G-9N
3983
P 7

IN-36-CR

GEOPHYSICAL PARAMETERS FROM THE ANALYSIS
OF LASER RANGING TO STARLETTE

143803

NASA GRANT NAG5-757

Semiannual Research Technical Report
for the period
August 1, 1990 – January 31, 1991

Submitted to

Ms. G. Wiseman
NASA Goddard Space Flight Center
Mail Code 280.1
Greenbelt, MD 20771

by the

Center for Space Research
The University of Texas at Austin
Austin, Texas 78712
(512) 471-1356

Principal Investigator:
Dr. B. E. Schutz

Co-Principal Investigators:
Dr. C. K. Shum
Dr. B. D. Tapley

April 4, 1991

GEOPHYSICAL PARAMETERS FROM THE ANALYSIS
OF LASER RANGING TO STARLETTE

NASA GRANT NAG5-757

SEMIANNUAL RESEARCH REPORT

SUMMARY

The University of Texas Center for Space Research (UT/CSR) research efforts under NASA Grant NAG5-757 covering the time period from August 1, 1990, through January 31, 1991, have concentrated on the following areas:

- *Laser Data Processing.* More than 15 years of Starlette data (1975–90) have been processed and cataloged.

- *Seasonal Variation of Zonal Tides.* Observed Starlette time series has been compared with meteorological data-derived time series.

- *Ocean Tide Solutions.* Error analysis has been performed using Starlette and other tide solutions.

- *Lunar Deceleration.* Formulation to compute theoretical lunar deceleration has been verified and applied to several tidal solutions.

Concise descriptions of research achievement for each of the above areas are given in the following sections. Copies of abstracts for some of the publications and conference presentations are included in the appendices.

DATA PROCESSING

More than 15 years (1975–1990) of Starlette data have been processed and compressed into normal points. Processing and editing of these data using improved force and measurement models is continuing. The identification of time spans during which the quick-look data has been noted, and effort is underway to attempt to replace these data using full-rate data. The procedure of data processing also included efforts to gather station eccentricity, biases information from experience of Lageos data processing which was performed on a routine basis at UT/CSR.

SEASONAL VARIATION OF ZONAL TIDES

In a joint study with R. Gutierrez and C. Wilson, Starlette observed annual and semiannual variations were compared with the time series derived from WMO monthly aire pressure data and twice-daily Navy sea level pressure data [Gutierrez et al., 1991]. Starlette time series were calculated for the node and the eccentricity vector from the time period 1980 through 1983 and compared with the meteorological results. The apparent coherence between the Starlette and Lageos node time series with the WMO node indicates that the global air pressure variations are a significant contribution to the variability in annual and

interannual geopotential sensitive to Lageos and Starlette. The dissimilarity between the semiannual component of meteorological time series and the satellite results shows that air pressure variation is not a primary source of perturbation on satellite orbits. Further work is ongoing to further interpret these results. The abstract of a paper summarizing some of the results of this work is attached in Appendix A.

OCEAN TIDE SOLUTION

Low degree and order tide solutions from multi-satellite processing (GEM-T2, TEG-2 and GRIM4C1) were compared with the Starlette tide solution, the Schwiderski solution and the tide solution from Geosat altimetry [Cartwright and Ray, 1991]. Only the (2,2) terms from M_2 and S_2 were compared using computed quantities of dissipation rates. It was found that there are large differences in the S_2 dissipation rates among the tide solutions, probably due to fact that satellite solutions have included tidal perturbations of meteorological origin and cannot be separated from the oceanic origin. The M_2 solution agrees better, however; for example, differences on the order of 1 cm were observed between the satellite solutions and with the altimetry solution. For example, the published standard deviation for the GEM-T2 solution is at the 0.5-cm level. Further analysis is ongoing.

LUNAR DECELERATION

Formulations to compute the effect of secular change in the mean motion of the Moon due to tidal dissipation in the ocean and solid Earth tides were verified. In particular, definition of phase and amplitude to calculate the tidal potential in the ecliptic reference system were clarified. The resulting formulation was used to compute lunar deceleration of the Moon's mean motion using several ocean tide models, including GEM-T1, GEM-T2, PTGF4A and Starlette tidal solutions. The values of satellite determined lunar deceleration values are in good agreement with the value obtained using lunar laser ranging data [Cheng et al., 1991].

PUBLICATIONS/PRESENTATIONS

The following is a list of publications and conference presentations pertinent to research activities supported partially by NASA Grant NAG5-757:

- Gutiérrez, R., R. Eanes, M. Cheng, and C. Wilson, Global air mass redistribution effects on the laser geodetic satellites Lageos and Starlette, submitted to *Journal of Geophysical Research*, 1991.

- Cheng, M. K., R. J. Eanes, and B. D. Tapley, Tidal deceleration of the Moon's mean motion, submitted to *Geophysical Journal International*, 1991.

APPENDIX A

GLOBAL AIR MASS REDISTRIBUTION EFFECTS ON THE LASER GEODETIC SATELLITES LAGEOS AND STARLETTE

R. Gutiérrez *et al.*

GLOBAL AIR MASS REDISTRIBUTION EFFECTS ON THE LASER GEODETIC SATELLITES LAGEOS AND STARLETTE

R. Gutiérrez, R. Eanes, M. Cheng, and C. Wilson

Orbital motion of the laser geodetic satellites, Lageos and Starlette, exhibit residual orbital motion with a coherent seasonal component, and it is hypothesized that air mass redistribution is the major source of these seasonal perturbations. Zonal spherical harmonic geopotential coefficients are computed from WMO monthly air pressure data and twice-daily Navy sea level pressures. These coefficients are used to predict a time series of the perturbation of the longitude of ascending node Ω and the eccentricity vector Ψ of Lageos for 1976 through 1985. Similar time series are estimated for Starlette for 1980 through 1983. Comparison of predicted and observed Ω and Ψ time series indicates that air pressure may be responsible for much of the unmodeled seasonal variation in the Earth's gravity field. Year-to-year variability in the observed Lageos and Starlette Ω time series is well matched by the predicted perturbations. Even after the removal of annual and semiannual components, significant coherence remains between predicted and observed Ω time series for both Lageos and Starlette.

APPENDIX B

TIDAL DECELERATION OF THE MOON'S MEAN MOTION

M. K. Cheng *et al.*

TIDAL DECELERATION OF THE MOON'S MEAN MOTION

M. K. Cheng, R. J. Eanes, and B. D. Tapley

The secular change in the mean motion of the Moon, $\dot{n}$, caused by the tidal dissipation in the ocean and solid Earth is due primarily to the effect of the diurnal and semidiurnal tides. The long-period ocean tides produce an increase in $\dot{n}$, but the effects are only 1% of the diurnal and semidiurnal ocean tides. In this investigation, expressions for the effects are obtained by developing the tidal potential in the ecliptic reference system. The computation of the amplitude of equilibrium tide and the phase corrections also are discussed. The averaged tidal deceleration of the Moon's mean motion, $\dot{n}$, from the most recent satellite ocean tide solutions is -25.2 ± 0.4 arcseconds/century^2. The value for $\dot{n}$ inferred from the satellite-determined ocean tide solution is in good agreement with the value obtained from the analysis of 20 years of lunar laser ranging observations.