# The need of long time series of observations for the natural planetary satellites

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▶ **To cite this version:**

Valéry Lainey. The need of long time series of observations for the natural planetary satellites. International Workshop NAROO-GAIA "A new reduction of old observations in the Gaia era", Paris Observatory, Jun 2012, Paris, France. pp. 27-28. hal-00758128

**HAL Id: hal-00758128**

**https://hal.sorbonne-universite.fr/hal-00758128**

Submitted on 14 May 2013

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# The need of long time series of observations for the natural planetary satellites

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At the time of spacecraft era, it is a rather common though to question the relevance of old astrometric data. Images performed from space probes provide absolute position within an uncertainty of about one to ten kilometers for most planetary satellites (Jacobson 1992, Duxbury and Callahan 1989, Tajeddine et al. 2012). Observations of Mars' moon Phobos can even achieve an accuracy of about 500 meters sometimes (Willner et al. 2008). Moreover position of moons in space is not limited to imaging techniques. Indeed, radio science data used routinely to control the spacecraft can be used to derive the position of moons when a flyby occurs. As an example, radio science experiments have constrained the position of Titan to about ten meters (Iess, priv. com.). This is far more precise than imaging techniques, even though limited to a very small number of flybys. More generally, radio science can be used to probe the gravity field of the planetary systems with high order accuracy in the spherical harmonics development. In contrast ground based observations achieve an accuracy of about 100 mas, with classical astrometric techniques. Assuming such observations are performed close to the opposition, this translates into 30 km, 300 km and 600 km for the system of Mars, Jupiter and Saturn respectively.
Hence, the importance of series of ground based observations stands essentially in the long time span for which such data are available. Indeed, some subtle dynamical effects can be revealed only after the monitoring over decades, when not a century, of observations (Lainey et al. 2009, 2012). This is clearly the case of tidal effects for which tidal dissipation in celestial bodies can barely be quantified from spacecraft. As an example, the tidal dissipation within Mars is still not derived from spacecraft, while Phobos tidal acceleration was first discovered by Sharpless in 1945.

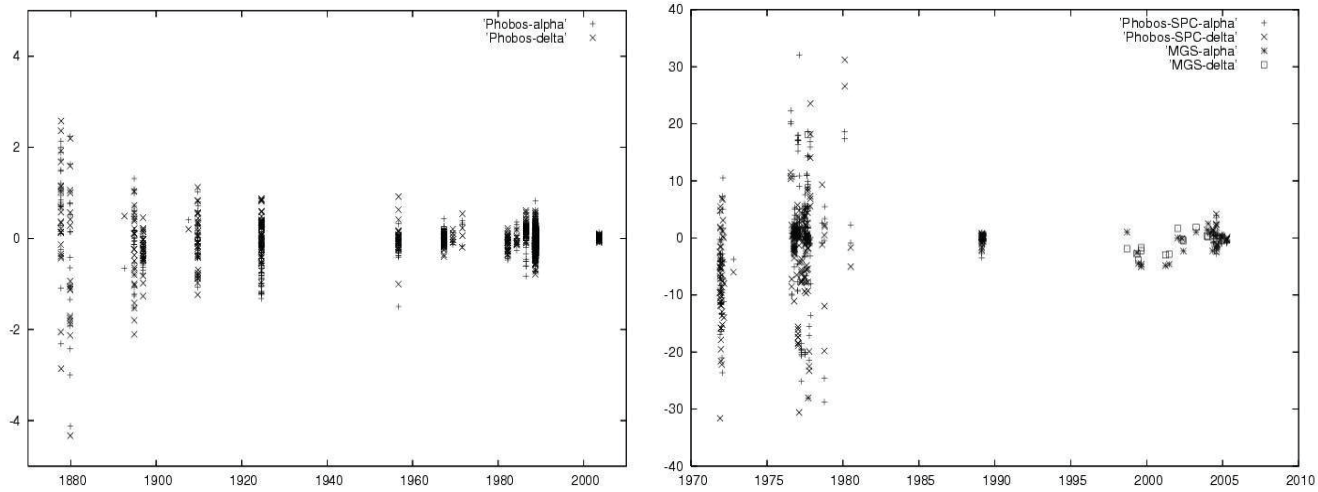


*Figure 1: Astrometric residuals of Phobos and Deimos for a selection of ground based observations (left) and space probe observations (right). The X-axes are in years and Y-axes are in arcsecond (left) and kilometers (right), respectively. We remind that 1" corresponds to about 300 km at the Mars opposition. A clear improvement is obtained for modern observations (see the residuals after 1990), whether performed from ground or space, but a gain of an order of magnitude in precision remains for spacecraft data.*

Improving the accuracy of old astrometric observations opens the way to an improvement in the determination of poorly known physical parameters, like tidal coefficients. As an example, one of the key points that remains to be quantified is the frequency dependence of tidal dissipation within giant planets. While it appears to be smooth (Lainey et al. 2012), a clear relationship has still to be revealed. Hence, the best way is to improve the quality of old data by a new reduction benefiting from modern star catalogues and

digital algorithm. A first experiment performed with few tens of plates made by Dan Pascu (USNO) in 1974 revealed a possible improvement of a factor 4 in precision (Robert et al. 2011). Such improvement opens the way to a much better constraint on physical parameters of the Jovian system as well as lets expect much valuable old data in the context of JUICE mission selected by ESA. Indeed, the expected great accuracy of JUICE data will provide a strong constraint on Galilean orbits at the time of the mission (2030-2032). Nevertheless, such constrain will be useful for seeking tidal parameters and other physical parameters involved in the orbital modeling, only if old data are accurate too.

An FP7 project called ESPaCE (Thuillot et al. 2011) has started in 2011 and includes, among other tasks, the digitization and astrometric reduction of several hundreds of plates essentially of the Mars, Jupiter and Saturn systems. While it is clear that many relevant plates will not be digitized during ESPaCE, at least the results in accuracy will directly benefit to the improvement of dynamical models. It may also be a pretty good demonstration for showing how much gain one may expect with a reprocessing of old data, and how much benefit such improvement in accuracy will be for our knowledge of the Solar system.

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