

Photometry of Titan, 1972-2014

At Lowell Observatory, we made Strömgren b (472 nm) and y (551 nm) photometric measurements of Titan at every Saturn apparition from 1972 to 2006, and after a gap, resumed in 2009. (Lockwood 1975, 1977; Lockwood and Thompson 2009). Each year we observe Titan on at least a few (and sometimes a dozen or more) nights, comparing its brightness with that of two nearby comparison stars of roughly solar color. We adjust the final Titan magnitudes to a solar phase angle of zero (a correction that can be as large as 0.03 mag at the maximum solar phase angle of 6°) and to a standard epoch 1950 heliocentric opposition distance of 9.539 AU.

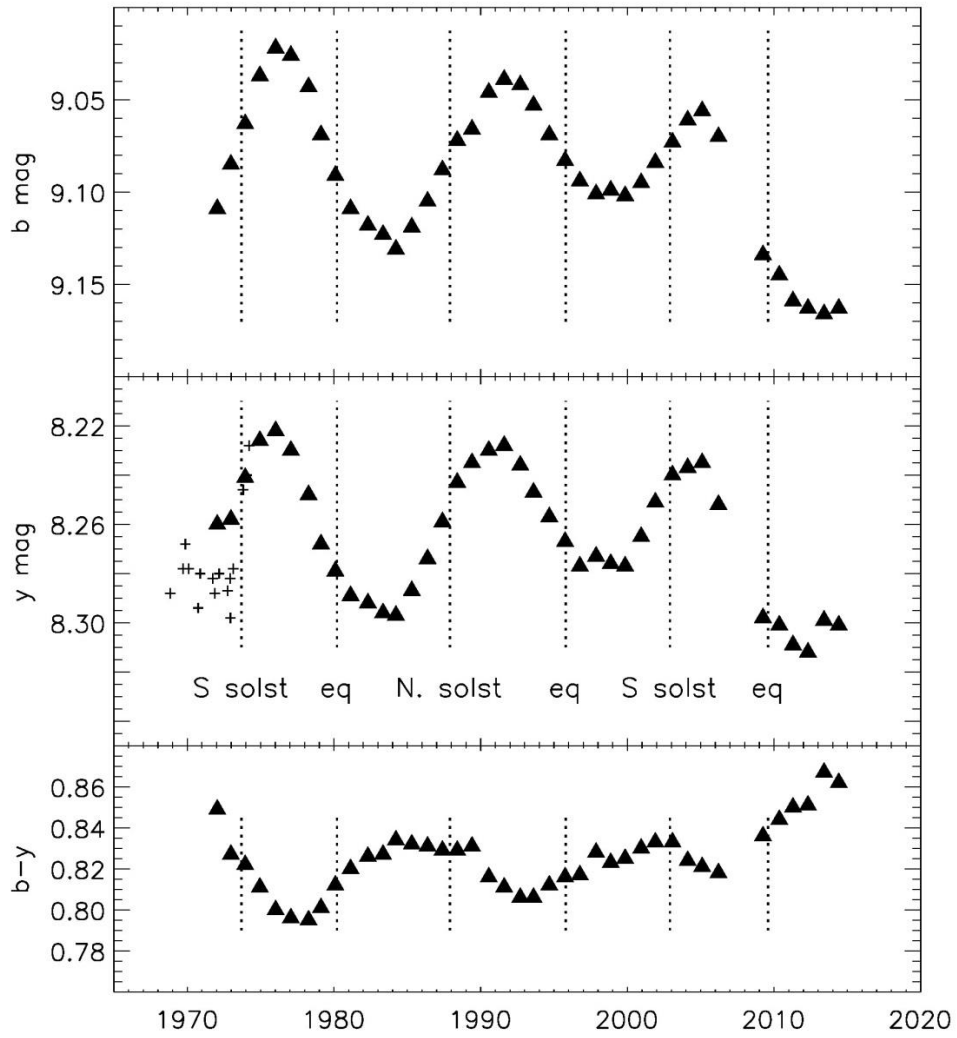
Separate annual observations of a running 5-year string of comparison star pairs including those for the current apparition tie the system of comparison star magnitudes into our local standard b , y photometric system. We have thus defined a set of precisely measured sunlike comparison stars for Titan all around the ecliptic. When we began a second Saturn orbit in 2001, we re-used the nearest pair of comparison stars from the previous orbit. These were necessarily a few degrees distant along the ecliptic from an ideal position, but using the exact pair over again offered a real advantage in orbit-to-orbit comparisons at closely similar ecliptic longitudes.

The figures below shows the b and y light curves beginning with the first apparition in 1972 (leftmost point) and ending with the latest point in 2014 (rightmost point). Crosses on the y lightcurve are V magnitudes from the literature transformed to the y magnitude scale. Seasonal waypoints are indicated by the dotted vertical lines. The bottom panel shows the variation of b - y color. Additional figures show Titan's brightness plotted as a function of ecliptic longitude, with separate data series for the first 29.5 year Titan (Saturn) orbit observed 1972-2001 and almost half of a second Titan year 2001-2014.

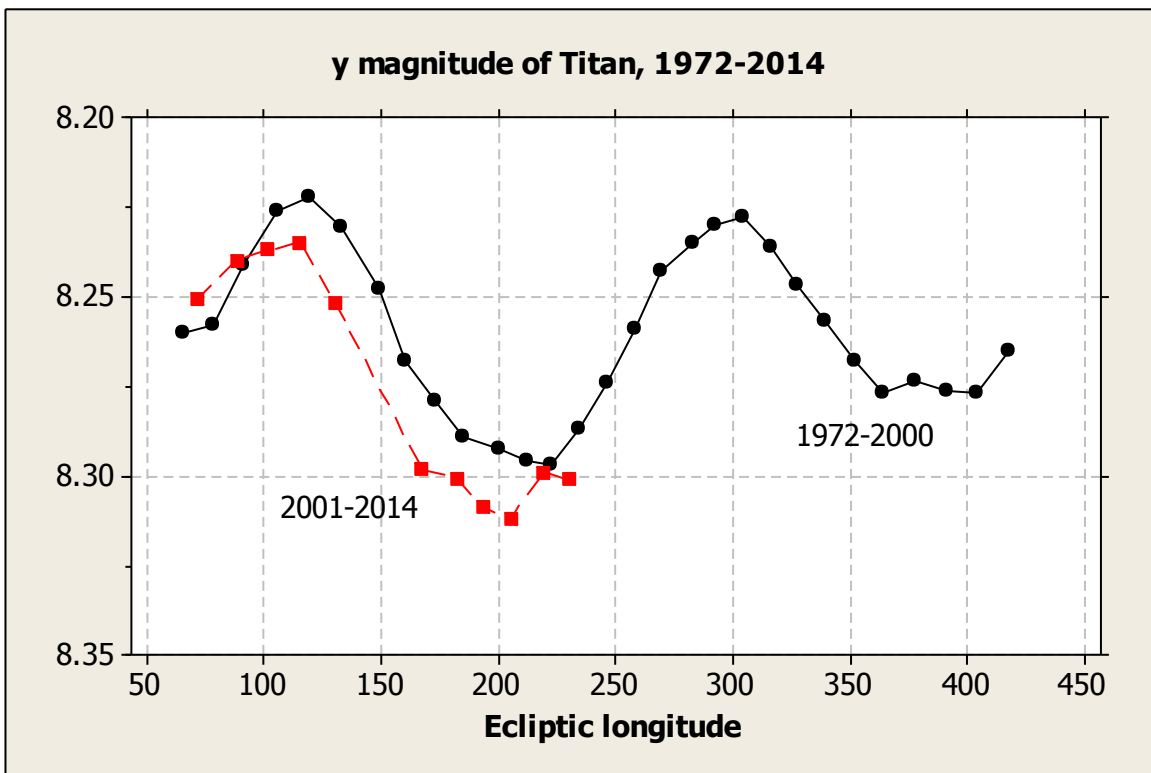
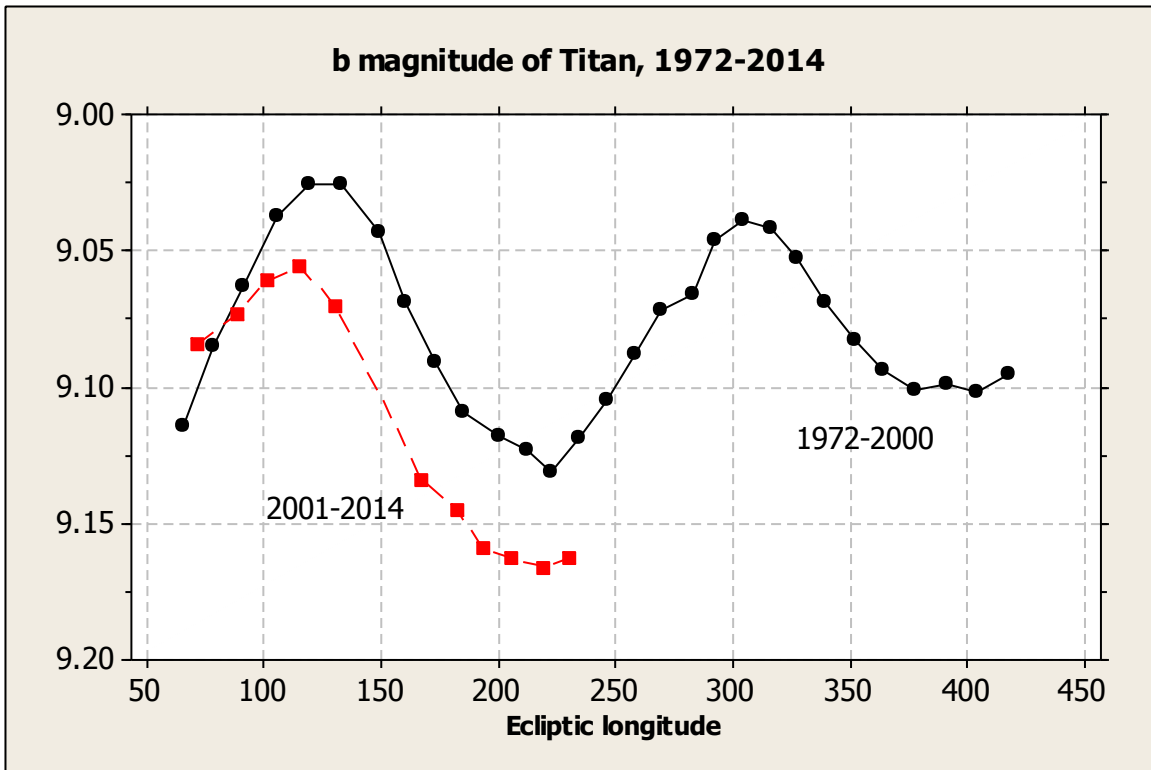
The table gives the mean opposition magnitudes of Titan at each observed apparition and their standard deviations along with ecliptic longitude, sub-Earth latitude, the range of solar phase angle covered before and after opposition, and the standard deviations of the differential magnitudes of the comparison stars.

References

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Lightcurves of Titan. Vertical lines indicate seasonal waypoints. Filled triangles—opposition b magnitudes of Titan at each apparition from 1972 to 2014. The lightcurve does not repeat perfectly in a second orbit beginning 29.5 years later in 2001 and is not symmetric with respect to equinox—the brightness extreme in southern autumn is significantly brighter than at the opposing season. (Center) Filled triangles—opposition y magnitudes from Lowell observations. Crosses are V data compiled by Andersson (1977) transformed to the Lowell y magnitude scale. (Bottom) $b - y$ colors.



Lightcurves of Titan in b and y plotted as a function of ecliptic longitude. Filled black circles are data from the first Titan year observed, 1971-2000. Filled red squares are data from the second Titan year beginning in late 2001.

Year	Mean JD 2,430,000 +	<i>n</i>	Ecliptic long.(deg)	Sub-Earth lat. (deg)	Phase Angle (deg)	<i>y</i> (mag)	<i>s.d.</i>	<i>b</i> (mag)	<i>s.d.</i>
1972.06*	11335.5	7	65	-30.1	4.7 6.2	8.260	0.007	9.109	0.008
1972.99	11674.0	12	78	-31.6	6.2 0.7 6.1	8.258	0.009	9.085	0.011
1973.96	12030.3	12	91	-31.4	6.7 0.3 5.3	8.241	0.008	9.063	0.011
1974.96*	12394.2	32	105	-29.6	6.4 0.3 6.4	8.226	0.008	9.037	0.007
1976.04	12788.1	11	119	-25.7	6.0 0.3 5.7	8.222	0.004	9.022	0.005
1977.07	13166.8	8	133	-20.5	6.1 0.8 6.1	8.230xx	0.006	9.026xx	0.006
1978.28	13606.7	18	149	-13.0	3.8 0.6 6.2	8.248	0.005	9.043	0.005
1979.13	13916.0	15	160	-7.3	6.1 0.4 6.0	8.268	0.004	9.069	0.007
1980.11	14275.1	9	173	-0.5	6.0 0.3 3.3	8.279	0.003	9.091	0.003
1981.14	14652.9	5	185	6.6	5.8 0.6 1.2	8.290xx	0.002	9.109	0.005
1982.32	15084.6	6	200	13.9	4.5 1.2 4.7	8.292	0.003	9.126xx	0.003
1983.36	15462.3	6	212	19.7	5.4 1.7 4.9	8.296	0.004	9.123	0.004
1984.23	15782.0	9	222	23.7	5.8 0.3 2.1	8.297	0.004	9.131	0.003
1985.32	16177.6	7	234	27.6	5.6 1.2 2.7	8.287	0.005	9.119	0.049
1986.39	16570.7	7	246	30.3	4.8 1.8 4.1	8.274	0.004	9.105	0.047
1987.41	16940.9	5	258	31.5	5.9 0.8 1.6	8.259	0.005	9.088	0.057
1988.41	17308.1	5	269	31.6	4.4 0.5	8.243	0.006	9.072	0.010
1989.42	17676.1	5	283	30.5	4.2 2.2	8.235	0.005	9.066	0.006
1990.57	18095.2	5	292	27.8	2.5 0.8 3.8	8.231	0.002	9.046	0.004
1991.61	18477.2	9	304	24.1	3.9 2.5 5.7	8.228	0.006	9.039	0.005
1992.71	18878.5	10	316	19.2	3.6 5.5	8.236	0.005	9.042	0.005
1993.62	19209.1	9	327	14.3	4.4 0.8 3.4	8.247	0.006	9.053	0.007
1994.69	19601.0	6	339	7.8	0.8 0.3 1.4	8.255	0.003	9.069	0.004
1995.77	19994.5	9	352	0.9	1.3 0.6 3.6	8.267	0.004	9.083	0.003
1996.77	20362.5	4	4	-5.9	0.6 0.5 3.7	8.277	0.003	9.094	0.003
1997.88	20766.0	3	18	-13.2	1.7 5.6	8.273	0.004	9.101	0.004
1998.88	21131.0	7	31	-19.1	0.7 0.6 4.9	8.276	0.003	9.099	0.004
1999.86	21490.0	6	44	-24.3	1.9 0.3 1.1	8.277	0.002	9.102	0.004
2000.95	21888.2	5	58	-28.6	4.6 4.1 6.2	8.265	0.003	9.095	0.004
2001.90	22248.5	5	71	-31.0	4.4 1.9 4.4	8.251	0.005	9.094	0.002
2003.14	22688.7	3	88	-31.7	2.5 5.4	8.240	0.002	9.073	0.003
2004.13	23047.2	4	101	-30.2	2.1 6.0	8.237	0.005	9.061	0.006
2005.10	23406.8	6	115	-27.2	3.6 2.8 6.3	8.235	0.007	9.056	0.006
2006.21	23813.2	4	130	-22.0	3.0 6.5	8.252	0.005	9.070	0.007

Year	Mean JD 2,430,000 +	<i>n</i>	Ecliptic long.(deg)	Sub-Earth lat. (deg)	Phase Angle (deg)	<i>y</i> (mag)	<i>s.d.</i>	<i>b</i> (mag)	<i>s.d.</i>
2009.25	24921.5	5	167	-2.9	1.0 4.8	8.298	0.004	9.134	0.007
2010.36	25328.4	7	192	4.8	2.1 6.0	8.301	0.006	9.145	0.007
2011.29	25668.4	8	193	10.7	4.9 0.7 3.5	8.309	0.005	9.159	0.005
2012.31	26041.4	6	205	17.2	2.5 0.7 3.8	8.312	0.006	9.163	0.006
2013.41	26442.2	4	219	21.1	2.3 4.1	8.299	0.008	9.166	0.004
2014.41	26809.2	4	230	...25.7	...1.0..2.8	8.301	0.003.	9.163	0.002

*Only one comparison star used for this season

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