

Astrometric Reduction of Cassini ISS Images of Enceladus in 2015 Based on Gaia DR1

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Abstract. The Gaia DR1 catalogue stars are taken as reference ones to reduce the Cassini ISS images of Enceladus in 2015, and a total of 494 Cassini-centered astrometric observation are obtained in right ascension(α) and declination (δ) in the international Celestial Reference Frame(ICRF). Compared with JPL ephemerides SAT367, we derive that their mean residuals are a few tens meters in $\alpha \cos(\delta)$ and a few kilometers in δ , and their standard deviation is not over 2 kilometers. Compared with the results from UCAC4 catalogue stars, The Gaia DR1 has the equivalent precision of reduction.

Keywords. Astrometric Reduction, Enceladus, Gaia DR1, Cassini ISS

1. Introduction

During the past a few years, the Cassini ISS images have been routinely used to measure the astrometric positions of planetary satellites (Cooper *et al.* 2006, Cooper *et al.* 2014, Tajeddine *et al.* 2013 and Tajeddine *et al.* 2015). The soft package Caviar has been also implemented for the task (Cooper *et al.* 2016), which is convenient to reduce space images. In the research, the ones in 2015 are measured by Caviar, and some of them are selected for comparing the effects resulted from Gaia DR1 (Gaia Collaboration 2016a and Gaia Collaboration 2016b) and UCAC4 (Zacharias *et al.* 2013).

2. Method

To reduce one image by CAVIAR involves two successive steps: pointing correction and limb fitting. In the first step, some catalogue stars are taken as reference ones to correct camera's pointing. To study how much the Gaia DR1 benefits the reduction, we take the same stars in Gaia DR1 and in UCAC4 catalogue respectively as reference stars in one image, and keep the same operation in the second step. So, each image will has two results of reduction, one from Gaia DR1, and the other from UCAC4. Finally, we compare the result pairs of total 368 images to analyze the effects of Gaia DR1.

3. Data and Results

All the images of Enceladus in 2015 have been taken by CASSINI ISS NAC from 2015-151T to 2015-337T.

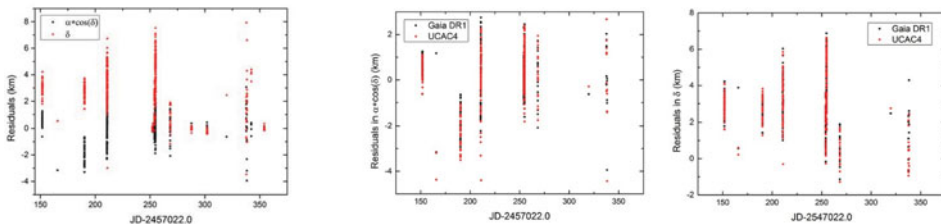
At first, 494 images of Enceladus have been measured by Caviar with Gaia DR1, and then the residuals of observed position relative to JPL ephemerides SAT367 are

Table 1. Mean values and standard deviations(SD) of residuals of these observed positions by using Gaia DR1 relative to the JPL SAT367 ephemeris.

	Mean	SD
Sample (pixel)	-0.0078	0.1466
Line (pixel)	0.3218	0.2525
$\alpha*\cos\delta$ (arcsec)	0.0091	0.1802
δ (arcsec)	0.4101	0.3210
$\alpha*\cos\delta$ (km)	0.0757	1.1174
δ (km)	2.8488	1.8862

Table 2. Mean values of (O-C)s in pixels, arcseconds and kilometers relative to the JPL SAT367 ephemeris, including standard deviations, when the Gaia DR1 and UCAC4 are used to obtain Enceladus' positions respectively.

	Gaia DR1		UCAC4	
	Mean	SD	Mean	SD
Sample (pixel)	-0.0044	0.1288	-0.0152	0.1459
Line (pixel)	0.3581	0.1656	0.3502	0.1728
$\alpha*\cos\delta$ (arcsec)	0.0125	0.1618	-0.0047	0.1825
δ (arcsec)	0.4569	0.2060	0.4465	0.2158
$\alpha*\cos\delta$ (km)	0.1013	1.1404	0.0187	1.2789
δ (km)	3.1460	1.5278	3.0676	1.5843



(a) The (o-c)s by using Gaia. (b) The (o-c)s by using Gaia DR1 and UCAC4 respectively.

Figure 1. The (O-C) residuals in km of observed positions relative to SAT367.

computed. The figure 1(a) displays the residuals and their mean and standard deviation values are listed in table 1. After that, 368 images of them have been reduced by Caviar with UCAC4 again. Figure 1(b) displays the (o-c)s of the position obtained by using Gaia DR1 and UCAC4 respectively relative to SAT367. Table 2 lists their means and standard deviations in different directions. From figure 1(b) and table 2, we can find that the two catalogues have equivalent effects. This is because the astrometric reduction's error comes from several sources that conceal the benefits from Gaia DR1's improvement.

4. Conclusion

A total of 494 ISS images of Enceladus in 2015 are reduced by using Gaia DR1, the best mean residual is 75.7m and their SD values are not over 2km. Comparing the results from UCAC4 and Gaia DR1, we find they bring the equivalent precision of reduction.

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