15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation (9)

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EFFECTS OF THERMOSPHERE TOTAL DENSITY PERTURBATIONS ON LEO ORBITS DURING SEVERE CONDITIONS USING SLR DATA AND TLE DATA SETS.

Abstract

This paper intends to build a bridge between solar activity and changes induced in the thermosphere total density, as revealed by orbital properties of artificial satellites and including space debris.

The study is based in parallel on precise geodetic satellites orbits (Starlette, Stella, Lares) adjusted to SLR data acquired by the ILRS network (centimetric accuracy level), and on TLE data sets provided by NORAD publickly available. The aim is twofold: first we identify over the period 1984-2015 a list of solar events that may be representative of the conditions that may heat the terrestrial atmosphere, in terms of geometrical configuration (solar event with a direction that can induce, or not, changes in the Earth's atmosphere) and the intensity of solar activity ; the goal is to identify whether these events have impacted or not the thermospheric density at some relevant altitudes where tracking data are available (through geodetic satellites or TLE data sets) ; a careful comparison between precise SLR orbit determination and TLE time series is provided. Second, we analyse to what extent a large set of TLE could be used as a proxy to constraint thermospheric model in case of a severe solar event.

Solar activity characterized by strong emissions of electromagnetic waves with specific intensity for specific wavelengths of the solar spectrum and by sunspots and groups of sunspots can create an intense heating in the aurora regions: strong winds can be generated in the thermosphere of the sunlit hemisphere of the Earth (EUV and X-rays) or of the polar regions (solar energetic particles and geomagnetic storms). For extreme events, this could lead to severe consequences on Precise Orbit Determination (POD) results due to the difficulty of modeling the drag force during such events. These events are an exceptional opportunity to estimate effects of the thermosphere total density perturbations on LEO orbits (artificial satellites and space debris) in extreme conditions.

The paper is presented by team gathering skills that complement each other, from solar-terrestrial relationships to precise orbit determination. Some examples, such as the strong event that occured late 2003, are analyzed using the recent models DTM (DTM2009, 2013), and conclusions are provided with

both short and long time scale points of view. Some general conclusions related to the effect of the atmospheric drag on the population of space debris in LEO are also provided.