

TIME-SERIES ANALYSIS OF GEODETIC STATION COORDINATES

MENTOR – FRANK LEMOINE CODE: 698

SCIENCE

JORDAN LARSON – UNIVERSITY OF MINNESOTA

ABSTRACT

This poster displays the time-series plots of some of the geodetic stations that possess Satellite Laser Ranging (SLR) systems. This satellite tracking technique was used to indirectly determine the position of each individual tracking station from 1993 to 2012. Four different satellites' tracking data were used: LAGEOS 1 & 2, STARLETTE, and STELLA. The data presented here shows the time of the stations' positions in the local East, North, and Up (ENU) coordinate system in relation to the position defined by the 2008 version of the International Terrestrial Reference Frame (ITRF2008). For each of these time histories, a WRMS value was calculated against a least squares linear fit to the data. Three different satellite combinations were looked at in order to see if the WRMS of fit would decrease as more satellites were added to the solution. This effect was not as apparent as expected and could not satisfactorily be proven.

INTRODUCTION & BACKGROUND

Geodesy is a branch of Earth science that deals with representing the Earth, including its gravitational field in three-dimensional time-varying space. The primary product geodesists produce is known as the International Terrestrial Reference Frame (ITRF) which describes the motion of a several hundred geodetic stations positions and velocities. The ITRF2008 is the latest version of this product and incorporates four different geodetic techniques in its solution. These include Satellite Laser Ranging (SLR), Very Long Baseline Interferometry (VLBI), Global Navigation Satellite System (GNSS) which includes GPS, and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS). The ITRF2008 provides vital support to many other space missions, especially Earth sciences which use laser altimetry, by establishing a reference frame for the measurements done by the instruments onboard the satellites. As of now, the ITRF2008 is accurate to within a few centimeters; however, in the near future millimeter accuracy will be necessary to properly support future scientific studies.

The research presented here looked at trying to improve the SLR contribution to the ITRF solutions by showing that adding in more satellites to the solution decreases the WRMS of fit. The two traditional SLR satellites used for ITRF2008 are LAGEOS 1 & 2. The other two satellites, STARLETTE and STELLA, were looked at separately and in combination with the LAGEOS satellites for each station and a WRMS of fit was calculated for each.

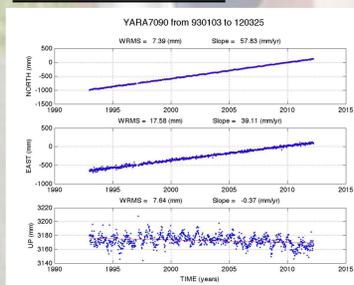
METHODS

At Goddard Space Flight Center (GSFC) weekly geodetic station solutions are calculated using a program called SOLVE. This program combines and reduces the normal equations that are the output given by another program called GEODYNE. Next, these solutions are transformed using a 7-parameter helmert transformation, which includes 3 translations, 3 rotations, and a scaling factor. Then, these weekly solutions are read into a program that calculates the residuals of the solution in relation to each station's modeled positions over time from the ITRF2008. Also, eccentricities inherent in the geometry of the stations are applied. Finally, these solutions are graphed for each station over the entire time span of available data (1993-2012). A linear least squares fit is computed for each station's position over time and a WRMS is calculated from the measured positions to the fitted line. This process was done using three different combinations of satellites in the solutions for the normal equations. The first was LAGEOS 1 & 2. The second was STARLETTE and STELLA. The final was all four. Comparative plots for the three different combinations are given for a well-defined station below.

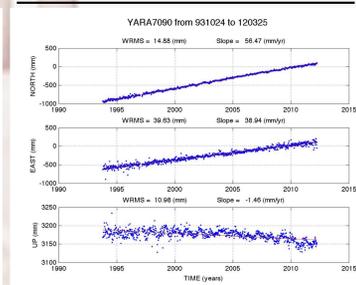
RESULTS & GRAPHS

Plots for Yarragadee Station for different satellite combinations:

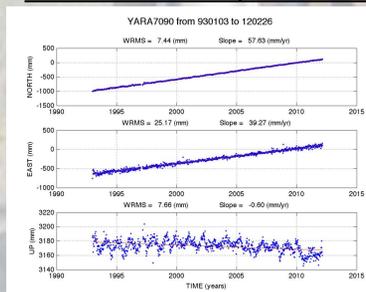
LAGEOS 1 & 2



STARLETTE & STELLA



LAGEOS 1 & 2, STARLETTE, & STELLA



The table below shows the the average results for each of the different satellite solutions. Each solution is separated by type of station which is based on the weighting scale that is given to it by GEODYNE with 1 being the "best" and 3 being the "worst".

Satellites in Solution	Type of Station	# of Stations	Average East WRMS	Average North WRMS	Average Up WRMS
LAGEOS 1 & 2	1	27	17.56	22.61	19.54
	2	20	35.04	29.86	19.13
	3	16	11.09	8.53	7.65
STARLETTE and STELLA	1	28	37.60	19.52	15.01
	2	20	49.66	36.19	20.79
	3	16	20.44	12.69	10.62
LAGEOS 1 & 2, STARLETTE, and STELLA	1	28	23.2	21.80	18.41
	2	20	39.07	27.94	17.86
	3	17	14.76	10.03	7.67

Table 1 – Statistics on the WRMS of fit for all satellite solutions divided by station type.

DISCUSSION & CONCLUSION

From the table above we can see that the best WRMS of fit come from type three which are the most down weighted stations in the GEODYNE solution. This seems to point at the fact that these weighting schemes may need to be updated.

Another observation that can be seen from the table is that the Average Up WRMS is better than the East and the North even though it can be seen in the Yarragadee station plots that there is a periodic signal in the Up coordinate that has not been accounted for in the current modeling. This phenomenon needs to be looked at further.

Finally, the effect of a lowered WRMS by including more satellites in the solution is not uniform or significant. It exists only in the North and Up coordinates for types 1 and 2, but not for any coordinates for type 3 and not for any East coordinates. In addition, the decrease is very small (the largest decrease being about 2 mm). This demonstrates that we cannot yet add the STARLETTE and STELLA satellites to the SLR solution to the future ITRFs.

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