Satellite Orbits In An Atmosphere Theory And Application 1st Edition
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Satellite Orbits

The satellite orbits under the influence of Air Drag and some other perturbations in an atmosphere density vary over time and space. A comprehensive understanding of the atmosphere and its effects on satellite orbits is essential for accurate orbit determination and prediction. The dynamics of the atmosphere, including temperature, pressure, and wind, can significantly influence the motion of satellites. The atmospheric density affects the drag force experienced by satellites, which in turn affects their orbit.

The study of satellite orbits in an atmosphere involves complex interactions between the satellite and the atmospheric environment. The equations of motion for a satellite in a non-spherical gravitational field and an atmosphere with a quadratic scale height are used to model the motion of satellites. The gravitational effects of an external body on the satellite orbit are also considered.

The rotation of the Earth and the changes in its atmospheric density can impact satellite orbits. The research described in this thesis provides a method to estimate satellite ballistic coefficients and assess their accuracy. Additionally, this thesis presents a novel way of estimating atmospheric density conditions based on the observed motion of satellites.

The method employed in this study utilizes the TLE sets to estimate mass ratios and other properties of a satellite. The observational results indicate that the values of mass ratios, as determined from the analysis of the satellite motion, can be used to estimate the global average density of the Earth's atmosphere. The method used in this study is applied to the data obtained from the analysis of satellite orbits to determine the density conditions and mass ratios of various satellites.

We review and interpret the values of upper-atmosphere rotation rate (zonal winds) obtained by analysing satellite orbits determined from observations. The history of the method is described, and historical results are compared with the present study. The observed results indicate that the density variations are significant and can have a significant impact on the satellite orbit prediction.

We describe the experimental results obtained by analysing satellite orbits in an atmosphere. The results are presented in the form of graphs and tables, which show the variation of the density conditions with altitude and time.

We use the results of this study to develop models of atmospheric density and its effects on satellite orbits. These models are used to predict the long-term effects of atmospheric density on satellite orbits and to assess the accuracy of the orbit prediction methods.

We conclude that the atmospheric density models used in this study are valid and can be used to estimate the atmospheric density conditions based on the observed motion of satellites. The results of this study provide a valuable resource for the analysis of satellite orbits in an atmosphere and for the prediction of satellite orbits.

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The paper uses perturbations in the inclination and in the longitude of the node for four nearly polar satellites to find values of the tidal number k and of the phases for the lunar and solar semi-diurnal tides. In order to obtain the desired accuracy, it was necessary to include the following perturbations in the analysis: (1) differences between UT2; and UT1, (2) the motions of the true coordinate systems of date, including the rotation of the elliptic, (3) atmospheric drag, (4) radiation pressure, including radiation scattered or emitted by the satellite and including radiation scattered by the earth as well as direct sunlight, (5) the atmospheric tide, (6) the gravitationnal perturbations produced by the sun and moon, and (7) the perturbations due to the zonal gravity harmonics. For many of these existing perturbation procedures are not accurate enough, and new methods were devised. The new methods are described. By-products of the perturbation analysis include a small decrease in estimates of upper atmosphere wind velocities and a substantial increase in the estimated force due to the atmospheric tide. The value found for the ratio of lunar to solar tidal friction torques is considerably greater than that given by any existing model, but is closer to the value generally given for linear friction than to that for non-linear friction. This does not imply that the friction is linear. It is shown that the relation between the torque ratio and the type of friction depends upon an unknown parameter of the equation. Over a large range of this parameter, which includes plausible values, the ratio of the frictional torques is independent of the law of friction. (Author).

The rotation of the upper atmosphere subjects a satellite to an aerodynamic force normal to the orbit, which has the effect of slightly reducing the inclination of the orbit to the equator. The average rotational speed of the upper atmosphere at heights a little above that of perigee can be evaluated from the observed changes in orbital inclination. Since the change in inclination is small (less than 0.1 degree), the values generally have to be averaged over several months, and they can also be regarded as applying over latitudes up to about half the inclination, the effects being strongest at the equator. Recent results reviewed in the report confirm a previous finding that the upper atmosphere at heights of 200 to 350 km rotates on average faster than the Earth, and that the average rate of rotation increases with height from about 1.1 rev/day at 200 km to nearly 1.4 rev/day at 350 km. However, it appears that the rotation rate decreases above 350 km, to about 1.0 rev/day at 420 km and 0.7 rev/day at 500 km. (Author).

The orbits of Earth satellites with perigee heights less than 600km are liable to be appreciably perturbed by the aerodynamic forces resulting from winds in the upper atmosphere, and analysis of the changes in the orbits provides a method of determining zonal (west-to-east) and meridional (north-to-south) winds. The theory hitherto used has been developed for orbits of eccentricity e 0.2. Here we develop the theory for the effect of zonal and meridional winds on the inclination i and right ascension of the node omega for satellites in orbits with e 0.2 moving in an oblate atmosphere. The results are expressed in terms of the change in orbital period, which is accurately known for actual satellites, so that the equations are independent of variations in air density and satellite cross-sectional area.

The contribution of Satellite Laser ranging (SLR) to the definition of the origin of the reference frame (geocenter coordinates), the scale, and low degree coefficients of the Earth's gravity field is essential due to the remarkable orbit stability of geodetic satellites and the accuracy of laser observations at a level of a few millimeters. Considering these aspects, SLR has an exceptional potential in establishing global networks and deriving geodetic parameters of the supreme quality. SLR faces today the highest requirements of the Global Geodetic Observing System (GGOS) yielding 1 mm of long-term station coordinate and 0.1 mm/y of station velocity stability. The goal of this work is to assess the contribution of the latest models and corrections to the SLR-derived parameters, to enhance the quality and reliability of the SLR-derived products, and to propose a new approach of orbit parameterization for low orbiting geodetic satellites. The impact of orbit perturbations is studied in detail, including perturbing forces of gravitational origin (Earth's gravity field, ocean and atmosphere tides) and perturbing forces of non-gravitational origin (atmospheric drag, the Yarkovsky effect, albedo and Earth's infrared radiation pressure). A multi-satellite combined solution is obtained using SLR observations to LAGEOS-1, LAGEOS-2, Starlette, Stella, and AJISSI. The quality of the SLR-derived parameters from the combined solution is compared with external solutions. The Earth rotation parameters are compared to the IERS-08-C04 series and the GNSS-derived series, whereas the time variable Earth's gravity field coefficients are compared to the CHAMP and GRACE-derived results.

The mathematical theory specifying the change delta i in a satellite's orbital inclination due to atmospheric rotation, in terms of the decrease in orbital period delta t, has been extended to an atmosphere with sinusoidal variation of density between day and night. It is found that with certain special sets of values for the orbital parameters, the day-to-night variation in the Earth's atmosphere can alter the equation for delta i/delta t by as much as 25%, though only for a few days. Appreciable changes in delta i/delta t persisting for several months can only occur for certain resonant orbits: the maximum change is then about 8%. Near-resonance is very unlikely, but the resonance conditions are derived so that dangerous orbits can be recognized and avoided. (Author).

At last, a book that has what every atmospheric science and meteorology student should know about satellite meteorology: the orbits of satellites, the instruments they carry, the radiation they detect, and, most importantly, the fundamental data that can be retrieved from their observations. Key Features: * Of special interest are sections on: * Remote sensing of atmospheric temperature, trace gases, winds, cloud and aerosol data, precipitation, and radiation budget * Satellite image interpretation * Satellite orbits and navigation * Radiative transfer fundamentals

The paper describes the method for determining the rotational speed of the Earth's upper atmosphere from the changes in the orbital inclinations of satellites, and briefly reviews the observational results so far obtained at heights above 180 km, both by this method and by measuring the movements of vapour trails. The results from satellite orbits indicate that the upper atmosphere of the Earth can alter the equation for delta i/delta t by as much as 25%, though only for a few days. Appreciable changes in delta i/delta t persisting for several months can only occur for certain resonant orbits: the maximum change is then about 8%. Near-resonance is very unlikely, but the resonance conditions are derived so that dangerous orbits can be recognized and avoided. It should be emphasized that the subject is full of uncertainties, and this paper is intended to draw attention to the difficulties, rather than to provide a coherent picture of the actual conditions. (Author).

The chief variations in upper-atmosphere density are described, and it is shown how each of them affects the orbits of close Earth satellites. The main features discussed are: (1) the irregular variations in density dependent on solar activity, which may cause great changes in a few days, as well as a 27-day recurrence tendency; (2) the day-to-night and semi-annual variations in density, which cause nearly-periodic changes in orbits: for the day-to-night variation the period is usually between 2 months and 2 years, while the semi-annual effect leads to maxima of density in April and October, and minima in January and July; and (3) the large changes in density during a sunspot cycle, which give rise to a 10- or 11-year recurrence tendency. The changes in orbital inclination caused by the rotation of the atmosphere are also described. (Author).

Fifty years after Sputnik, artificial satellites have become indispensable monitors in many areas, such as economics, meteorology, telecommunications, navigation and remote sensing. The specific orbits are important for the proper functioning of the satellites. This book discusses the great variety of satellite orbits, both in shape (circular to highly elliptical) and properties (gestationary, Sun-synchronous, etc.). This volume starts with an introduction into geodesy. This is followed by a presentation of the fundamental equations of mechanics to explain and demonstrate the properties for all types of orbits. Numerous examples are included, obtained through IXION software developed by the author. The book also includes an exposition of the historical background that is necessary to help the reader understand the main stages of scientific thought from Kepler to GPS. This book is intended for researchers, teachers and students working in the field of satellite technologies, astronomers, geographers and all those involved in space exploration will find this information valuable. Michel Caderou’s book is an essential treatise in orbit mechanics for mathematics students, lecturers and practitioners in this field, as well as other aerospace systems engineers. —Charles Elachi, Director, NASA Jet Propulsion Laboratory.
The report presents the development of a solution for satellite orbits in a nonrotating atmosphere and takes into account the second through fourth zonal harmonics of the gravitational potential. It is basically an extension of Lane's work in that his power-law representation of the atmospheric density function, which implies a linear density scale height, is replaced by a density function with a quadratic density scale height. The quadratic scale height is shown to provide a substantially better fit to the atmospheric density. To integrate the equations of motion analytically, it is necessary to expand the density function in a series. Limitations which appear in the Lane and the Brouwer and Hori theories for small eccentricities, low inclinations, and critical inclinations still exist. (Modified author abstract).

Satellites as they cross the night sky look like moving stars, which can be accurately tracked by an observer with binoculars as well as by giant radars and large cameras. These observations help to determine the satellite's orbit, which is sensitive to the drag of the upper atmosphere and to any irregularities in the gravity field of the Earth. Analysis of the orbit can be used to evaluate the density of the upper atmosphere and to define the shape of the Earth. Desmond King-Hele was the pioneer of this technique of orbit analysis, and this book tells us how the research began, before the launch of Sputnik in 1957. For thirty years King-Hele and his colleagues at the Royal Aircraft Establishment, Farnborough, developed and applied the technique to reveal much about the Earth and air at a very modest cost. In the 1960s the upper-atmosphere density was thoroughly mapped out for 100 to 2000 km, revealing immense variation of density with solar activity and between day and night. In the 1970s and 1980s a picture of the upper-atmosphere winds emerged, and the profile of the pear-shaped Earth was accurately charted. The number of satellites now orbiting the earth is over 5000. This book is the story of how this inexpensive research of their orbits developed to yield a rich harvest of knowledge about the Earth and its atmosphere, in a scientific narrative that is enlivened with many personal experiences.

The story of how small changes in satellite orbits have led to great changes in our views of the Earth and atmosphere is told in this narrative from the pioneer of this orbit analysis technique.

This book on space geodesy presents pioneering geometrical approaches in the modelling of satellite orbits and gravity field of the Earth, based on the gravity field missions CHAMP, GRACE and GOCE in the LEO orbit. Geometrical approach is also extended to precise positioning in space using multi-GNSS constellations and space geodesy techniques in the realization of the terrestrial and celestial reference frame of the Earth. This book addresses major new developments that were taking place in space geodesy in the last decade, namely the availability of GPS receivers onboard LEO satellites, the multitude of the new GNSS satellite navigation systems, the huge improvement in the accuracy of satellite clocks and the revolution in the determination of the Earth's gravity field with dedicated satellite missions.