derived by VLBI and GPS

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Very Long Baseline Interferometry (VLBI) and Global Positioning System (GPS) techniques start, as in all areas of science, with a given set of assumptions that are taken to be self-evident and from which all other ideas are derived. They are prone to a large extent to numerous approximations, e.g., time-light equation. Up to now, none of the available space geodetic techniques is able to estimate polar motion without aliasing from precession and nutation. Their separation is only done in an empirical way, based on their different frequency characteristics. But, whenever the observational precision improves, a clear separation becomes complicated. We need the celestial and terrestrial reference system to describe satellite orbits or radio source positions and terrestrial station coordinates. Both systems can be connected by only three rotation (Euler) angles. The basic approximate observation equation of GPS shows the practical inconceivability to calculate a free network between satellites and the terrestrial stations for the same moment. Because of the difference between mathematics and the physical world, many corrections (e.g., tidal, oceanic, clock, atmospheric, relativistic) are estimated or modeled and applied to the observables. These corrections are needed, because Least Squares Adjustment only gives satisfying results if the residuals (i.e., observed minus computed delays) follow a Gaussian distribution. Otherwise the unknown parameters will be biased. Thus, both techniques have reached an incomparable precision, which allows to study geophysical properties of the Earth such as continental drift or station height variations due to oceanic and atmospheric loading. Furthermore, associated station motions due to events like earthquakes can be detected. They affect the International Terrestrial Reference Frame (ITRF2000). Stations impressed with such sudden jumps must be detected and excluded from daily or weekly VLBI and GPS analysis. In general, a deformable Earth cannot have a body-fixed coordinate system where no displacements occur. GPS and VLBI use a

reference frame, which is realized through stations fixed on the Earth's surface. The mean surface curl underlies the condition to vanish. In VLBI, we know that station coordinate time series are less useful for global geophysical investigations requiring a higher accuracy level, as only a few stations are available to represent the complete Earth's surface. The number of GPS stations, as maintained by the International GPS Service (IGS), reaches nowadays (January 2005) approximately 400. The underlying terrestrial reference frame, called IGb00, includes 99 station positions and velocities. It has been aligned to ITRF2000 at epoch 1998.0 using an unweighted 14-parameters transformation.

In this presentation, we determine six and seven similarity transformation parameters for each epoch of so-called „free" network solutions between different Analysis Centers or techniques versus the ITRF2000. Our study shows the effect of the involved stations number, contributing to realize the reference frame, on the transformation parameters. Differences in estimated parameters lead to different results. We cannot distinguish between real and artefact crustal motion on individual sites, when two groups adopt a different set of stations to define the terrestrial reference frame. Baselines are independent of translations and rotations, and therefore only the scale problem remains. We even detected episodic baseline length changes in both space geodetic techniques. The strength of VLBI lies in the twenty years observations for a few baselines and the precise estimation of Universal Time variability. The GPS network is much more dense, but has only a shorter time-scale of observations. GPS and VLBI benefit from each other due to their complementarity. The longer the observation series, the better the baseline rate can be estimated. GPS and VLBI baseline trends agree to a very high degree, but both differ from the IGb00 or ITRF2000 reference frame. This potential, based on baselines, should be considered for future ITRF realizations. Since July 2004, the weekly coordinate solutions of the various IGS Analysis Centers agree substantially better. This clearly indicates, that a reprocessing of all GPS data, with available software packages, followed by an overall IGS combination should only be a question of time.