

K. SLR TRACKING OF GPS-35

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NASA's GSFC and the NRL co-sponsored an experiment to launch a corner cube retroreflector (CCR) array on one of the Global Positioning Satellites (GPS). After more than a year of negotiations with the USAF, the launch on Aug. 31, 1993 ushered in the era of SLR tracking of GPS spacecraft. Once the space operations group finished the check-out procedures for the new satellite, the agreed upon SLR sites were allowed to track it. The first site to acquire GPS-35 was the Russian system at Maidanak and closely after the MLRS system at McDonald Observatory, Texas.

The laser tracking network is currently tracking the GPS spacecraft known as GPS-35 or PRN 5 with great success. From the NASA side there are five stations that contribute data regularly and nearly as many from the international partners. Upcoming modifications to the ground receivers will allow for a further increase in the tracking capabilities of several additional sites and add some desperately needed southern hemisphere tracking within the coming month. Figure 1 indicates the amount of collected data by site and geographical region. In the meantime we are analyzing the data and we are comparing SLR-derived orbits to those determined on the basis of GPS radiometric data.

The nature of the SLR data set is such that data collected as late as the previous day can be incorporated in the daily analysis on a regular basis. A long-arc (~80 days) reduction produces a trajectory with an rms discrepancy of only 24 mm (Figure 2). The entire data transfer, preprocessing, reformatting, and computation of the orbit requires a maximum of two hours and involves one person. This implies that results can be disseminated to the users' network within the same day. To this day, the radiometric data derived orbits are not available to users sooner than 10-14 days after the data collection occurs. Furthermore, these orbits are disjoint, with possible biases between consecutive arcs. The data set is now being scrutinized along with radiometric data to evaluate the possible biases in the latter and identify their source. Analyses with more dense tracking when it becomes available, can give us some insight on the many sources of systematic errors in the radiometric data. Due to the nature of these measurements (one way, RF), complete separation of clock errors from orbital errors is not possible. Residual ionosphere errors and errors from tropospheric refraction result in additional degradation of the radiometric products. The reflection of rf signals near the antenna site (multipath) is an additional source of error which varies from site to site and is quite difficult to quantify on the basis of radiometric data alone. A proper characterization of the error spectrum of the on-board clocks is also of interest, especially to those using GPS signals for time-transfer. Another source of

error in computing orbits for the GPS spacecraft is the description of attitude changes, especially during eclipsing seasons. The currently available theoretical model known as ROCK4, is being used for all spacecraft with only a scale adjustment and a discrimination between Block I and Block II types. Better handling of the non-conservative force modeling can be achieved using precise SLR tracking and the resulting orbits, to "tune" these models to each spacecraft individually. Finally, geodetic positioning can benefit from the increased accuracy orbits of CCR-carrying GPS spacecraft in two ways:

- 0 The better orbits result directly in better positioning and they can also allow for the reliable resolution and "fixing" of the ambiguities of doubly-differenced phase measurements; and
- 0 The latter strengthens the estimation procedure since it converts in effect the very precise but relative measure of change in range to absolute range.

The results of these preliminary studies were presented to the International GPS Geodynamics Service (IGS) governing Board at their meeting during the Fall 1993 AGU. The Board endorsed the continuation of the SLR tracking of GPS-35 and were eager to exploit the use of the more precise ephemerides and the SLR data set themselves. The upcoming launch of the last Block II GPS spacecraft (not before March 9, 1994), will place in orbit a second CCR array. Double differences that involve these two spacecraft will be the best data set to test the effectiveness of ambiguity fixing and better orbit quality on geodetic products, e.g. positions, baselines, Earth orientation, etc.

GPS-35 Laser Tracking Support

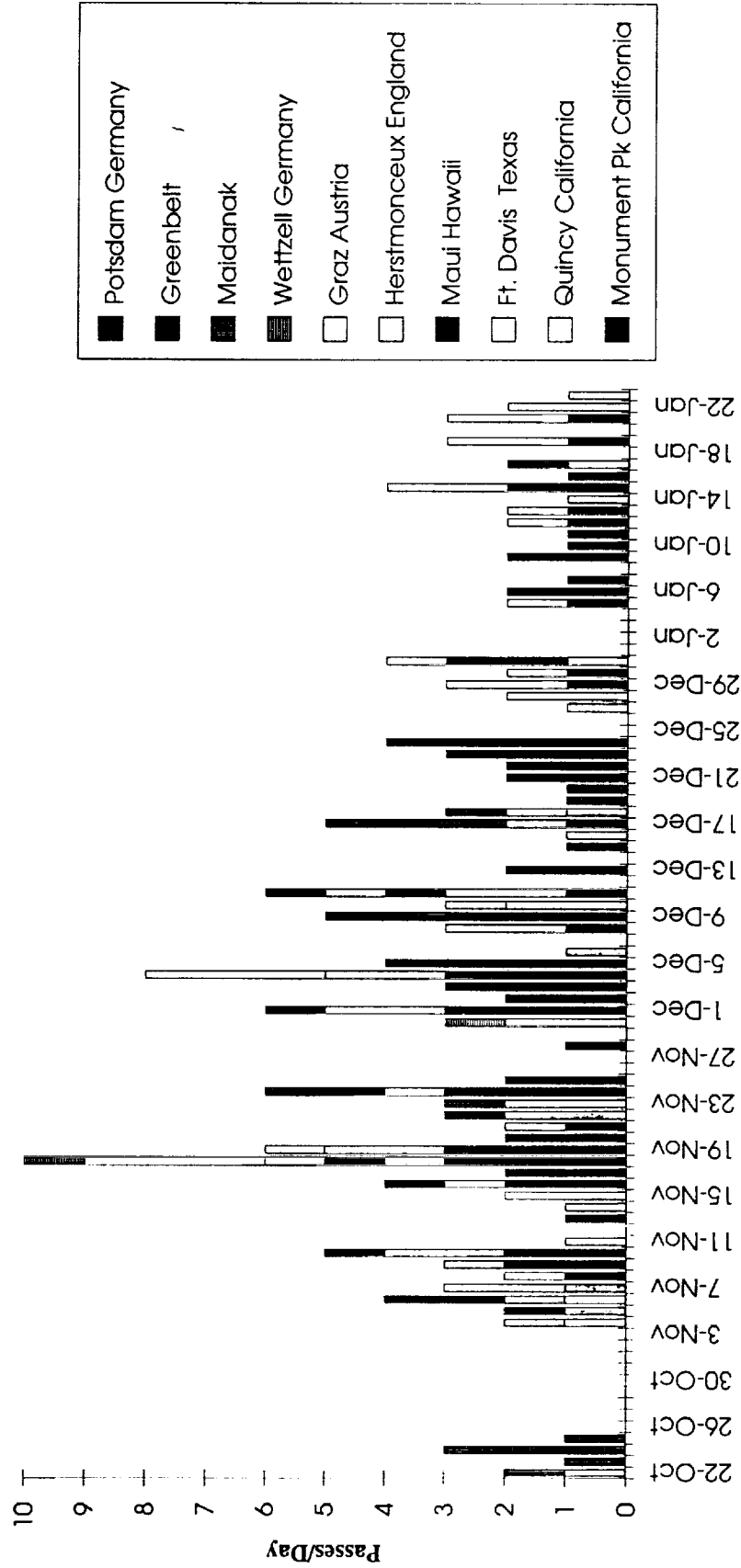


Figure 1.

GPS-35 (PRN 5) Orbit Determination From SLR Tracking

80-day Arc: Nov. 5, 1993 - Jan. 26, 1994

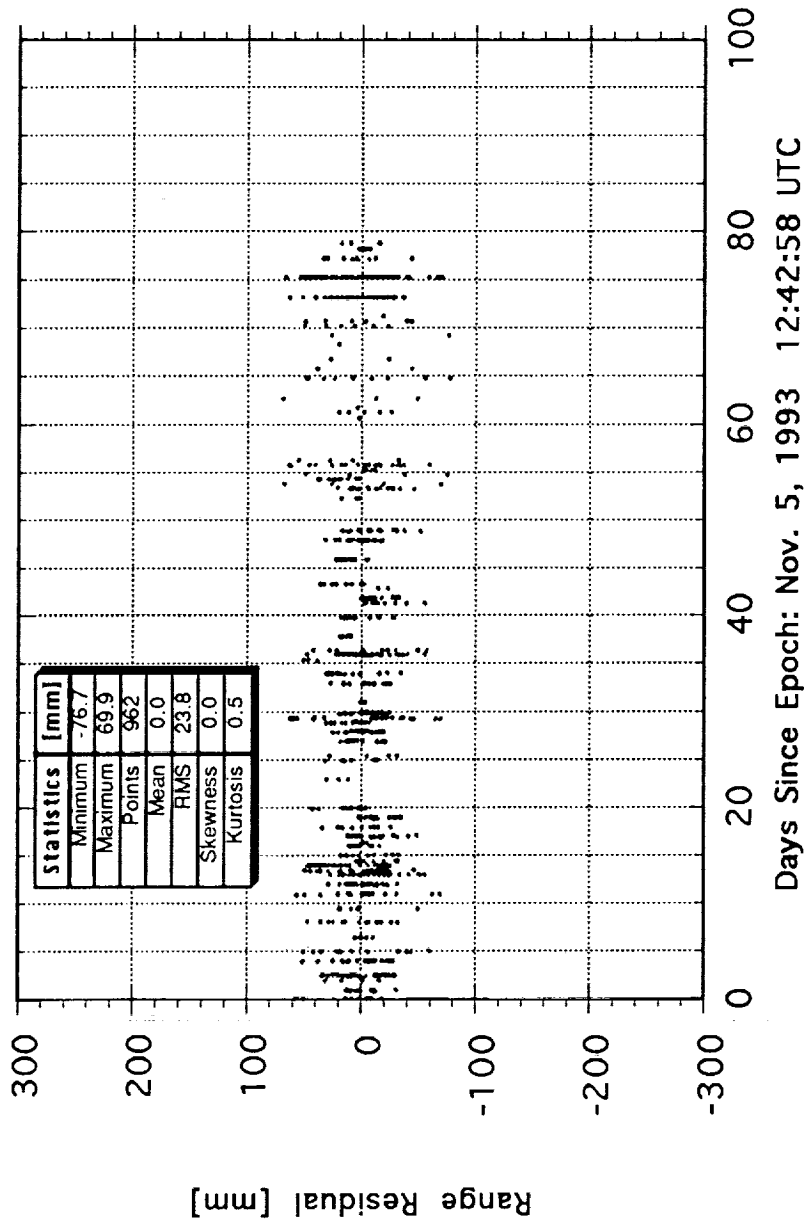


Figure 2.