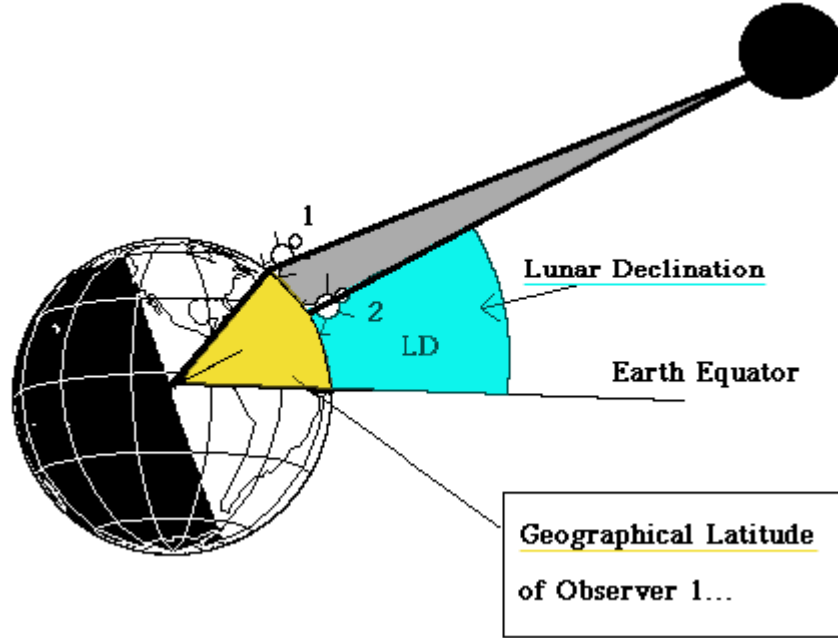




Eclipse 2011

ഗ്രഹണാ ഗണിതം

കിരഹുണ അഡവണെ



Balu Saravana Sarma

Prohithar – Astrologer – Ganitham

No9, 4th street, Kalyan Nagar, Tambaram West, Chennai 45, INDIA.

Ph: +91 44 2226 1742, Cell: +91 98403 69677

Email: prohithar@gmail.com

www.prohithar.com

ECLIPSES, 2011

In the year 2011, there are four eclipses, two of the Sun and two of the Moon.

I	January	4	Partial eclipse of the Sun	Pages 320-325
II	June	1	Partial eclipse of the Sun	Pages 326-328
III	June	15	Total eclipse of the Moon	Page 335
IV	July	1	Partial eclipse of the Sun	Pages 329-331
V	November	25	Partial eclipse of the Sun	Pages 332-334
VI	December	10	Total eclipse of the Moon	Page 336

I-Partial Eclipse of the Sun, January 4, 2011, Tuesday

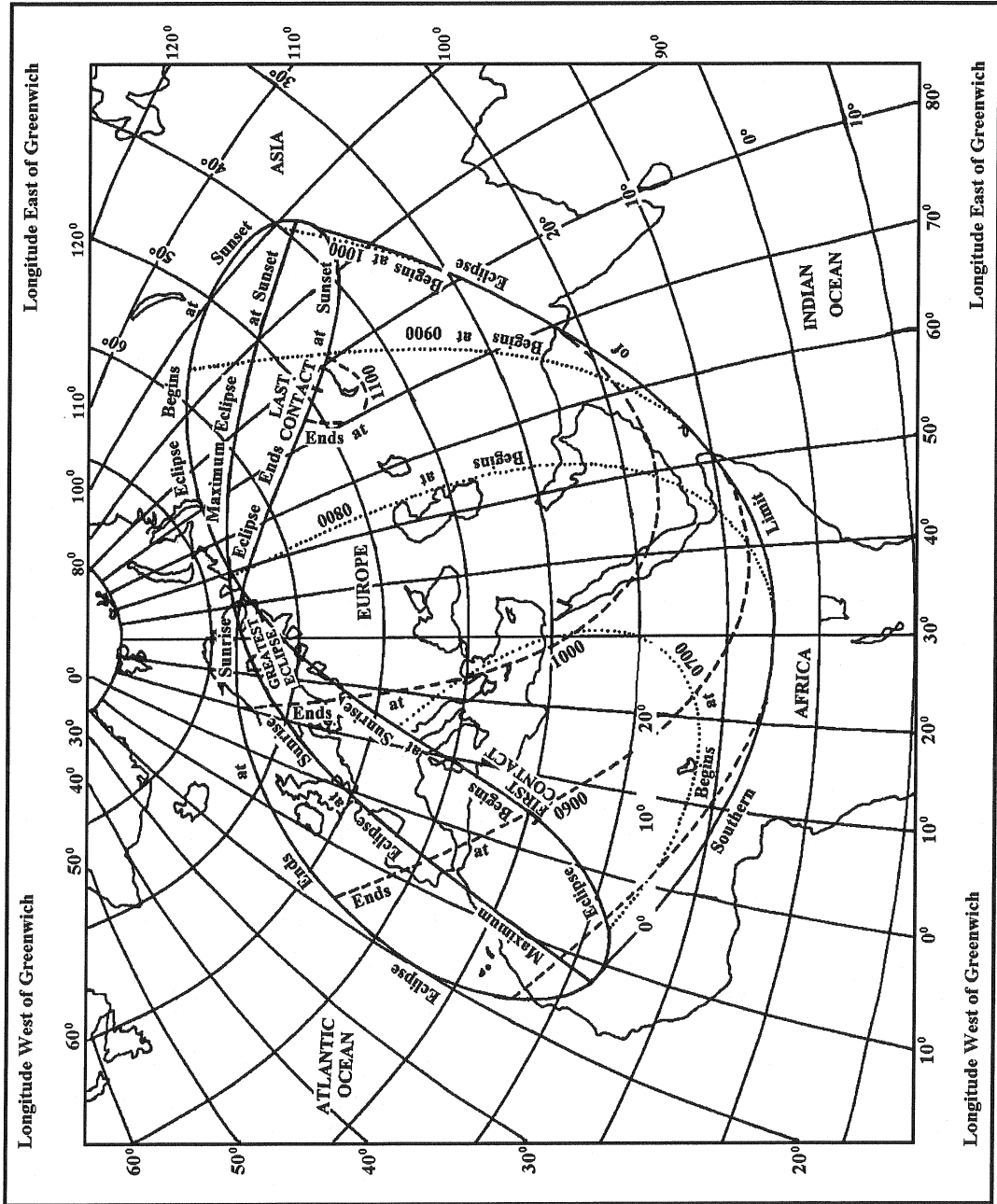
Visible in India

ELEMENTS OF THE ECLIPSE						
Universal Time of Conjunction in Right Ascension : January 4 ^d 9 ^h 15 ^m 12 ^s .558						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	18	59	19.43	18	59	19.43
Hourly Motion			135.41			11.00
	°	'	"	°	'	"
Declination	-21	43	30.24	-22	44	23.21
Hourly Motion		+6	09.17			+15.59
Equatorial Horizontal Parallax		56	11.27			8.94
True Semi-diameter		15	18.61		16	17.28

CIRCUMSTANCES OF THE ECLIPSE										
	Universal Time			Indian Standard Time			Latitude		Longitude	
	d	h	m	d	h	m	°	'	°	'
Eclipse begins	4	06	40.2	4	12	10.2	+28	48.9	+4	28.6
Greatest eclipse*	4	08	50.6	4	14	20.6	+64	40.7	+20	54.4
Eclipse ends	4	11	00.9	4	16	30.9	+48	42.7	+77	28.5

*Magnitude of the eclipse = 0.857

PARTIAL SOLAR ECLIPSE OF JANUARY 4, 2011



ECLIPSES, 2011

BESSELIAN ELEMENTS OF THE PARTIAL ECLIPSE OF THE SUN
JANUARY 4

Terrestrial Time (TT)		Co-ordinates of the Centre of Shadow on the Fundamental Plane		Direction of the Axis of Shadow *					Radius of Penumbra on the Fundamental Plane
h	m	x	y	sin d	cos d	μ			l ₁
				°	'	''			
6	00	-1.689505	+0.741343	-0.386765	+0.922178	268	49	16.7	+0.563188
	10	-1.603446	+0.758756	-0.386754	+0.922183	271	19	14.5	+0.563217
	20	-1.517386	+0.776176	-0.386743	+0.922187	273	49	12.7	+0.563245
	30	-1.431326	+0.793603	-0.386733	+0.922192	276	19	10.6	+0.563273
	40	-1.345265	+0.811036	-0.386722	+0.922196	278	49	08.4	+0.563300
7	50	-1.259204	+0.828476	-0.386711	+0.922201	281	19	06.5	+0.563326
	00	-1.173143	+0.845922	-0.386700	+0.922206	283	49	04.4	+0.563352
	10	-1.087083	+0.863374	-0.386689	+0.922210	286	19	02.6	+0.563377
	20	-1.001022	+0.880833	-0.386678	+0.922215	288	49	00.5	+0.563402
	30	-0.914962	+0.898298	-0.386668	+0.922219	291	18	58.3	+0.563426
8	40	-0.828903	+0.915770	-0.386657	+0.922224	293	48	56.5	+0.563449
	50	-0.742844	+0.933247	-0.386646	+0.922228	296	18	54.4	+0.563472
	00	-0.656787	+0.950731	-0.386635	+0.922233	298	48	52.6	+0.563494
	10	-0.570731	+0.968221	-0.386624	+0.922237	301	18	50.4	+0.563516
	20	-0.484676	+0.985717	-0.386613	+0.922242	303	48	48.2	+0.563537
9	30	-0.398623	+1.003219	-0.386603	+0.922246	306	18	46.4	+0.563557
	40	-0.312572	+1.020728	-0.386592	+0.922251	308	48	44.3	+0.563577
	50	-0.226523	+1.038242	-0.386581	+0.922256	311	18	42.1	+0.563596
	00	-0.140475	+1.055762	-0.386570	+0.922260	313	48	40.3	+0.563615
	10	-0.054430	+1.073288	-0.386559	+0.922265	316	18	38.2	+0.563633
10	20	+0.031612	+1.090820	-0.386548	+0.922269	318	48	36.4	+0.563650
	30	+0.117652	+1.108358	-0.386537	+0.922274	321	18	34.2	+0.563667
	40	+0.203689	+1.125901	-0.386526	+0.922278	323	48	32.0	+0.563683
	50	+0.289722	+1.143450	-0.386516	+0.922283	326	18	30.2	+0.563699
	00	+0.375753	+1.161005	-0.386505	+0.922288	328	48	28.1	+0.563714
11	10	+0.461780	+1.178566	-0.386494	+0.922292	331	18	26.3	+0.563728
	20	+0.547804	+1.196132	-0.386483	+0.922297	333	48	24.1	+0.563742
	30	+0.633823	+1.213704	-0.386472	+0.922301	336	18	22.0	+0.563755
	40	+0.719839	+1.231282	-0.386461	+0.922306	338	48	20.2	+0.563768
	50	+0.805851	+1.248865	-0.386450	+0.922310	341	18	19.0	+0.563780
11	00	+0.891858	+1.266453	-0.386439	+0.922315	343	48	16.2	+0.563791
	10	+0.977862	+1.284047	-0.386428	+0.922320	346	18	14.0	+0.563802
	20	+1.063860	+1.301646	-0.386417	+0.922324	348	48	11.9	+0.563813

tan f₁ = 0.004756

TT hr	d			Variations per minute			
	°	'	''	x	y	μ	
						'	''
7	-22	44	58	+0.008 605	+0.001 745	15	00
8	-22	44	43	+0.008 606	+0.001 749	15	00
9	-22	44	29	+0.008 605	+0.001 753	15	00
10	-22	44	14	+0.008 603	+0.001 756	15	00
11	-22	43	59	+0.008 600	+0.001 759	15	00

$\xi' = 0.004364\rho\cos\phi'\cos(\mu+\lambda)$

$\eta' = 0.004364\xi\sin d$

*d stands for declination and μ, hour angle.

PARTIAL ECLIPSE OF THE SUN, JANUARY 4
LOCAL CIRCUMSTANCES RELATING TO INDIA

BEGINNING OF ECLIPSE FOR STATIONS IN INDIA
TIME IN I.S.T

Latitude (North)	Longitude (East of Greenwich)		
	68°	72°	76°
28°	h m 14 27.7	h m 14 46.4	h m 15 08.9
24°	14 43.4		

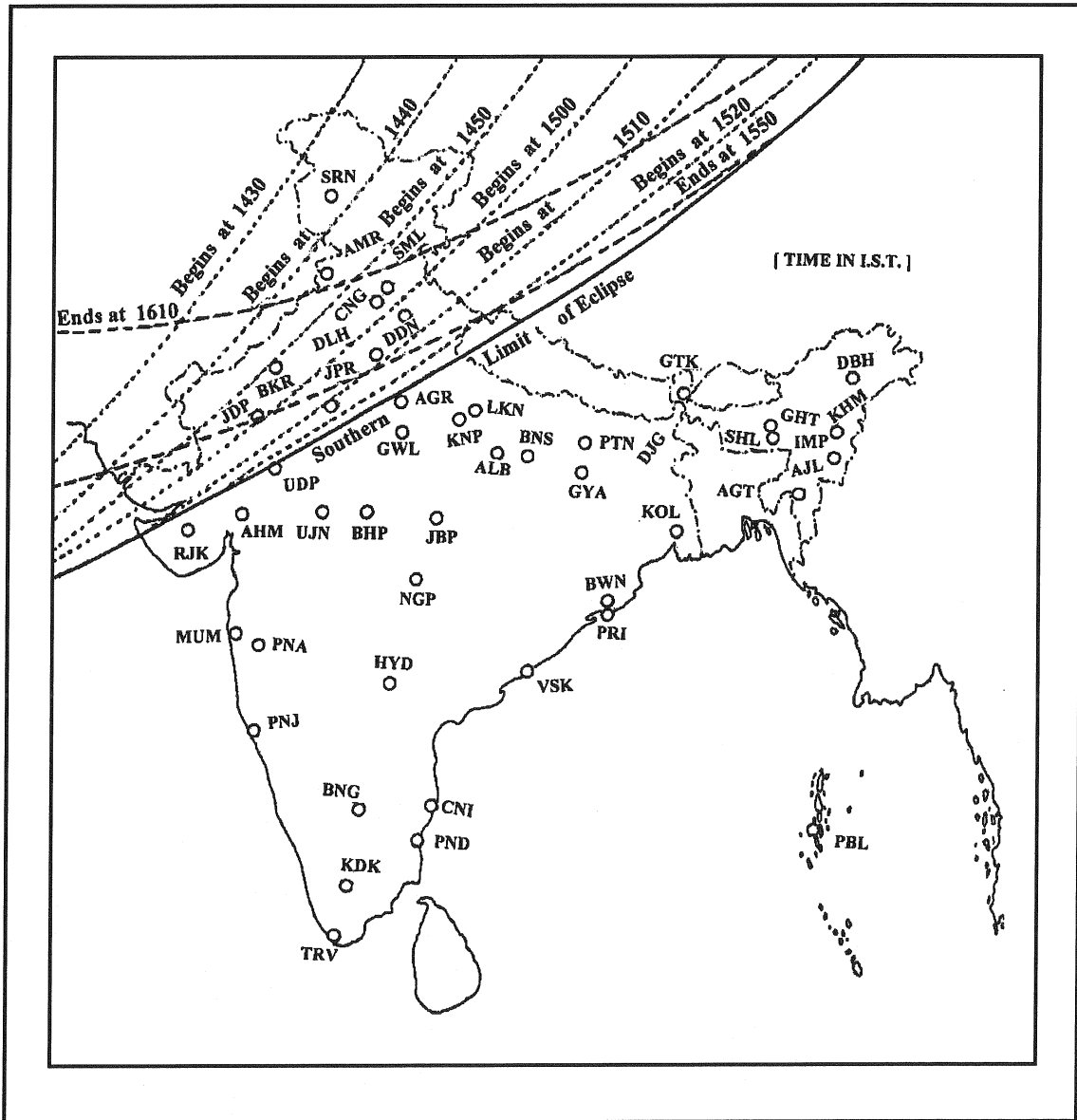
ENDING OF ECLIPSE FOR STATIONS IN INDIA
TIME IN I.S.T

Latitude (North)	Longitude (East of Greenwich)		
	68°	72°	76°
28°	h m 16 06.2	h m 16 01.4	h m 15 51.5
24°	15 48.7		

Southern limit of partial phase through India

TIME (IST)	Latitude (Geographic)	Longitude (Geographic)
h m	° ' "	' "
15 20	22 52	70 17
15 21	23 12	70 47
15 22	23 33	71 18
15 23	23 54	71 49
15 24	24 15	72 21
15 25	24 37	72 54
15 26	25 00	73 28
15 27	25 23	74 03
15 28	25 46	74 39
15 29	26 10	75 16
15 30	26 35	75 54
15 31	27 00	76 34
15 32	27 26	77 16
15 33	27 53	77 59
15 34	28 21	78 44
15 35	28 51	79 33
15 36	29 21	80 23
15 37	29 52	81 16
15 38	30 25	82 12
15 39	30 59	83 11
15 40	31 37	84 18
15 41	32 16	85 29
15 42	32 57	86 45
15 43	33 43	88 12

PARTIAL SOLAR ECLIPSE OF JANUARY 4, 2011



PARTIAL ECLIPSE OF THE SUN, JANUARY 4

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE RELATING TO
CERTAIN PLACES IN INDIA AND NEIGHBOURHOOD

Place	Eclipse Begins (I.S.T.) h m	P °	V °	Greatest Phase (I.S.T.) h m	Magni- -tude	Eclipse Ends (I.S.T.) h m	P °	V °
Ajmer	15 13.0	324	284	15 28.1	0.014	15 43.2	344	299
Amritswar	14 45.3	305	274	15 29.6	0.128	16 11.1	5	319
Chandigarh	14 57.4	312	276	15 32.0	0.080	16 05.0	359	312
Derhadun	15 05.2	316	278	15 33.4	0.054	16 00.5	354	307
Delhi	15 11.9	321	281	15 32.1	0.027	15 52.0	348	302
Dwarka	15 07.1	327	290	15 17.6	0.006	15 28.2	340	298
Haridwar	15 08.0	318	279	15 33.4	0.044	15 58.1	352	305
Jaipur	15 19.2	327	286	15 29.9	0.007	15 40.7	342	296
Jalandhar	14 48.1	307	275	15 30.1	0.115	16 09.5	3	318
Nainital	15 22.3	326	284	15 34.7	0.011	15 47.1	344	297
Simla	14 57.0	311	276	15 32.4	0.084	16 06.1	359	313
Srinagar	14 37.6	300	272	15 29.6	0.183	16 17.8	12	327
Karachi	14 33.7	309	284	15 15.5	0.094	15 55.1	359	316
Lahore	14 43.2	305	274	15 28.8	0.135	16 11.5	6	320
Rawalpindi	14 32.8	299	273	15 27.3	0.195	16 17.7	13	329

ECLIPSES, 2011

II-Partial Eclipse of the Sun, June 1, Wednesday

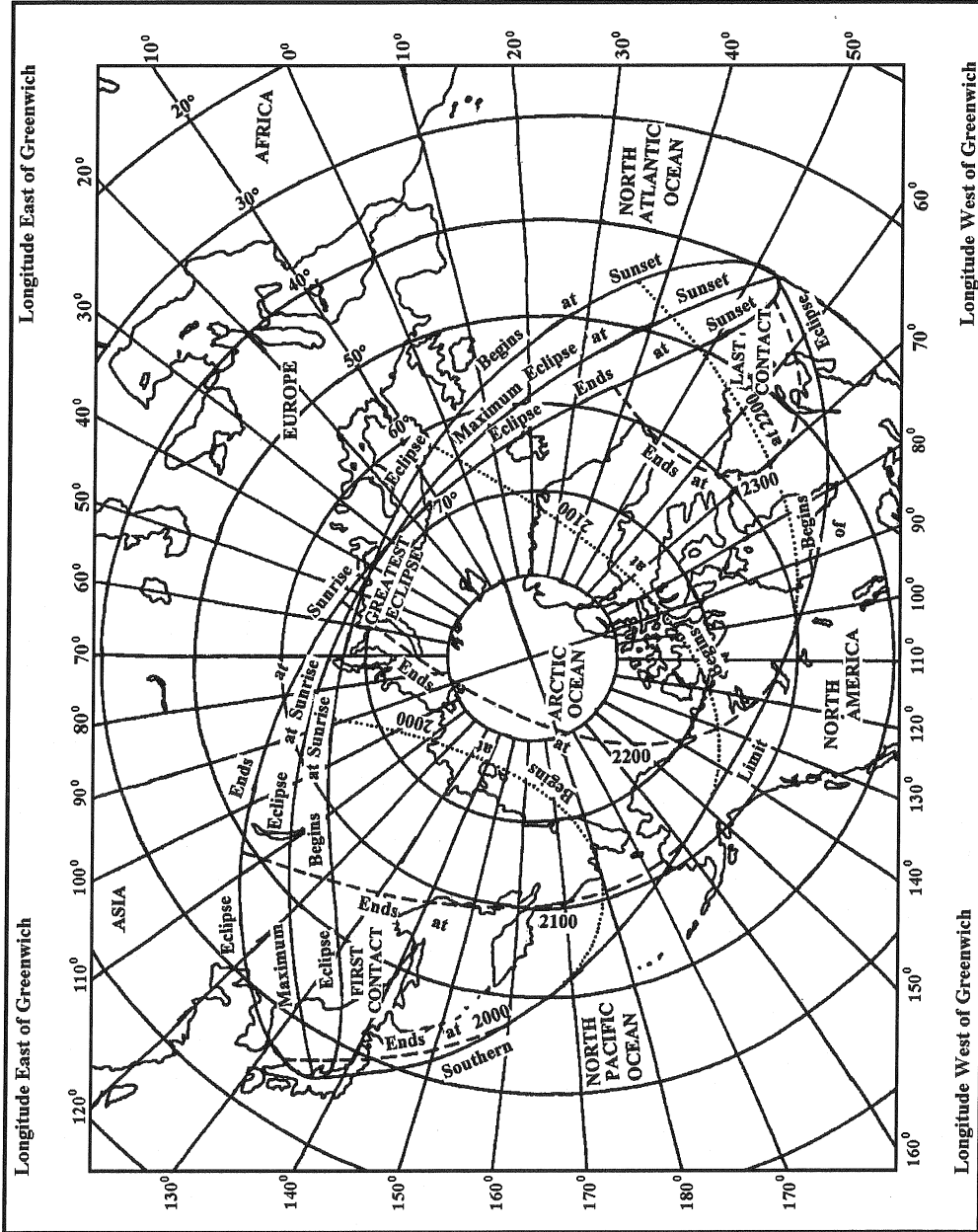
Not visible in India

ELEMENTS OF THE ECLIPSE						
Universal Time of Conjunction in Right Ascension : June 1 ^d 21 ^h 21 ^m 58 ^s .212						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	4	37	54.35	4	37	54.35
Hourly Motion			137.92			10.25
	°	'	"	°	'	"
Declination	23	13	27.81	22	05	49.26
Hourly Motion		1	34.45			20.04
Equatorial Horizontal Parallax		55	54.46			8.67
True Semi-diameter		15	14.03		15	47.82

CIRCUMSTANCES OF THE ECLIPSE										
	Universal Time			Indian Standard Time			Latitude		Longitude	
	d	h	m	d	h	m	°	'	°	'
Eclipse begins	1	19	25.3	2	00	55.3	+44	22.3	+134	45.4
Greatest eclipse*	1	21	16.2	2	02	46.2	+67	47.0	+46	45.0
Eclipse ends	1	23	06.9	2	04	36.9	+48	24.5	-50	02.3

*Magnitude of the eclipse = 0.6014

PARTIAL SOLAR ECLIPSE OF JUNE 1, 2011



ECLIPSES, 2011

BESSELIAN ELEMENTS OF THE PARTIAL ECLIPSE OF THE SUN
JUNE 1

Terrestrial Time (TT)		Co-ordinates of the Centre of Shadow on the Fundamental Plane		Direction of the Axis of Shadow *					Radius of Penumbra on the Fundamental Plane
h	m	x	y	sin d	cos d	μ			l ₁
				°	'	''			
18	50	-1.342559	+1.156507	+0.375900	+0.926660	103	02	17.5	+0.556410
19	00	-1.254882	+1.160340	+0.375915	+0.926654	105	32	17.5	+0.556400
	10	-1.167201	+1.164162	+0.375930	+0.926648	108	02	17.2	+0.556390
	20	-1.079515	+1.167974	+0.375945	+0.926642	110	32	17.2	+0.556379
	30	-0.991827	+1.171775	+0.375960	+0.926636	113	02	16.9	+0.556367
	40	-0.904136	+1.175565	+0.375975	+0.926630	115	32	16.9	+0.556355
	50	-0.816440	+1.179344	+0.375990	+0.926624	118	02	16.9	+0.556342
20	00	-0.728743	+1.183113	+0.376005	+0.926618	120	32	16.4	+0.556329
	10	-0.641043	+1.186872	+0.376020	+0.926612	123	02	16.4	+0.556315
	20	-0.553339	+1.190619	+0.376035	+0.926606	125	32	16.1	+0.556301
	30	-0.465634	+1.194356	+0.376050	+0.926600	128	02	16.1	+0.556286
	40	-0.377926	+1.198082	+0.376065	+0.926594	130	32	15.7	+0.556270
	50	-0.290216	+1.201798	+0.376079	+0.926587	133	02	15.7	+0.556254
21	00	-0.202505	+1.205502	+0.376094	+0.926581	135	32	15.7	+0.556237
	10	-0.114792	+1.209196	+0.376109	+0.926575	138	02	15.4	+0.556220
	20	-0.027076	+1.212879	+0.376124	+0.926569	140	32	15.4	+0.556202
	30	+0.060639	+1.216552	+0.376139	+0.926563	143	02	15.0	+0.556183
	40	+0.148356	+1.220214	+0.376154	+0.926557	145	32	15.0	+0.556164
	50	+0.236075	+1.223865	+0.376169	+0.926551	148	02	15.0	+0.556144
22	00	+0.323793	+1.227505	+0.376183	+0.926545	150	32	14.6	+0.556124
	10	+0.411512	+1.231134	+0.376198	+0.926539	153	02	14.3	+0.556103
	20	+0.499232	+1.234753	+0.376213	+0.926533	155	32	14.3	+0.556082
	30	+0.586952	+1.238361	+0.376228	+0.926527	158	02	14.3	+0.556059
	40	+0.674671	+1.241958	+0.376243	+0.926521	160	32	13.9	+0.556037
	50	+0.762391	+1.245544	+0.376258	+0.926515	163	02	13.9	+0.556014
23	00	+0.850110	+1.249120	+0.376272	+0.926509	165	32	13.6	+0.555990
	10	+0.937829	+1.252684	+0.376287	+0.926503	168	02	13.6	+0.555965
	20	+1.025547	+1.256238	+0.376302	+0.926497	170	32	13.6	+0.555940

$$\tan f_1 = 0.004611$$

TT hr	d			Variations per minute			
	°	'	''	x	y	μ	
						'	''
19	+22	04	51	+0.008 768	+0.000 382	15	00
20	+22	04	11	+0.008 770	+0.000 376	15	00
21	+22	05	31	+0.008 771	+0.000 369	15	00
22	+22	05	51	+0.008 772	+0.000 363	15	00
23	+22	06	11	+0.008 772	+0.000 356	15	00

$$\xi' = 0.004364 \rho \cos \phi' \cos (\mu + \lambda)$$

$$\eta' = 0.004364 \xi \sin d$$

*d stands for declination and μ , hour angle

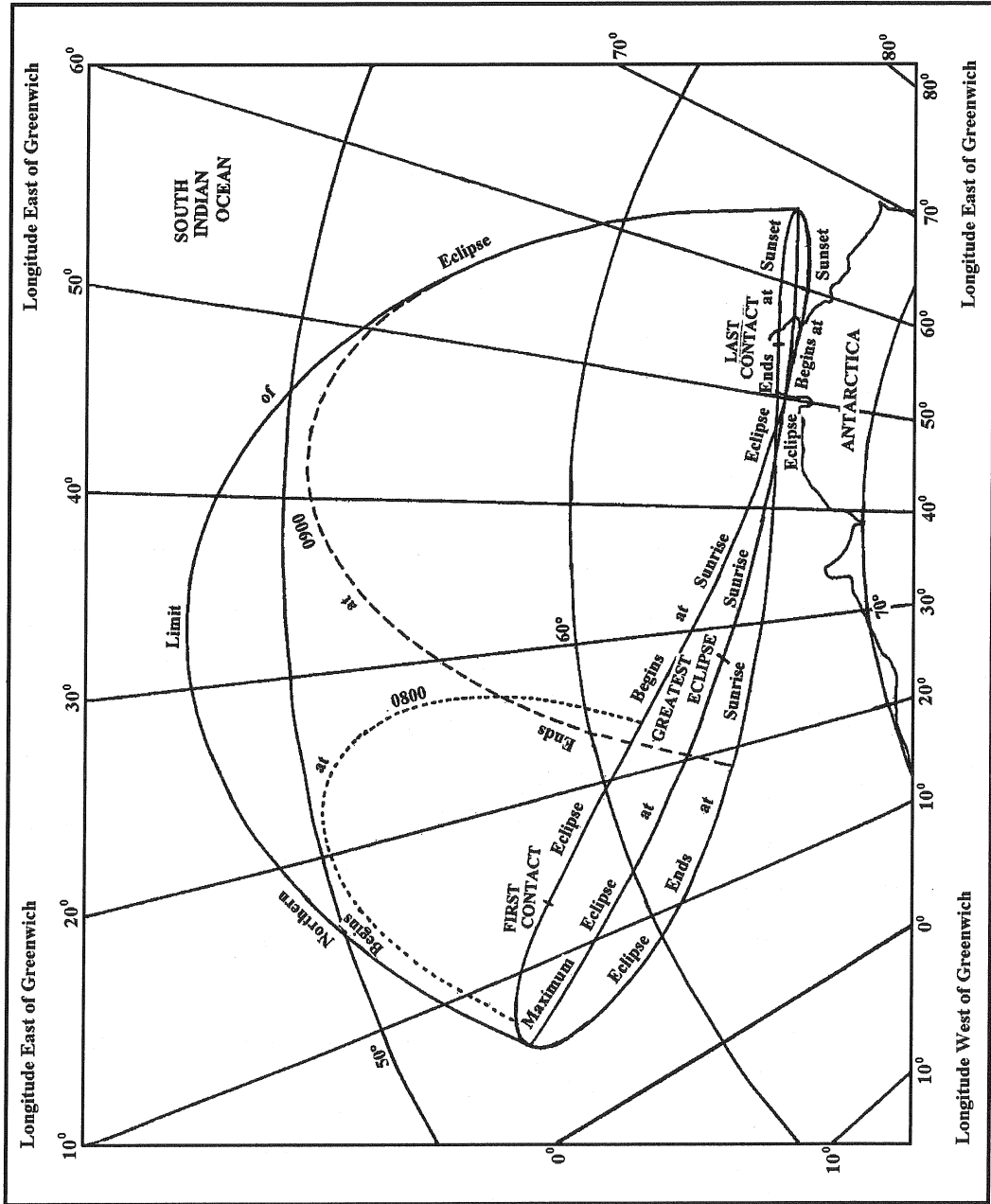
IV-Partial Eclipse of the Sun, July 1, Friday.
Not visible in India

ELEMENTS OF THE ECLIPSE						
Universal Time of Conjunction in Right Ascension : July 1 ^d 9 ^h 05 ^m 30 ^s .732						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	6	40	06.35	6	40	6.35
Hourly Motion			142.34			10.35
	°	'	"	°	'	"
Declination	21	40	25.39	23	07	01.43
Hourly Motion		-5	18.4			-9.93
Equatorial Horizontal Parallax		57	25.3			08.65
True Semi-diameter		15	39.37		15	45.38

CIRCUMSTANCES OF THE ECLIPSE										
	Universal Time			Indian Standard Time			Latitude		Longitude	
	d	h	m	d	h	m	°	'	°	'
Eclipse begins	1	7	53.7	1	13	23.7	-56	53.7	+13	26.2
Greatest eclipse*	1	8	38.4	1	14	08.4	-65	10.6	+28	44.0
Eclipse ends	1	9	22.8	1	14	52.8	-66	13.7	+54	29.5

*Magnitude of the eclipse = 0.0970

PARTIAL SOLAR ECLIPSE OF JULY 1, 2011



BESSELIAN ELEMENTS OF THE PARTIAL ECLIPSE OF THE SUN
JULY 1

Terrestrial Time (TT)		Co-ordinates of the Centre of Shadow on the Fundamental Plane		Direction of the Axis of Shadow *					Radius of Penumbra on the Fundamental Plane
h	m	x	y	sin d	cos d	μ ° ' "			l ₁
7	00	-1.130144	-1.326096	+0.392756	+0.919643	284	03	16.0	+0.548002
	10	-1.040903	-1.340737	+0.392749	+0.919646	286	33	15.8	+0.547988
	20	-0.951660	-1.355383	+0.392742	+0.919649	289	03	15.5	+0.547973
	30	-0.862415	-1.370035	+0.392735	+0.919652	291	33	15.1	+0.547958
	40	-0.773169	-1.384691	+0.392728	+0.919655	294	03	14.4	+0.547942
8	50	-0.683921	-1.399352	+0.392721	+0.919658	296	33	14.0	+0.547925
	00	-0.594672	-1.414019	+0.392715	+0.919660	299	03	13.7	+0.547908
	10	-0.505422	-1.428690	+0.392708	+0.919663	301	33	13.3	+0.547890
	20	-0.416171	-1.443366	+0.392701	+0.919666	304	03	13.0	+0.547872
	30	-0.326920	-1.458047	+0.392694	+0.919669	306	33	12.5	+0.547853
9	40	-0.237668	-1.472732	+0.392687	+0.919672	309	03	12.2	+0.547833
	50	-0.148416	-1.487422	+0.392681	+0.919675	311	33	11.9	+0.547813
	00	-0.059164	-1.502117	+0.392674	+0.919678	314	03	11.5	+0.547792
	10	+0.030088	-1.516817	+0.392667	+0.919681	316	33	11.2	+0.547770
	20	+0.119339	-1.531521	+0.392660	+0.919684	319	03	10.9	+0.547748
10	30	+0.208590	-1.546229	+0.392653	+0.919687	321	33	10.4	+0.547725
	40	+0.297840	-1.560942	+0.392647	+0.919690	324	03	10.1	+0.547702
	50	+0.387089	-1.575660	+0.392640	+0.919693	326	33	09.7	+0.547678
10	00	+0.476336	-1.590382	+0.392633	+0.919696	329	03	09.4	+0.547653

tan f₁ = 0.004599

TT hr	d			Variations per minute			
	°	'	"	x	y	μ ° ' "	
7	+23	07	34	+0.008 924	-0.001 464	15	00
8	+23	07	25	+0.008 925	-0.001 467	15	00
9	+23	07	16	+0.008 925	-0.001 470	15	00

$$\xi' = 0.004364\rho\cos\phi'\cos(\mu+\lambda)$$

$$\eta' = 0.004364\xi\sin d$$

*d stands for declination and μ, hour angle

ECLIPSES, 2011

V-Partial Eclipse of the Sun, November 25, Friday.
Not visible in India

ELEMENTS OF THE ECLIPSE						
Universal Time of Conjunction in Right Ascension : November 25 ^d 6 ^h 31 ^m 20 ^s .492						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	16	02	15.68	16	02	15.68
Hourly Motion			160.02			10.61
	°	'	"	°	'	"
Declination	-21	45	08.24	-20	41	01.72
Hourly Motion		-3	58.54			-29.65
Equatorial Horizontal Parallax		60	44.90			08.91
True Semi-diameter		16	33.16		16	13.63

CIRCUMSTANCES OF THE ECLIPSE										
	Universal Time			Indian Standard Time			Latitude		Longitude	
	d	h	m	d	h	m	°	'	°	'
Eclipse begins	25	04	23.3	25	09	53.3	-34	46.7	+5	42.0
Greatest eclipse*	25	06	20.3	25	11	50.3	-68	34.6	-82	31.8
Eclipse ends	25	08	17.3	25	13	47.3	-44	59.1	+164	34.4

*Magnitude of the eclipse = 0.9049

ECLIPSES, 2011

BESSELIAN ELEMENTS OF THE PARTIAL ECLIPSE OF THE SUN
NOVEMBER 25

Terrestrial Time (TT)		Co-ordinates of the Centre of Shadow on the Fundamental Plane		Direction of the Axis of Shadow *					Radius of Penumbra on the Fundamental Plane
h	m	x	y	sin d	cos d	μ			l ₁
				°	'	''			
4	00	-1.455586	-0.911156	-0.352831	+0.935687	243	18	09.4	+0.540410
	10	-1.360132	-0.920936	-0.352853	+0.935679	245	48	08.3	+0.540432
	20	-1.264674	-0.930704	-0.352875	+0.935670	248	18	07.2	+0.540454
	30	-1.169212	-0.940461	-0.352898	+0.935662	250	48	06.5	+0.540474
	40	-1.073747	-0.950206	-0.352920	+0.935654	253	18	05.4	+0.540494
5	50	-0.978278	-0.959940	-0.352942	+0.935645	255	48	04.3	+0.540513
	00	-0.882807	-0.969663	-0.352964	+0.935637	258	18	03.5	+0.540531
	10	-0.787332	-0.979374	-0.352986	+0.935629	260	48	02.5	+0.540549
	20	-0.691856	-0.989073	-0.353008	+0.935620	263	18	01.4	+0.540566
	30	-0.596377	-0.998761	-0.353030	+0.935612	265	48	00.7	+0.540582
6	40	-0.500896	-1.008437	-0.353052	+0.935604	268	17	59.6	+0.540597
	50	-0.405414	-1.018101	-0.353074	+0.935595	270	47	58.6	+0.540612
	00	-0.309930	-1.027754	-0.353096	+0.935587	273	17	57.8	+0.540626
	10	-0.214445	-1.037395	-0.353118	+0.935579	275	47	56.8	+0.540640
	20	-0.118959	-1.047024	-0.353140	+0.935570	278	17	55.7	+0.540652
7	30	-0.023473	-1.056642	-0.353162	+0.935562	280	47	55.0	+0.540664
	40	+0.072014	-1.066247	-0.353184	+0.935554	283	17	53.9	+0.540675
	50	+0.167501	-1.075841	-0.353206	+0.935545	285	47	52.9	+0.540686
	00	+0.262988	-1.085424	-0.353228	+0.935537	288	17	52.1	+0.540696
	10	+0.358474	-1.094994	-0.353250	+0.935529	290	47	51.0	+0.540705
8	20	+0.453960	-1.104552	-0.353272	+0.935520	293	17	49.9	+0.540713
	30	+0.549445	-1.114099	-0.353294	+0.935512	295	47	48.8	+0.540721
	40	+0.644928	-1.123634	-0.353316	+0.935504	298	17	48.1	+0.540727
	50	+0.740410	-1.133157	-0.353338	+0.935495	300	47	47.0	+0.540734
	00	+0.835891	-1.142667	-0.353360	+0.935487	303	17	46.3	+0.540739

$$\tan f_1 = 0.004736$$

TT hr	d			Variations per minute			
	°	'	''	x	y	μ	
4	-20	39	38	+0.009 545	-0.009 790	15	00
5	-20	40	07	+0.009 548	-0.009 711	15	00
6	-20	40	36	+0.009 549	-0.009 641	15	00
7	-20	41	06	+0.009 549	-0.009 570	15	00

$$\xi' = 0.004364 \rho \cos \phi' \cos (\mu + \lambda)$$

$$\eta' = 0.004364 \xi \sin d$$

*d stands for declination and μ, hour angle

ECLIPSES, 2011

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III- Total Eclipse of the Moon, June 15 2011, Wednesday.

Visible in India.

Eclipse will be visible in the region covering South America, Africa, Europe, The Middle East, Asia, Australia, Antarctica, the Atlantic Ocean, the Indian Ocean and southwestern Pacific Ocean.

The places from where the beginning of the umbral phase is visible at the time of moonset are some regions of South Pacific Ocean, Fiji, some regions of North Pacific Ocean and parts of north-eastern Russia.

The places from where the ending of umbral phase is visible at the time of moonrise are some regions of South Pacific Ocean, parts of western Chile, Bolivia, parts of north west Brazil, some regions of North Atlantic Ocean.

The eclipse is visible throughout India.

ELEMENTS OF THE ECLIPSE						
Universal Time of Opposition in Right Ascension : June 15 ^d 20 ^h 13 ^m 08 ^s .574						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	17	35	33.65	5	35	33.65
Hourly Motion			151.24			10.39
	°	'	"	°	'	"
Declination	-23	13	49.85	23	19	06.15
Hourly Motion		+1	46.32			+6.05
Equatorial Horizontal Parallax		58	35.25			8.66
True Semi-diameter		15	57.83		15	46.87

CIRCUMSTANCES OF THE ECLIPSE											
	Universal Time			Indian Standard Time			Position Angle measured from the North Point of Moon's Limb (N.E.S.W.)	The Moon being in the Zenith in			
	d	h	m	d	h	m		Latitude		Longitude	
							°	°	'	°	'
Moon enters penumbra	15	17	23.1	15	22	53.1	90	-23	18	97	43
Moon enters umbra	15	18	22.6	15	23	52.6	92	-23	17	83	23
Moon enters totality	15	19	22.1	16	00	52.1	98	-23	15	69	05
Middle of the eclipse*	15	20	12.6	16	01	42.6	--	-23	14	56	58
Moon leaves totality	15	21	03.0	16	02	33.0	256	-23	12	44	52
Moon leaves umbra	15	22	02.6	16	03	32.6	262	-23	10	30	33
Moon leaves penumbra	15	23	02.2	16	04	32.2	263	-23	08	16	13

*Magnitude of the eclipse = 1.705 (Moon's diam = 1.0). Distance between the centers at middle 315".1

Radius of shadow cone at Moon's distance : Penumbra 4551".4, Umbra 2621".0

EASTERN AND WESTERN LIMITS OF VISIBILITY

Eastern Limit Moonset at beginning (18h 22.6m U.T.)						Western Limit Moonrise at ending (22h 02.6m U.T.)					
Latitude		Longitude		Latitude		Longitude		Latitude		Longitude	
°	°	'	°	°	'	°	°	'	°	°	'
-50	-155	46	+10	+169	02	-50	-90	07	+10	-55	07
40	165	27	20	164	22	40	80	30	20	50	29
30	172	14	30	159	00	30	73	45	30	45	08
20	-177	36	40	152	13	20	68	24	40	38	24
-10	+177	44	50	142	32	-10	63	46	50	28	46
+0	+173	23	+60	+125	12	+0	-59	27	+60	-11	35

The eclipse is visible in the region west of the eastern limit and east of the western limit. Here, Moonset and Moonrise times relate to visibility of the center of the Moon on the horizon.

ECLIPSES, 2011

IV- Total Eclipse of the Moon, December 10 2011, Saturday.

Visible in India.

Eclipse will be visible in the region covering Africa, Europe, the Middle East, Asia, Australia, North America, Greenland, the Indian Ocean, the Pacific Ocean, and the Arctic Ocean.

The places from where the beginning of the umbral phase is visible at the time of moonset are parts of Mexico, eastern U.S.A, eastern Canada and Greenland.

The places from where the ending of umbral phase is visible at the time of moonrise are parts of Europe, Africa and some regions of Southern Ocean.

The eclipse is visible throughout India

ELEMENTS OF THE ECLIPSE						
Universal Time of Opposition in Right Ascension : Dec. 10 ^d 14 ^h 32 ^m 20 ^s .273						
	MOON			SUN		
	h	m	s	h	m	s
Right Ascension	5	08	35.07	17	08	35.07
Hourly Motion			134.17			10.99
	°	'	"	°	'	"
Declination	22	33	12.41	-22	54	38.78
Hourly Motion			-6.17	-		13.49
Equatorial Horizontal Parallax		55	13.91			8.93
True Semi-diameter		15	02.98		16	16.66

CIRCUMSTANCES OF THE ECLIPSE											
	Universal Time			Indian Standard Time			Position Angle measured from the North Point of Moon's Limb (N.E.S.W.)	The Moon being in the Zenith in			
	d	h	m	d	h	m		Latitude		Longitude	
							°	°	'	°	'
Moon enters penumbra	10	11	31.8	10	17	01.8	77	+22	33	183	40
Moon enters umbra	10	12	45.4	10	18	15.4	68	+22	33	165	54
Moon enters totality	10	14	05.7	10	19	35.7	31	+22	33	146	30
Middle of the eclipse*	10	14	31.8	10	20	01.8	--	+22	33	140	13
Moon leaves totality	10	14	58.0	10	20	28.0	331	+22	33	133	56
Moon leaves umbra	10	16	18.3	10	21	48.3	294	+22	33	114	32
Moon leaves penumbra	10	17	31.7	10	23	01.7	285	+22	32	96	46

*Magnitude of the eclipse = 1.110 (Moon's diam = 1.0). Distance between the centers at middle 1285".5

Radius of shadow cone at Moon's distance : Penumbra 4377".1, Umbra 2386".0

EASTERN AND WESTERN LIMITS OF VISIBILITY

Eastern Limit Moonset at beginning (12h 45.4m U.T.)						Western Limit Moonrise at ending (16h 18.3m U.T.)					
Latitude		Longitude		Latitude		Longitude		Latitude		Longitude	
°	°	'	°	°	'	°	°	'	°	°	'
-50	-133	46	+10	-99	54	-50	+54	11	+10	+20	20
40	124	30	20	95	25	40	44	55	20	15	50
30	117	59	30	90	14	30	38	24	30	10	40
20	112	48	40	83	42	20	33	13	40	+4	09
-10	108	18	50	74	26	-10	28	44	50	-5	07
+0	-104	06	+60	-58	06	+0	+24	32	+60	-21	27

The eclipse is visible in the region west of the eastern limit and east of the western limit. Here, Moonset and Moonrise times relate to visibility of the center of the Moon on the horizon.

OCCULTATIONS, 2011

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PLANETS BY THE MOON

Sl. No	Date and Ingress - Egress Times (U.T.)		Planet	Age of the Moon	Magnitude of Planet	Area of Visibility
	h -- h					
1.	July 27	14.9 – 19.2	Mars	26.3	-4.0	Samoa, Republic of Kiribati, French Polynesia, southern half of South America except southernmost tip
2.	Oct.27/28	23.9– 04.4	Mercury	1.3	-4.5	Malaysia, Indonesia, S.E. Papua New Guinea, Australia, New Zealand, New Caledonia, French Polynesia

OCCULTATIONS, 2011

ELEMENTS OF OCCULTATIONS OF PLANETS

Sl. No.	T ₀ (U.T. of Conj. in R.A.)			H ₀		Y	x'	y'	Body Occulted					
									Right Ascension			Declination		
	d	h	m	h	m				h	m	s	°	'	"
1.	July 27	17	04.5	7	42.9	-0.5082	0.5446	-0.0349	5	40	20.85	23	35	55.35
2.	Oct.28	2	14.2	13	21.6	-0.2231	0.5533	-0.0912	15	16	59.84	-20	01	11.33