3 Computation of the HW95 tidal potential catalogue

Our catalogue HW95 of the Earth tide generating potential has been computed by using an expansion of the form

$$V_{(t)} = \sum_{\ell=1}^{\ell=\ell_{max}} \sum_{m=0}^{m=\ell} \left(\frac{r}{a}\right)^{\ell} \overline{P}_{\ell m}(\cos\theta) \sum_{i} \left[C_i^{\ell m}(t)\cos(\alpha_i(t)) + S_i^{\ell m}(t)\sin(\alpha_i(t))\right] \quad (5)$$

The time dependent tidal potential coefficients are given by

$$C_i^{\ell m}(t) = \mathrm{C0}_i^{\ell m} + t \cdot \mathrm{C1}_i^{\ell m} \quad (6)$$

$$S_i^{\ell m}(t) = \mathrm{S0}_i^{\ell m} + t \cdot \mathrm{S1}_i^{\ell m} \quad (7)$$

where the potential coefficients $\mathrm{C0}_i^{\ell m}$ and $\mathrm{S0}_i^{\ell m}$ have the dimension $\mathrm{m}^2/\mathrm{s}^2$ and the linear drift coefficients $\mathrm{C1}_i^{\ell m}$ and $\mathrm{S1}_i^{\ell m}$ have the dimension $\mathrm{m}^2/\mathrm{s}^2/\mathrm{J.cy}$. The arguments $\alpha_i(t)$ are computed from

$$\alpha_i(t) = m \cdot \lambda + \sum_{j=1}^{j=11} k_{ij} \cdot arg_j(t) \quad \text{with } k_{i1} = m. \quad (8)$$

The integer coefficients k_{ij} are given in our catalogue, while the eleven astronomical arguments $arg_j(t)$ (τ = mean local lunar time, s = mean lunar longitude, h = mean solar longitude, p = mean longitude of lunar perigee, N' = negative mean longitude of the lunar ascending node, p_s = mean longitude of solar perigee, L_{Mer} = mean longitude of Mercury, L_{Ven} = mean longitude of Venus, L_{Mar} = mean longitude of Mars, L_{Jup} = mean longitude of Jupiter, L_{Sat} = mean longitude of Saturn) can be computed from polynomials in time, given

Table 12: Fundamental frequencies in °/hour after Simon et al. (1994) at J2000

j	argument	symbol	frequency [°/hour]
1.	mean local lunar time	τ	14.492 052 120 18
2.	mean lunar longitude	s	0.549 016 519 73
3.	mean solar longitude	h	0.041 068 639 91
4.	mean longitude of lunar perigee	p	0.004 641 813 41
5.	negative mean longitude of lunar ascending node	N'	0.002 206 406 87
6.	mean longitude of solar perigee	p_s	0.000 001 961 51
7.	mean longitude of Mercury	L_{Mer}	0.170 515 710 90
8.	mean longitude of Venus	L_{Ven}	0.066 757 030 52
9.	mean longitude of Mars	L_{Mar}	0.021 836 295 20
10.	mean longitude of Jupiter	L_{Jup}	0.003 463 726 64
11.	mean longitude of Saturn	L_{Sat}	0.001 395 746 14

Table 13: Polynomial coefficients for astronomical arguments after Simon et al. (1994), units are: ° and °/1000 yrs

j	Constant	t	t^2	t^3	t^4
1.	242.149 804 529 99	127 037 328.885 530 56	0.176 961 11	−0.001 831 40	0.000 088 24
2.	218.316 645 629 99	4 812 678.811 957 50	−0.146 638 89	0.001 851 40	−0.000 153 55
3.	280.466 450 160 02	360 007.697 488 06	0.030 322 22	0.000 020 00	−0.000 065 32
4.	83.353 243 119 98	40 690.136 352 50	−1.032 172 22	−0.012 491 68	0.000 526 55
5.	234.955 444 990 00	19 341.362 619 72	−0.207 561 11	−0.002 139 42	0.000 165 01
6.	282.937 340 980 01	17.194 576 67	0.045 688 89	−0.000 017 76	−0.000 033 23
7.	252.250 905 519 99	1 494 740.721 722 33	0.030 349 84	0.000 018 11	−0.000 065 32
8.	181.979 800 850 00	585 192.129 533 30	0.031 013 95	0.000 014 90	−0.000 065 32
9.	355.432 999 580 02	191 416.963 702 97	0.031 051 87	0.000 015 64	−0.000 065 32
10.	34.351 518 740 03	30 363.027 748 48	0.022 329 72	0.000 037 01	−0.000 052 14
11.	50.077 444 300 00	12 235.110 686 22	0.051 907 83	−0.000 029 85	−0.000 097 40

Table 11: IERS 1992 numerical constants used for the HW95 catalogue

Item	Numerical value	Comment
f	1 / 298.256 421 984 6	flattening of the Earth's ellipsoid
a	6 378 136.3 m	semi-major axis of the Earth's ellipsoid
$J_{2\oplus}$	$1.082\,636\,2 \cdot 10^{-3}$	2nd degree zonal harmonic coeff. of the Earth's gravity field
GM	$3.986\,004\,418 \cdot 10^{14}$ m^3/s^2	geocentric gravitational constant
M/Ea	0.012 300 034	ratio of mass of Moon to that of the Earth
S/Me	6 023 600	ratio of mass of Sun to that of the Mercury
S/Ve	408 523.71	ratio of mass of Sun to that of the Venus
S/Ea	332 946.045	ratio of mass of Sun to that of the Earth
S/Ma	3 098 708.	ratio of mass of Sun to that of the Mars
S/Ju	1 047.348 6	ratio of mass of Sun to that of the Jupiter
S/Sa	3 497.90	ratio of mass of Sun to that of the Saturn

Example for tidal potential catalogue:

Listing of those 45 waves with amplitudes exceeding $1 \cdot 10^{-2}$ m^2/s^2:

number	l	m	k 2	k 3	k 4	k 5	k 6	k 7	k 8	k 9	k 10	k 11	frequency (deg/hour)	C0	S0	C1	S1	nam
1	MO	2	0	0	0	0	0	0	0	0	0	0	0.00000000	-5944286666.	0.	-1935360.	0.	MO
3	SU	2	0	0	0	0	0	0	0	0	0	0	0.00000000	-2751200919.	0.	-890704.	0.	SO
23	MO	2	0	0	0	0	1	0	0	0	0	0	0.00220641	771788513.	0.	-325040.	0.	
194	SU	2	0	0	1	0	0	-1	0	0	0	0	0.04106668	-137899524.	0.	306581.	0.	SA
358	SU	2	0	0	2	0	0	0	0	0	0	0	0.08213728	-855082729.	0.	885919.	0.	SSA
799	MO	2	0	1	-2	1	0	0	0	0	0	0	0.47152105	-185961196.	0.	-64233.	0.	MSM
946	MO	2	0	1	0	-1	0	0	0	0	0	0	0.54437471	-972501389.	0.	-322767.	0.	MM
984	MO	3	0	1	0	0	0	0	0	0	0	0	0.54901652	0.	-103721679.	0.	22110.	
1325	MO	2	0	2	-2	0	0	0	0	0	0	0	1.01589576	-161326507.	0.	-56860.	0.	MSF
1512	MO	2	0	2	0	0	0	0	0	0	0	0	1.09803304	-1841041825.	0.	1939970.	0.	MF
1529	MO	2	0	2	0	0	1	0	0	0	0	0	1.10023945	-763323862.	0.	324410.	0.	
1989	MO	2	0	3	0	-1	0	0	0	0	0	0	1.64240775	-352500762.	0.	370294.	0.	MTM
2001	MO	2	0	3	0	-1	1	0	0	0	0	0	1.64461415	-146096331.	0.	62177.	0.	
3876	MO	2	1	-3	0	2	0	0	0	0	0	0	12.85428619	0.	129857156.	0.	-66007.	2Q1
3979	MO	2	1	-3	2	0	0	0	0	0	0	0	12.92713984	0.	156593207.	0.	-60053.	SIG1
4251	MO	2	1	-2	0	1	-1	0	0	0	0	0	13.39645449	0.	185063773.	0.	44599.	
4263	MO	2	1	-2	0	1	0	0	0	0	0	0	13.39866089	0.	981305656.	0.	-510204.	Q1
4388	MO	2	1	-2	2	-1	0	0	0	0	0	0	13.47151455	0.	186260860.	0.	-76093.	RO1
4664	MO	2	1	-1	0	0	-1	0	0	0	0	0	13.94082919	0.	966886565.	0.	220455.	
4681	MO	2	1	-1	0	0	0	0	0	0	0	0	13.94303560	0.	5125256711.	0.	-2762670.	O1
5059	MO	2	1	0	0	-1	0	0	0	0	0	0	14.48741031	0.	-144896357.	0.	63561.	
5110	MO	2	1	0	0	1	0	0	0	0	0	0	14.49669393	0.	-402872065.	0.	161257.	M1
5525	SU	2	1	1	-3	0	0	1	0	0	0	0	14.91786468	0.	139201619.	0.	-415011.	PI1
5653	SU	2	1	1	-2	0	0	0	0	0	0	0	14.95893136	0.	2380313224.	0.	-1207214.	P1
5946	MO	2	1	1	0	0	-1	0	0	0	0	0	15.03886223	0.	142689589.	0.	-141064.	
5958	MO	2	1	1	0	0	0	0	0	0	0	0	15.04106864	0.	-4925288540.	0.	1908945.	K1
5961	SU	2	1	1	0	0	0	0	0	0	0	0	15.04106864	0.	-2279779400.	0.	875007.	K1
5978	MO	2	1	1	0	0	1	0	0	0	0	0	15.04327505	0.	-977663900.	0.	-226210.	
6244	SU	2	1	1	2	0	0	0	0	0	0	0	15.12320592	0.	-102392652.	0.	159986.	FI1
6738	MO	2	1	2	0	-1	0	0	0	0	0	0	15.58544335	0.	-403016900.	0.	187668.	J1
7106	MO	2	1	3	0	0	0	0	0	0	0	0	16.13910168	0.	-220445439.	0.	349751.	OO1
7112	MO	2	1	3	0	0	1	0	0	0	0	0	16.14130809	0.	-141251705.	0.	150453.	
8628	MO	2	2	-2	0	2	0	0	0	0	0	0	27.89535483	313070026.	0.	8483.	0.	2N2
8720	MO	2	2	-2	2	0	0	0	0	0	0	0	27.96820848	377850712.	0.	2561.	0.	MI2
8976	MO	2	2	-1	0	1	0	0	0	0	0	0	28.43972953	2365821950.	0.	40182.	0.	N2
9082	MO	2	2	-1	2	-1	0	0	0	0	0	0	28.51258319	449404707.	0.	-2587.	0.	NI2
9323	MO	2	2	0	0	0	-1	0	0	0	0	0	28.98189783	-461038339.	0.	258211.	0.	
9337	MO	2	2	0	0	0	0	0	0	0	0	0	28.98410424	12356348081.	0.	130692.	0.	M2
9622	MO	2	2	1	0	-1	0	0	0	0	0	0	29.52847895	-349288916.	0.	-1547.	0.	L2
9947	SU	2	2	2	-3	0	0	1	0	0	0	0	29.95893332	335581352.	0.	-823253.	0.	T2
10068	SU	2	2	2	-2	0	0	0	0	0	0	0	30.00000000	5738394275.	0.	138617.	0.	S2
10303	MO	2	2	2	0	0	0	0	0	0	0	0	30.08213728	1067392061.	0.	-1036988.	0.	K2
10306	SU	2	2	2	0	0	0	0	0	0	0	0	30.08213728	494523165.	0.	-563232.	0.	K2
10318	MO	2	2	2	0	0	1	0	0	0	0	0	30.08434369	465420663.	0.	-184316.	0.	
12022	MO	3	3	0	0	0	0	0	0	0	0	0	43.47615636	-149687399.	0.	993.	0.	M3