XI. *Researches on the Tides.—Tenth Series. On the Laws of Low Water at the Port of Plymouth, and on the Permanency of Mean Water. By the Rev.* W. Whewell, *B.D. F.R.S., Fellow of Trinity College, Cambridge.*

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In former communications to the Society, the laws of high water at Plymouth and other places have been the subject of my researches. These being obtained, the laws of low water are a subject of importance and interest on many accounts. The first ground of my pursuing this subject was the desire to ascertain how far the *mean water*, that is, the height midway between high and low water, is permanent during the changes which high and low water undergo. That it is approximately so at Plymouth, had been ascertained both by Mr. Walker and myself, by means of a comparison of a short series of observations. But it was desirable to know with more exactness what was the real amount of this permanency, when, by using a long series of observations of high and low water, the irregularities arising from accident, and from taking imperfect cycles of inequalities, were eliminated.

There was another reason which made this inquiry important at the present time. An operation has been recently carried on by the direction and at the expense of the British Association, with a view of ascertaining what surface ought to be taken as the permanent level of the sea. A Level Line has been carried with great care and accuracy from the north shore of Somerset to the south shore of Devon; and the position of this line has been fixed, so as to be recognised at any future time, by means of marks* at Axmouth, at East Quantockshead, at Stolford, and at Portishead. This line has also been referred to the sea at its extremities; and the observations show that the height of mean water coincides, at least very nearly, at different places, as well as at the same place at different times. While the difference of levels of low water at Axmouth on the English Channel, and Wick Rocks on the Bristol Channel, is not less than twelve feet; the mean water at those two places coincides in level within a few inches. In order to determine further what accuracy may be attained

* These marks, and their respective heights above a certain arbitrary level, are as follows:

	Height.
Copper bolt in a granite block at Axmouth	83·6513 feet.
Copper bolt in a granite block at East Quantockshead........	244·4365 feet.
Copper bolt in a granite block at Stolford..................	125·1114 feet.
Iron bolt in the rock at Portishead........................	102·5795 feet.

The account of the operation of carrying the Level Line to these different points, and comparing its position with that of the surface of the sea, will appear in the Transactions of the British Association for 1838.

in this result, we are led to inquire what is the degree of permanency at one place. I may further add, that it cannot but be instructive to know how far the corrections of the height and time of low water, for lunar parallax and declination, agree in form and amount with the same corrections already obtained for high water.

I took, therefore, six years of observations at Plymouth (1833—1838), made, as I had reason to believe, with care and accuracy under the superintendence of Mr. Walker, at present the Queen's Harbour Master at that port: and I had them discussed by Mr. Ross of the Hydrographer's Office at the Admiralty; by which gentleman, on this as on former occasions, the requisite calculations have been performed with much zeal and intelligence.

The method employed in discussing the observations was the same, with slight modifications, as in former researches. The low waters were referred to a transit of the moon anterior by about two days to the time at which each occurred; and according to the hours of these transits, were divided into twelve horary groups, from 0^h to 1^h, from 1^h to 2^h, and so on. In order to find the laws of the heights, the mean height was taken for each of these groups. The mean parallax for each group was very nearly the absolute mean lunar parallax; and the mean declination for each group differed from the absolute mean by a small quantity, according to a known law. Hence the mean heights of the separate horary groups, compared with one another, gave the law of the height as depending upon the hour of transit; that is, they gave the semimenstrual inequality of height for low water.

1. *Of the Permanency of the Height of Mean Water.*

The height of low water, cleared of the effects of lunar parallax, and very nearly of the effects of lunar declination, and compared with the height of high water similarly cleared, enabled me to ascertain whether the mean water also was affected by a semimenstrual inequality. The following are the results of this calculation, keeping the six successive years separate.

Height of Mean Water at Plymouth.

Transit	h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30	Mean.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1833.	9 $10\frac{3}{4}$	10 0	10 $1\frac{3}{4}$	10 $3\frac{3}{4}$	10 $5\frac{1}{2}$	10 $6\frac{1}{2}$	10 6	10 $4\frac{3}{4}$	10 $3\frac{3}{4}$	10 $1\frac{3}{4}$	9 11	9 $10\frac{1}{2}$	10 2·5
1834.	10 0	10 2	10 3	10 $4\frac{1}{2}$	10 6	10 7	10 6	10 $2\frac{1}{2}$	10 1	10 $0\frac{1}{2}$	9 $11\frac{1}{2}$	9 $10\frac{1}{2}$	10 2·6
1835.	10 1	10 1	10 $1\frac{1}{2}$	10 $3\frac{1}{2}$	10 $4\frac{1}{4}$	10 6	10 $5\frac{1}{4}$	10 3	10 $1\frac{3}{4}$	10 $0\frac{1}{2}$	10 0	10 $0\frac{3}{4}$	10 2·4
1836.	10 $1\frac{1}{2}$	10 $2\frac{1}{2}$	10 4	10 $6\frac{1}{2}$	10 7	10 $8\frac{1}{2}$	10 $6\frac{1}{2}$	10 $4\frac{1}{2}$	10 $3\frac{1}{2}$	10 $1\frac{1}{2}$	10 $1\frac{1}{2}$	10 $0\frac{1}{2}$	10 4·0
1837.	10 0	10 1	10 2	10 4	10 $6\frac{1}{2}$	10 $6\frac{1}{2}$	10 5	10 $2\frac{1}{2}$	10 $1\frac{1}{2}$	10 0	10 0	9 11	10 2·3
1838.	10 4	10 $4\frac{1}{2}$	10 $6\frac{1}{2}$	10 8	10 $8\frac{1}{2}$	10 9	10 $8\frac{3}{4}$	10 $5\frac{1}{2}$	10 $5\frac{1}{2}$	10 4	10 $4\frac{1}{4}$	10 $4\frac{1}{2}$	10 6·1

It appears from this table that the height of mean water is constant from year to year within two or three inches.

It appears also that the mean water for each fortnight has a semimenstrual inequality amounting to six or seven inches; the height of the mean water being greatest when the transit is at 6^h, and least when the transit is at 12^h. The immediate cause of this inequality of the mean water is, that the semimenstrual inequality of low water is greater than that of high water; as I shall soon have further occasion to remark.

How far this small semimenstrual inequality of the height of mean water is universal for all places, I am not at present able to pronounce. But I am strongly disposed to believe that the difference in the amount of the semimenstrual inequality of high water and of low water depends upon local circumstances; and therefore that the semimenstrual inequality of the mean height is a casual and partial result; the general rule being that the mean height is constant, except so far as it is slightly modified by local circumstances.

2. *Of the Semimenstrual Inequality of the Height of Low Water at Plymouth.*

The height of low water is affected by the moon's declination, and hence the mean height of low water for a year depends upon the mean declination. Now the mean declination for the year is different in successive years in consequence of the change of position of the moon's orbit. Hence the mean height of low water will be different in successive years. The same may be said of high water. The following is the comparison of the successive years now under discussion with reference to this circumstance.

Mean Annual Low Water and High Water at Plymouth, compared with the Mean Lunar Declination.

	1833.	1834.	1835.	1836.	1837.	1838.
Mean declination .	14° 14′	15° 17′	16° 15′	17° 12′	17° 37′	17° 50′
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Low water	4 1	4 2	4 3¼	4 5½	4 2½	4 7½
High water......	16 4	16 3	16 1½	16 2½	16 2	16 4¾

It appears from this, that in the mean low water there is a tolerably regular increase corresponding to the increase of declination, and amounting to about two inches for each degree of declination. In the high waters, this change is less marked. When we obtain a declination table from the observations, we find that about the middle part of this table, (from decl. 12° to 18°), the correction for declination is about one inch for each degree, which accordingly I shall adopt.

Hence the semimenstrual lines for successive years, obtained by merely taking the mean results of the year, will differ in consequence of the different mean declinations of the moon. And in order to obtain from them a table suited to the absolute mean of lunar declination, which for such purposes is about $16\frac{1}{2}°$, we must correct the result of each year by a proper quantity; which quantity may, without sensible error, be supposed the same for all hours of transit, and at Plymouth will amount, as I have said, to about one inch for each degree.

If we suppose the moon to move in the ecliptic, the mean of all her simple declinations will be less than 15°; but since the declination correction varies as the square of the declination, we must take as the mean declination of the tables, that which gives the mean correction; which is about $16\frac{1}{2}$°, as stated above. The mean declinations in page 153 are obtained by adding the simple declinations only. Hence it appears that the year which corresponds most nearly to the mean declination correction is the year 1833; and to this, therefore, the others will be reduced.

The semimenstrual inequality for each year will be given at the end of the paper: and for the reasons already stated, I subtract one inch from the heights for 1834, two inches for 1835, three inches for 1836, three inches for 1837, and four inches for 1838. I thus obtain the following results.

Semimenstrual Inequality of the Height of Low Water at Plymouth reduced to 1833.

Moon's Transit.	h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30	Mean.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1833.	2 1	2 7	3 6	4 8	5 $9\frac{1}{2}$	6 7	6 5	5 $5\frac{1}{2}$	4 3	3 2	2 4	2 0	
1834.	2 2	2 11	3 8	4 8	5 $9\frac{1}{2}$	6 7	6 5	5 3	4 1	3 2	2 5	2 0	
1835.	2 3	2 9	3 6	4 8	5 $8\frac{1}{2}$	6 7	6 4	5 $4\frac{1}{2}$	4 $3\frac{1}{2}$	3 2	2 6	2 $1\frac{1}{2}$	
1836.	2 $2\frac{1}{2}$	2 10	3 $8\frac{1}{2}$	4 11	6 0	6 10	6 6	5 5	4 $3\frac{1}{2}$	3 2	2 $5\frac{1}{2}$	2 1	
1837.*	2 0	2 7	3 5	4 7	5 10	6 6	6 3	5 2	4 0	2 11	2 4	2 0	
1838.	2 $4\frac{1}{2}$	2 11	3 10	4 11	5 11	6 8	6 $7\frac{1}{2}$	5 5	4 4	3 3	2 $8\frac{1}{2}$	2 5	
Mean..	2 $2\frac{1}{4}$	2 $9\frac{1}{4}$	3 $7\frac{1}{4}$	4 9	5 10	6 $7\frac{1}{2}$	6 5	5 $4\frac{1}{2}$	4 $2\frac{1}{2}$	3 $1\frac{1}{2}$	2 $5\frac{1}{2}$	2 $1\frac{1}{4}$	4 $1\frac{1}{2}$

In order to compare this with the semimenstrual inequality of high water at the same place, I take the mean of these heights, which I find to be 4 feet $1\frac{1}{2}$ inch, and I express each height by its defect or excess with reference to this mean. In like manner, taking the table of the semimenstrual inequality of high water at Plymouth, I find the mean height to be 16 feet $3\frac{1}{2}$ inches; and I express each other height by the excess or defect with reference to this. In this way I obtain two comparable expressions for the semimenstrual inequality of low and high water as follows:

Moon's transit	h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Low water....	$-23\frac{1}{4}$	$-16\frac{1}{4}$	$-6\frac{1}{4}$	$+7\frac{1}{2}$	$+20\frac{1}{2}$	+30	$+27\frac{1}{2}$	+15	+ 1	−12	−20	$-24\frac{1}{4}$
High water....	$+16\frac{1}{2}$	$+12\frac{1}{2}$	$+5\frac{1}{2}$	− 4	$-13\frac{1}{2}$	$-20\frac{1}{2}$	−20	$-12\frac{1}{2}$	− 3	+ 8	+14	$+17\frac{1}{4}$

Thus it appears that the *semimenstrual inequality of low water at Plymouth is greater than that of high water* in the ratio of 3 to 2 nearly, the total amounts being respectively $53\frac{1}{4}$ inches, and 37 inches. The total semimenstrual inequality of the mean water is half the difference of those two, or eight inches nearly: but this is to be reduced in consequence of the correction for parallax.

* There is a seeming anomaly in the results of 1837, which is caused, at least in part, by employing apparent time for that year, while the others (calculated afterwards) were referred to mean time.

3. *The Parallax Correction of the Height of Low Water at Plymouth.*

The parallax correction is obtained from all years alike, by taking the residue of each observation which remains when the semimenstrual inequality is taken away, and arranging these residues (for each hour of the moon's transit) according to the parallax. The mean declination for each column of such an arrangement is very nearly the absolute mean declination for the year; and hence the different heights will depend almost entirely upon the different parallaxes. In this manner we obtain the effect of parallax, arranged according to hours of moon's transit. But as the effect upon the height is nearly the same for all hours of transit, I take the mean of all the twelve hours, and thus obtain the parallax correction for the height of low water. I place along with this the parallax correction for the height of high water at

Parallax	$54'\frac{1}{2}$	$55'\frac{1}{2}$	$56'\frac{1}{2}$	$57'\frac{1}{2}$	$58'\frac{1}{2}$	$59'\frac{1}{2}$	$60'\frac{1}{2}$	$61'\frac{1}{2}$
Low water ..	$+8$	$+6$	$+3\frac{1}{2}$	$+0\frac{1}{2}$	-4	$-8\frac{1}{2}$	-13	-15
High water. .	$-7\frac{1}{2}$	$-4\frac{1}{2}$	$-1\frac{1}{2}$	$+1\frac{1}{2}$	$+4\frac{1}{2}$	$+7\frac{1}{2}$	$+10\frac{1}{4}$	

the same place. Hence it appears that at Plymouth the parallax correction for height is somewhat greater for low water than for high water.

In the Appendix, where the parallax corrections for the separate hours are given, it will be seen that although the *mean* parallax correction for parallax $57'\frac{1}{2}$ is very small, and may almost be taken as 0, the parallax correction for the different hours for this value of the parallax, ranges from $-4{\cdot}4$ inches to $+3{\cdot}7$ inches. This arises from the circumstance that the range of parallax at different hours is not the same, owing to the moon's *variation*. By reason of the sun's action upon her, her orbit is an oval, the smaller axis of which is in the direction of the sun. Hence at syzygy she comes so near the earth, that her parallax amounts to $61'\frac{1}{2}$; but at quadratures her parallax never exceeds $59'\frac{1}{2}$. Consequently the mean parallax at syzygy is about $58'$, and at quadrature about $57'$. Hence if we take $57'\frac{1}{2}$ for the mean parallax, the semimenstrual curve, obtained as above, is affected by a parallax correction, which is $-$ at 0^h, and $+$ at 6^h transit. If we take away this correction, so as to obtain the true mean semimenstrual inequality, we find the following.

Semimenstrual Inequality of Low Water at Plymouth, for the Mean Parallax and Declination.

	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Transit	0 30	1 30	2 30	3 30	4 30	5 30	6 30	7 30	8 30	9 30	10 30	11 30
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
H. low water	2 7	2 $11\frac{1}{2}$	3 9	4 $10\frac{1}{2}$	5 $9\frac{1}{2}$	6 6	6 $1\frac{1}{2}$	5 2	4 3	3 3	2 8	2 4

The total amount of this semimenstrual inequality is now 50 inches; and as the total inequality for high water is 37 inches, the total semimenstrual inequality for mean water amounts to $6\frac{1}{2}$ inches.

4. *The Declination Correction of the Height of Low Water at Plymouth.*

The declination correction is obtained in a manner analogous to the parallax correction, from each year's observations. But the correction thus obtained is that which supposes the mean declination of each year to require no correction. Now this mean declination in different years is, as we have said, different. Therefore the declination correction so calculated will be different in different years; and hence we should require different declination tables in different positions of the moon's nodes. But the semimenstrual inequality is also different in different years, in virtue of the difference of the moon's mean declination. And when we take from the semimenstrual inequalities that which is requisite to reduce them to the mean declination 16½°, and add it to the declination corrections for each year, the declination corrections for different years coincide very nearly. For this purpose we add one inch to 1834, two inches to 1835, three inches to 1836, three inches to 1837, four inches to 1838, which were subtracted before. In this way we obtain the following results. These are the mean declination corrections, no account being taken of the difference of hours, which produces little effect.

I also add the declination corrections as obtained for high water at Plymouth. By comparison it will appear that the low water corrections are larger, especially for the high declinations.

Declination Correction. Plymouth.

Declination......	0° to 3°	3° to 6°	6° to 9°	9° to 12°	12° to 15°	15° to 18°	18° to 21°	21° to 24°	24° to 27°
	in.	in.	in.	in.	in.	in.	in.	in.	in.
Low water 1833..	−5½	−4½	−4½	−2	−1½	− ½	+2½	+5½	
1834..	−6	−7	−5	−4	−1	+ ½	+2½	+7	+11
1835..	−5	−4½	−5	−2	−1½	+ 1	+3	+6	+ 9½
1836..	−6½	−7	−4½	−4	−1	0	+4	+7	+11
1837..	−3½	−5	−3½	−2½	−2	+ ½	+4	+6	+ 9
1838..	−3½	−5	−2½	−2½	−1½	+ ½	+5	+6½	+12
Mean	−5	−5½	−4¼	−2¾	−1½	+ ½	+3½	+6½	+10½
High water......	+4¾	+3¾	+3	+2	+1	0	−1½	−3	− 5

There can be little doubt that the correction, as here given, for low water is more exact than that for high water, the process by which it is deduced having been applied in a more regular manner. And I may further observe, that the discussions, of which I have now been stating the results, remove all doubt on the question whether the declination correction, empirically deduced, varies as the square of the declination. The correction for low water given above, follows that law with great precision, as appears thus. The above corrections, reduced to 40ths of an inch and to declination 0, are as follows; and the squares of the corresponding declinations are expressed in the line below.

Correction . . .	10	− 10	40	100	150	230	350	470	630
Square of decl. .	1	16	49	100	169	256	361	484	625

I expect shortly to be able to give, as a Sequel to this memoir, a discussion of the *times* of low water at Plymouth corresponding to this discussion of the heights.

Postscript.

As a further proof how very nearly constant is the height of mean water, I annex the result of one year's observations made at Dundee, discussed by Mr. Dessiou. It will be seen that the differences are confined within 1½ inch, except at 11 and 12 o'clock, when they become about two inches more. This is in a (spring) tide of fourteen feet.

Dundee Tide Observations, 1837. Semimenstrual Inequality, Height of High and Low Water, and Mean Height.

Moon's Transit.	Interval between Moon's Transit and High Water.	Height of High Water.	Height of Low Water.	Height of Mean Water.
h m	h m	ft. in.	ft. in.	ft. in.
0	2 35	17 6·4	3 8·7	10 7·5
30	2 26·5	17 7·5	3 6	10 6·7
1 0	2 19·5	17 7·6	3 5	10 6·3
1 30	2 12·6	17 7·2	3 5·3	10 6·2
2 0	2 6	17 6·5	3 6	10 6·2
2 30	1 58·5	17 5·2	3 7·3	10 6·2
3 0	1 51	17 2	3 9	10 5·5
3 30	1 43·4	16 9·4	3 11·5	10 4·2
4 0	1 38	16 5	4 5·2	10 5·1
4 30	1 32·8	16 0·7	4 11·0	10 5·8
5 0	1 30·2	15 9·7	5 3·1	10 6·4
5 30	1 31·2	15 6·6	5 7·3	10 6·9
6 0	1 34·5	15 1·4	5 11·8	10 6·6
6 30	1 41·2	14 8	6 4·2	10 6·1
7 0	1 56	14 6·8	6 6	10 6·4
7 30	2 14·6	14 7	6 6·5	10 6·7
8 0	2 30	14 10·2	6 3·3	10 6·7
8 30	2 42	15 2	5 10·3	10 6·1
9 0	2 50·2	15 6	5 5·5	10 5·7
9 30	2 54	15 10	5 1·4	10 5·7
10 0	2 53·8	16 3·5	4 9	10 6·2
10 30	2 51	16 9·3	4 3·5	10 6·4
11 0	2 48	17 2	4 2	10 8
11 30	2 43·5	17 5	4 0·4	10 8·7

APPENDIX,

Showing the results of the Calculations on which the preceding Memoir is founded.

Plymouth. Heights of Low Water. Semimenstrual Line.

	h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1833.	2 1	2 7	3 6	4 8	5 9½	6 7	6 5	5 5½	4 3	3 2	2 4	2 0
1834.	2 3	3 0	3 9	4 9	5 10½	6 8	6 6	5 4	4 2	3 3	2 6	2 1
1835.	2 5	2 11	3 8	4 10	5 10½	6 9	6 6	5 6½	4 5½	3 4	2 8	2 3½
1836.	2 5½	3 1	3 11½	5 2	6 3	7 1	6 9	5 8	4 6½	3 5	2 8½	2 4
1837.	2 3	2 10	3 8	4 10	6 1	6 9	6 6	5 5	4 3	3 2	2 7	2 3
1838.	2 8½	3 3	4 2	5 3	6 3	7 0	6 11½	5 9	4 8	3 7	3 0½	2 9

	Declination.									Parallax.							
	$0^h\ 30^m$.									$0^h\ 30^m$.							
	0° to 3°	3° to 6°	6° to 9°	9° to 12°	12° to 15°	15° to 18°	18° to 21°	21° to 24°	24° to 28°	54½′	55½′	56½′	57½′	58½′	59½′	60½′	61½′
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1833.	+ 3·2	+ 9·5	+ 8·6	+ 2·5	− 3·3	+ 3·9	− 8·3	− 3·4		− 6·9	− 7·8	− 5·0	− 2·9	− 1·8	+ 8·2	+12·7	+14·6
1834.	+11·4	+ 6·7	+ 3·3	+ 6·4	+ 7·8	− 3·0	− 2·0	− 8·9	−11·7	− 6·5	−16·0	−12·8	− 7·3	− 2·5	+ 6·5	+10·7	+21·7
1835.	+ 9·5	+ 2·8	+ 8·2	+ 7·2	+ 1·8	+ 3·0	− 4·0	− 4·9	− 7·1	−12·9	− 3·4	− 1·8	− 2·8	+ 6·2	+11·0	+14·8	+ 9·1
1836.	+12·0	+ 9·7	+ 4·0	− 0·3	+ 3·1	+ 9·0	+ 3·1	+ 1·2	−11·6	−15·9	− 0·5	+ 5·6	− 0·5	+10·5	+10·0	+ 8·7	− 1·0
1837.	+ 5·4	+ 9·5	+11·6	+ 4·8	+ 6·6	+ 4·4	− 3·9	−10·5	− 6·5	−12·2	− 6·9	− 7·3	− 0·5	+ 9·4	+ 8·5	+10·2	+12·3
1838.	+ 5·0	+ 8·7	+10·2	+ 5·7	+ 6·0	+ 6·0	+ 1·2	+ 1·0	− 9·3	− 2·6	−10·0	− 9·6	−12·3	− 7·5	+ 3·3	+10·8	+19·9
	+ 7·8	+ 7·8	+ 7·6	+ 4·4	+ 3·7	+ 3·9	− 2·3	− 4·3	− 9·2	− 9·5	− 7·4	− 5·1	− 4·4	+ 2·4	+ 7·9	+11·3	+12·8
	$1^h\ 30^m$.									$1^h\ 30^m$.							
1833.	+16·0	+ 1·5	+ 2·2	+ 4·2	+ 6·0	− 2·8	− 1·2	− 8·7		− 9·0	− 7·3	− 6·7	− 6·6	+ 1·7	+ 5·2	+14·6	+15·7
1834.	+ 6·0	+15·8	+ 7·5	+ 3·5	+ 2·0	+10·2	− 9·7	− 6·7	− 7·6	− 5·3	−13·1	− 5·3	− 8·3	+ 2·0	+ 2·3	+14·0	+25·3
1835.	+ 7·3	+11·5	+ 8·7	+ 0·3	+ 7·0	+ 2·0	− 7·0	− 8·8	− 6·0	−12·9	− 2·2	+ 1·5	− 1·6	+ 5·8	+13·0	+ 9·6	+12·7
1836.	+ 8·0	+11·7	+10·6	+ 9·0	+ 5·0	+ 6·3	− 2·1	− 4·3	− 9·8	−11·7	− 3·7	+ 5·3	+14·7	+ 3·6	+ 7·3	+ 4·1	+ 1·0
1837.	+ 6·2	+ 4·8	+ 7·0	+ 6·2	+ 5·7	+ 1·7	− 2·4	− 0·8	− 6·4	− 8·3	− 5·2	− 4·4	− 2·3	+ 1·5	+ 7·6	+13·3	+14·0
1838.	+ 7·0	+ 7·5	+ 1·0	+ 6·8	+11·4	+11·4	+ 0·9	+ 1·3	−10·7	− 3·6	−10·3	−15·7	− 9·0	− 7·6	+ 4·8	+17·3	+18·0
	+ 8·4	+ 8·8	+ 6·2	+ 5·0	+ 6·2	+ 4·8	− 3·6	− 4·7	− 8·1	− 8·5	− 7·0	− 4·2	− 2·2	+ 1·2	+ 6·7	+12·1	+14·5
	$2^h\ 30^m$.									$2^h\ 30^m$.							
1833.	+ 0·2	+13·7	+10·0	− 2·8	+ 2·5	+ 2·1	− 2·4	− 7·6		− 6·3	− 8·6	− 7·6	+ 2·0	+ 0·4	+ 8·8	+12·5	
1834.	+ 9·6	+ 4·0	+ 5·0	+13·0	+ 4·8	− 2·7	− 2·7	− 7·0	− 8·9	− 4·3	− 8·9	− 4·2	− 4·0	− 2·7	− 1·8	+18·6	
1835.	+10·6	+ 4·6	+11·6	+ 8·0	+ 7·4	− 1·2	− 0·4	− 5·9	−10·4	−12·7	− 0·5	0	+ 6·7	+ 1·5	+ 9·4	+10·5	
1836.	+12·5	+12·8	+ 8·0	+12·0	+ 6·2	+ 2·2	− 1·0	− 6·3	−10·7	−13·6	− 2·7	+11·0	+14·2	+ 6·8	+ 3·4	+ 1·8	
1837.	+ 8·0	+ 6·3	+ 1·6	+ 0·2	+ 3·2	+ 4·4	+ 3·2	− 1·6	− 5·9	− 9·1	− 5·6	− 1·2	− 2·2	− 1·8	+ 8·7	+15·3	
1838.	+ 0·7	+ 7·8	+18·3	+ 6·3	+ 9·6	+ 0·6	+ 8·0	+ 1·8	−10·4	− 1·7	− 7·4	−14·0	− 8·6	− 3·2	+ 6·8	+19·1	
	+ 6·9	+ 8·2	+ 9·1	+ 6·1	+ 5·6	+ 0·9	+ 0·8	− 4·4	− 9·3	− 8·0	− 5·6	− 2·7	+ 1·3	+ 0·2	+ 5·9	+13·0	
	$3^h\ 30^m$.									$3^h\ 30^m$.							
1833.	+ 5·4	− 0·2	+ 6·9	+ 6·2	+ 5·6	+ 2·2	− 7·4	− 4·2		− 3·7	− 6·4	− 5·2	− 1·9	+ 6·3	+ 8·4	+14·5	
1834.	+ 7·7	+ 9·8	+ 6·3	− 0·2	− 3·8	+ 3·5	+ 3·0	− 3·8	−13·4	− 5·5	− 7·0	− 8·6	− 3·7	− 5·8	+12·8	+22·2	
1835.	+ 6·3	+ 7·0	+12·4	+11·7	+ 2·2	− 0·8	+ 5·0	− 0·9	−11·4	− 8·6	− 2·5	+ 4·0	+ 4·0	+10·2	+ 3·7	+ 5·0	
1836.	+14·5	+12·8	+ 6·2	+ 7·4	− 1·2	+ 2·0	+ 0·1	− 3·4	− 8·2	−11·4	− 2·0	+ 3·7	+12·1	+ 8·8	+ 2·6	+ 5·7	
1837.	+ 0·3	+ 2·8	+ 6·8	+ 9·0	+ 5·0	+ 6·0	− 2·8	− 5·9	− 3·6	− 6·7	− 6·4	+ 0·3	− 5·7	− 1·0	+10·7	+21·3	
1838.	+17·3	+13·7	+ 8·0	+ 5·5	+ 6·2	+ 4·7	+ 7·0	− 4·3	−11·3	− 0·1	− 8·7	− 8·4	−13·4	− 3·0	+11·7	+26·8	
	+ 8·6	+ 7·6	+ 7·8	+ 6·6	+ 2·3	+ 2·9	+ 0·7	− 3·8	− 9·6	− 6·0	− 5·5	− 2·4	− 1·4	+ 2·6	+ 8·3	+15·9	

Table (Continued).

	Declination.									Parallax.							
	0° to 3°	3° to 6°	6° to 9°	9° to 12°	12° to 15°	15° to 18°	18° to 21°	21° to 24°	24° to 28°	54½′	55½′	56½′	57½′	58½′	59½′	60½′	61½′
4h 30m.										**4h 30m.**							
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.		
1833.	+ 6·2	+ 7·2	+ 5·2	+ 1·3	+ 1·8	+ 0·6	− 0·7	− 8·3		− 4·9	− 7·8	− 6·3	+ 3·3	+ 3·3	+14·0		
1834.	+ 0·2	+ 6·8	+ 7·0	+ 7·0	+ 3·6	+ 5·5	− 1·5	− 6·0	−15·0	− 6·4	− 4·2	− 6·3	− 6·1	+ 3·8	+14·5		
1835.	+14·0	+ 9·5	+ 2·0	+ 4·1	+ 8·0	+ 6·8	+ 0·2	− 7·9	−10·1	− 7·7	− 2·9	− 0·3	+ 7·6	+10·5	+ 2·4		
1836.	+10·3	+ 8·4	+ 7·2	+ 7·8	+ 6·5	+ 0·8	− 1·2	− 7·3	− 7·4	−13·5	− 1·6	+ 8·5	+ 8·0	+ 9·1	+ 3·1		
1837.	+10·5	+ 8·8	+ 0·5	+ 2·6	− 0·6	− 3·0	− 1·1	+ 5·7	− 1·4	− 7·0	− 2·0	− 6·0	− 1·2	+ 5·5	+14·7		
1838.	+10·0	+17·7	+10·4	+13·5	+ 7·2	+ 0·6	− 1·7	− 7·8	− 9·0	+ 4·2	− 7·5	−10·0	− 9·5	+ 3·8	+16·0		
	+ 8·5	+ 9·7	+ 5·4	+ 6·0	+ 4·4	+ 1·9	− 1·0	− 5·3	− 8·6	− 5·9	− 4·3	− 3·4	+ 0·4	+ 6·0	+10·8		
5h 30m.										**5h 30m.**							
1833.	+ 6·8	+11·0	+ 4·2	− 3·5	− 1·7	+ 2·2	− 2·4	− 4·6		− 4·9	− 8·1	− 4·4	− 0·6	+ 8·2	+13·3		
1834.	+ 7·4	+ 4·8	+ 5·6	+ 7·5	+ 3·5	− 0·9	− 4·3	− 5·5	− 7·7	− 6·3	− 6·7	− 5·6	− 2·0	+ 8·9	+17·7		
1835.	+ 8·0	+11·4	+15·7	+ 5·6	+ 4·5	− 0·6	− 0·7	− 5·6	− 9·1	− 7·6	− 7·5	+ 5·7	+ 0·3	+ 2·1	+10·9		
1836.	+12·3	+18·5	+10·0	+ 8·8	+ 8·7	+ 6·0	− 4·6	− 6·9	− 9·1	−14·3	+ 4·7	+10·7	+14·8	+13·3	+ 0·6		
1837.	+10·0	+ 9·0	+ 9·4	+ 0·3	+ 5·0	+ 7·6	− 1·0	− 8·7	− 6·1	− 6·3	− 4·8	− 3·0	+ 2·9	+ 3·3	+14·7		
1838.	+11·8	+14·8	+ 8·0	+ 4·6	+ 7·8	+ 5·8	+ 2·4	− 6·8	−10·7	+ 1·1	− 8·8	−11·9	− 7·4	+ 9·7	+16·0		
	+ 9·4	+11·6	+ 8·8	+ 3·9	+ 4·6	+ 3·4	− 8·4	− 6·4	− 8·5	− 6·4	− 5·2	− 1·4	+ 1·3	+ 7·6	+12·2		
6h 30m.										**6h 30m.**							
1833.	+ 4·0	+ 1·4	+ 9·0	+ 9·0	− 1·8	− 2·9	− 2·7	− 5·5		− 7·4	− 7·3	+ 0·1	+ 6·0	+ 4·1	+13·9		
1834.	+ 8·4	+13·4	+ 6·2	− 2·2	− 0·2	+ 1·0	− 4·1	− 2·4	− 9·5	− 2·3	− 8·4	− 7·7	− 1·9	+ 8·2	+16·3		
1835.	+ 7·8	+ 6·2	+ 3·0	+ 3·7	+ 3·7	+ 2·0	− 4·0	− 3·0	− 9·0	− 8·1	− 3·6	− 4·1	+ 5·7	+ 3·6	+13·7		
1836.	+10·5	+ 7·8	+ 5·5	+ 4·7	− 0·2	+ 2·8	+ 4·0	− 0·9	− 9·1	−14·7	+ 1·4	+ 7·8	+10·0	+ 8·3	+ 5·8		
1837.	+ 5·0	+10·3	+14·2	+10·7	+ 6·0	− 1·6	− 3·0	+ 0·4	− 8·9	− 8·2	− 6·7	+ 2·7	+ 6·2	+ 6·8	+ 8·1		
1838.	+10·6	+ 2·0	+ 8·0	+ 5·2	+ 3·4	+ 2·5	− 1·1	+ 0·1	− 6·5	− 1·1	− 7·1	− 6·8	− 3·7	+ 9·1	+10·9		
	+ 7·7	+ 6·9	+ 7·6	+ 5·2	+ 1·8	+ 0·6	− 1·8	− 1·9	− 8·6	− 7·0	− 5·3	− 1·3	+ 3·7	+ 6·7	+11·5		
7h 30m.										**7h 30m.**							
1833.	+ 1·0	+ 7·2	+ 4·5	+ 1·7	+ 4·9	+ 4·2	− 4·3	− 6·0		−10·5	− 5·6	+ 1·7	+ 4·8	+ 5·3	+11·6		
1834.	+ 6·2	+ 5·3	+ 1·0	+ 7·0	− 3·3	− 2·1	+ 1·3	− 3·9	− 7·0	− 5·1	− 8·9	−11·0	− 5·8	+ 5·1	+14·9		
1835.	+12·3	+ 1·5	+ 1·2	− 2·8	+ 1·8	+ 3·3	+ 1·3	− 1·0	− 4·5	− 8·7	− 7·5	− 2·4	+ 2·6	+ 9·0	+14·7		
1836.	+ 2·5	+ 3·3	+ 8·5	+ 9·0	+ 3·6	+ 4·2	− 6·4	+ 1·0	− 6·1	−13·1	− 3·7	+ 0·6	+13·1	+ 8·6	+ 4·3		
1837.	+ 5·7	+ 9·7	+ 0·8	+ 1·0	+ 7·4	+ 8·5	− 3·3	− 5·4	− 3·8	− 8·1	− 7·8	− 0·3	− 0·3	+ 8·3	+ 9·0		
1838.	− 8·3	+ 1·2	+ 4·5	+ 4·0	+ 5·2	+ 4·5	+ 4·2	+ 0·5	− 5·0	− 1·0	− 7·0	− 7·6	+ 2·7	+ 1·3	+ 7·1		
	+ 3·2	+ 4·7	+ 3·4	+ 3·3	+ 2·3	+ 3·8	− 1·2	− 2·5	− 5·3	− 7·8	− 6·8	− 3·2	+ 2·9	+ 6·3	+10·3		
8h 30m.										**8h 30m.**							
1833.	+ 8·4	− 0·6	− 2·0	+ 0·3	− 0·3	+ 2·1	− 0·9	− 3·4		− 9·9	− 6·1	− 1·3	− 1·7	+11·7	+ 8·6	+17·0	
1834.	+11·0	+ 1·9	+ 3·8	+ 5·0	+ 6·6	− 4·3	− 3·0	− 3·4	− 9·3	− 3·7	− 9·3	−12·3	− 9·0	+ 1·2	+13·9	+19·5	
1835.	+ 5·2	+ 3·3	+12·5	+ 5·2	− 2·2	+ 1·0	− 0·7	+ 0·9	− 5·7	−11·0	− 5·3	− 2·5	− 0·1	+ 9·6	+13·0	+15·0	
1836.	+ 9·0	+10·8	+ 5·2	+ 3·0	+ 5·5	+ 2·7	− 1·9	− 5·4	− 4·5	−12·3	− 5·8	+ 7·3	+ 9·4	+ 9·0	+ 6·6	+ 9·8	
1837.	+ 4·8	+11·7	+ 9·7	+ 4·0	+ 4·0	− 3·5	+ 5·6	+ 0·7	− 6·0	−10·7	0	− 1·8	+ 7·0	+ 6·8	+ 9·2	+10·6	
1838.	+ 3·0	− 1·7	0	+ 3·0	+ 1·8	+ 2·0	+ 4·8	+ 6·5	− 4·3	− 2·6	− 7·4	− 1·4	− 6·6	+ 2·8	+ 5·8	+13·3	
	+ 6·9	+ 4·3	+ 4·9	+ 3·4	+ 2·6	0	+ 0·7	− 0·7	− 6·0	− 8·4	− 5·6	− 2·0	− 0·2	+ 6·9	− 9·5	+14·2	
9h 30m.										**9h 30m.**							
1833.	+ 9·0	+ 3·8	− 3·0	+ 5·0	+ 0·3	− 1·8	− 0·5	− 3·9		− 9·6	− 4·8	− 6·7	+ 1·7	+ 4·3	+ 9·5	+12·9	
1834.	+ 5·8	+15·2	+15·5	+ 1·5	− 0·6	− 1·0	− 3·9	− 6·1	− 9·5	− 1·3	−11·7	−11·2	−11·1	− 4·2	+ 4·6	+20·8	
1835.	+ 4·8	+ 3·8	− 0·5	− 0·4	+ 7·6	− 0·7	+ 0·9	− 3·3	−11·2	−12·2	− 8·0	− 2·6	− 1·7	+ 6·4	+10·2	+14·2	
1836.	+ 8·5	+10·6	+ 9·7	+ 7·3	+ 2·4	− 0·9	− 0·4	− 3·7	− 6·8	−12·9	− 6·4	− 0·3	+11·6	+10·0	+ 9·7	+ 9·2	
1837.	+11·3	+ 4·6	+ 2·7	+ 7·0	+13·2	+ 6·7	− 5·7	− 1·6	− 7·1	−12·7	− 2·6	+ 5·7	− 2·6	+ 2·0	+11·7	+10·5	
1838.	+10·2	+10·4	+ 3·0	+ 5·4	+ 0·9	+ 1·7	− 2·5	− 1·3	− 6·5	− 6·3	− 8·0	− 5·5	− 8·0	− 7·5	+ 6·5	+14·5	
	+ 8·3	+ 8·1	+ 4·6	+ 4·3	+ 4·0	+ 0·7	− 2·0	− 3·3	− 8·2	− 9·2	− 6·9	− 3·4	− 1·7	+ 1·8	+ 8·7	+13·7	

TABLE (Continued).

	Declination. 10h 30m.									Parallax. 10h 30m.							
	0° to 3°	3° to 6°	6° to 9°	9° to 12°	12° to 15°	15° to 18°	18° to 21°	21° to 24°	24° to 28°	54′½	55′½	56′½	57′½	58′½	59′½	60′½	61′½
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1833.	− 1·7	+ 7·0	+ 5·8	− 1·7	− 5·8	+ 5·5	− 3·5	− 1·6		− 9·2	− 7·6	− 5·7	− 4·2	+ 2·7	+ 8·0	+13·5	+20·7
1834.	+13·0	+ 4·3	+ 0·8	+ 8·2	+ 8·7	− 2·9	− 0·7	− 6·1	−12·7	− 4·5	− 5·0	−12·7	−14·5	− 5·0	− 0·1	+16·4	+27·0
1835.	+ 2·6	+ 8·2	+ 7·8	+ 7·0	+ 1·7	− 3·8	+ 0·4	− 5·0	− 4·3	−12·9	− 7·3	− 8·0	+ 3·4	+ 5·3	+11·2	+14·1	+15·0
1836.	+10·3	+ 8·6	+ 5·5	+ 4·5	− 0·7	+ 3·2	− 1·5	− 7·7	− 4·8	−13·1	− 5·8	+ 2·7	+ 3·3	+10·6	+12·8	+ 7·0	+ 9·0
1837.	− 1·0	+ 9·5	+13·8	+ 8·4	− 1·2	+ 5·1	+ 2·0	−12·3	− 6·3	−13·3	− 3·8	− 0·4	+ 3·4	+ 3·3	+ 8·2	+14·1	+13·3
1838.	+ 5·5	+10·0	+10·2	+14·0	+ 1·8	+ 1·7	− 3·6	− 5·6	− 6·0	− 7·2	− 5·4	− 6·0	− 8·0	− 2·6	+ 0·6	+11·9	+28·7
	− 4·8	+ 7·9	+ 7·3	+ 6·7	+ 0·8	+ 1·5	− 1·1	− 6·4	− 6·8	−10·0	− 5·8	− 5·0	− 2·8	+ 2·7	+ 6·8	+12·8	+19·0
	11h 30m.									11h 30m.							
1833.	+ 9·0	− 0·6	+ 1·7	+ 5·5	+ 9·4	− 4·3	+ 0·2	− 5·8		− 8·2	− 6·8	−12·0	− 1·2	− 0·2	+ 2·7	+10·7	+16·9
1834.	+ 3·3	+10·4	+15·7	+ 2·8	− 0·9	+ 8·1	− 4·0	− 9·4	−13·3	− 6·0	−12·4	−19·3	−13·5	− 5·0	− 0·2	+11·4	+21·1
1835.	+ 6·3	+ 8·7	+ 7·7	− 1·2	+ 1·7	+ 3·0	+ 0·6	− 3·9	− 6·1	−12·3	− 1·7	− 8·7	+ 2·1	+ 8·2	+ 8·1	+18·3	+ 7·3
1836.	+ 7·0	+ 8·7	+ 8·0	+ 9·5	+ 8·2	− 2·0	− 2·6	− 4·8	− 7·6	−13·2	− 5·1	− 0·5	+ 5·4	+16·2	+10·9	+ 6·4	+ 5·3
1837.	+16·8	+16·0	− 1·4	+ 9·2	+ 6·3	− 6·2	+ 1·2	+ 5·2	− 9·9	−14·7	− 3·2	− 5·0	+ 1·6	+ 5·0	+10·3	+13·2	+12·5
1838.	+21·3	+14·0	− 0·7	+ 6·2	+ 5·2	+ 2·2	− 5·5	− 8·6	− 4·8	− 6·3	− 5·6	− 8·5	− 9·5	− 0·8	− 9·0	+11·7	+22·1
	+10·6	+ 9·5	+ 5·2	+ 5·3	+ 5·0	+ 0·1	− 1·7	− 4·6	− 8·3	−10·1	− 5·8	− 9·0	− 2·5	+ 3·9	+ 3·8	+12·0	+14·2

Declination. Mean for each Hour of Transit.

1833.											
h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30
ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
14 5	14 5	14 37	14 4	14 44	14 42	13 49	13 1	14 15	14 8	14 17	15 1
14 10	13 20	14 12	14 19	14 36	15 15	12 25	14 26	13 16	14 34	14 21	14 23
14 36	14 18	14 9	15 18	13 26	15 29	13 56	14 51	13 44	14 12	12 59	14 54
14 15	14 17	14 54	14 18	14 57	12 37	15 44	14 0	14 53	13 12	14 23	13 52
14 17	14 0	14 28	14 30	14 26	14 31	13 59	14 5	14 2	14 2	14 0	14 32
1834.											
15 58	14 10	16 5	14 22	16 13	14 47	16 10	16 14	14 23	15 56	14 37	16 1
14 46	16 7	14 44	15 57	14 39	16 2	16 6	14 58	15 32	14 22	15 55	13 58
13 54	16 36	14 26	16 42	14 15	15 27	14 20	15 2	14 32	16 29	16 13	14 35
15 37	15 11	16 20	15 1	15 15	15 16	14 12	14 6	16 5	16 3	15 24	14 8
15 4	15 31	15 24	15 31	15 6	15 23	15 12	15 5	15 8	15 43	15 32	14 41
1835.											
17 1	16 22	15 56	15 42	16 29	15 45	15 22	16 42	15 38	16 29	14 59	16 56
15 55	17 59	15 26	17 12	15 33	16 17	15 30	15 22	16 49	15 13	16 34	14 59
15 36	16 22	15 40	17 19	15 43	18 13	16 36	15 39	17 32	14 40	16 45	16 13
17 26	15 26	16 36	15 43	17 26	16 42	16 13	16 46	16 3	17 2	14 30	17 37
16 30	16 32	15 55	16 29	16 18	16 44	15 55	16 7	16 31	15 51	15 42	16 26

TABLE (Continued).

1836.											
h m 0 30	h m 1 30	h m 2 30	h m 3 30	h m 4 30	h m 5 30	h m 6 30	h m 7 30	h m 8 30	h m 9 30	h m 10 30	h m 11 30
ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
17 27	15 33	18 1	16 15	18 26	16 54	18 41	16 32	17 9	18 4	15 55	17 50
15 40	18 45	15 23	18 59	15 46	18 31	16 14	18 6	15 51	18 4	17 9	17 45
17 55	17 39	17 5	17 53	16 11	18 18	16 41	17 10	17 15	16 14	18 33	15 24
17 56	16 20	18 35	16 24	17 27	17 39	16 59	16 40	18 4	16 40	16 27	17 16
17 15	17 4	17 16	17 23	16 58	17 50	17 9	17 7	17 5	17 16	17 1	17 4
1837.											
18 11	17 28	16 49	18 13	18 17	18 16	19 7	17 18	19 38	16 12	17 17	16 27
18 21	16 52	17 25	16 37	18 39	18 44	18 33	18 32	17 11	18 1	16 36	18 36
16 59	17 2	18 3	16 47	19 19	18 14	15 30	18 26	17 2	17 18	18 1	16 56
15 22	17 19	16 32	18 39	18 28	16 45	17 55	17 16	18 11	17 21	17 54	16 45
17 9	17 10	17 12	17 34	18 41	18 0	17 46	17 58	18 1	17 13	17 27	17 11
1838.											
17 55	18 31	17 14	18 7	17 40	16 3	18 15	17 8	19 5	16 56	19 20	18 22
16 52	18 0	17 20	18 13	17 23	17 18	16 58	18 23	17 34	18 32	18 2	18 22
17 50	17 11	16 28	18 23	17 27	19 6	17 9	18 37	17 14	17 48	17 32	17 51
17 15	18 14	17 36	18 22	18 38	18 0	18 52	17 9	18 19	17 1	18 20	18 8
17 28	17 59	17 10	18 16	17 47	17 37	17 49	17 49	18 3	17 34	18 19	18 11