

A problem with the Venus terms in the ETERNA software

Bernard Ducarme* , Qinwen Xi**

* *Research Associate NFSR, Royal Observatory of Belgium, Av. Circulaire 3, B-1180 Brussels, Belgium*

** *Institute of Seismology, Chinese Seismological Bureau, Beijing*

A large peak is found in the spectrum of the differences (Fig. 1) between the tidal prediction program MT80TW (ICET, <http://www.astro.oma.be/ICET/>), based on the original Tamura's formula (BIM99, 6813-6855, 1987), and PREDICT (H.G.Wenzel, 1996). It is located inside the T_2 group. It is well known that some constituents, derived from Jupiter and Venus (Fig. 2), are located in this group (waves 978, 979, 983 and 984).

A direct comparison of the Tamura's formula with Wenzel (1994) ones is not easy as the two authors are not using the same arguments to define the Jupiter and Venus positions.

Tamura argument f_7 is referring to Jupiter's opposition and f_8 to Venus superior conjunction.

Wenzel argument k_{10} is the mean longitude of Jupiter and k_8 the mean longitude of Venus.

It is easy to convert from one system to the other as

$$f_8 = 180^\circ - (h - k_8)$$

And

$$f_7 = h - k_{10}$$

where h is the mean longitude of the sun.

From the first order expression in PREDICT with origin in JD 2451545.0

$$h = 280^\circ.47 + 360007.70 \cdot \text{DTM}$$

$$k_8 = 181^\circ.98 + 585192.13 \cdot \text{DTM}$$

we get

$$f_8 = 81^\circ.51 + 225184.4 \cdot \text{DTM}$$

In Tamura, 1987 we have

$$f_8 = 81^\circ.5 + 22518.44 \cdot \text{TD}$$

with $\text{DTM} = \text{TD}/10$

We see that at the first order in TD the definition is identical. It should be noted that an initial phase of 180° is equivalent to a change of sign of the term. It will matter only for terms where the argument f_8 is multiplied by an odd number. Among the few terms generated from Venus in Tamura development only the term 984, located in the group T_2 , has an odd argument (-1) for f_8 . Its sign should thus be changed with respect to original Tamura work when the Wenzel formulation is used. It is not what has been done by Wenzel.

One will find in Table 1 a comparison of the Venus terms 979 and 984 (T_2 group) with angular speed $29^\circ.94862323$ and $29^\circ.97431161$ in the original Tamura (1987), TamuraHW (Wenzel normalisation) and Hartmann-Wenzel (HW95) tidal developments:

In HW95 potential (variant c) the sign of the terms corresponding to 984 is effectively reversed to introduce the 180° initial phase in the definition of the argument, but it is not so in the transposition of the Tamura development (TamuraHW). PREDICT is always using the Wenzel convention for TamuraHW as well as for HW95. The result is thus not correct using TamuraHW and a fictitious wave with a peak to peak amplitude close to 0.015 nms^{-2} is created (Fig 1.). The associated RMS errors is 0.0057 nms^{-2} .

When the sign of term 984 is changed in TamuraHW the difference between PREDICT and MT80tw is comprised between -0.01 nms^{-2} and $+0.02 \text{ nms}^{-2}$ with a RMS error of 0.0028 nms^{-2} .

Table 1

Comparison of the Venus terms in T2 group according to different authors

a) Tamura amplitudes expressed in Doodson's convention

b) Tamura amplitude expressed in fully normalised harmonics following Wenzel in TamuraHW.

c) HW95

VE: direct Venus potential, SU: indirect effect (perturbation term)

	τ	s	h		f_8	k_8							
For term 979													
a)	979	2	2	-2	0	0	0	0	-2	29.94862323	-.000021	.00000	SU
b)	979	2	2						-2	29.94862323	-285595.	0.	SU
c) 9916 2 2 0													
									-2	29.94862322	-283878	-1879.	SU
	9917_	2	2	0					-2	29.94862322	12598.	-2537.	VE
For term 984													
a)	984	2	2	-2	0	0	0	0	-1	29.97431161	.000013	.000000	SU
b)	984	2	2	-1					-1	29.97431161	<u>176797.</u>	0.	SU
.													
c) 9992 2 2 -1													
									-1	29.97431161	-181048.	334.	SU
	9993	2	2	-1					-1	29.97431161	-20551.	3020.	VE
.													

For the tidal analysis this error can affect the determination of the T_2 wave (term 982), a rather weak constituent next to the incriminated term 984. This can only be tested on a very good data set such as the superconducting gravimeter C034L at Moxa for which the standard deviation on the unit weight is 0.576 nms^{-2} .

The analysis has been performed on 1302 days between 2000/01/01 and 2003/08/31 with program ANALYZE, PERTZEV filter and Tamura or HW95 developments. The first column is the result before the correction, the second one the result after the correction and the third one HW95 with 3,268waves (threshold 1.10^{-6}).

The tidal analysis results are slightly modified in the vicinity of T_2 as shown below in Table 2. The differences are concentrated on T_2 . L_2 which has the same theoretical amplitude is practically not modified. The results become closer to the results of HW95. The difference is well below the associated errors even on T_2 . It is thus not necessary to reprocess all previous analyses.

Bibliography

- Tamura Y., 1987: A harmonic development of the tide-generating potential. Bull. Inf; Marées Terrestres, 99, 6813-6855.
- Hartmann, T., Wenzel, H.-G., 1994: Catalogue of the Earth tide generating potential due to the planets. Bull. Inf. Marées Terrestres, 119, 8847-8880.
- Wenzel, H.-G., 1996: The nanogal software: Earth tide data processing package ETERNA 3.30. Bull. Inf. Marées Terrestres, 124, 9425-9439.

Table 2							
Tidal analysis results around the group T2 where the term 984 is located							
	TamuraHW previous		TamuraHW corrected		HW95		
RMS error on unit weight (nms ⁻²)	0.576		0.575		0.572		
	A _{th} (nms ⁻²)	δ	α	δ	α	δ	α
LAMBDA2	2.2284	1.18179 ±.00466	1°.2593 ±.2261	1.18174 ±.00468	1°.2593 ±.2267	1.18208 ±.00473	1°.3334 ±.2294
L2	8.5416	1.17387 ±.00136	1°.6332 ±.0666	1.17387 ±.00137	1°.6325 ±.0668	1.17331 ±.00138	1°.5706 ±.0676
T2	8.2191	1.18840 ±.00128	0°.3550 ±.0618	1.18817 ±.00128	0°.3595 ±.0619	1°.18778 ±.00130	0°.3613 ±.0627
S2	140.5965	1.18354 ±.00008	0°.3860 ±.0037	1.18355 ±.00008	0°.3862 ±.0037	1.18352 ±.00008	0°.3914 ±.0038

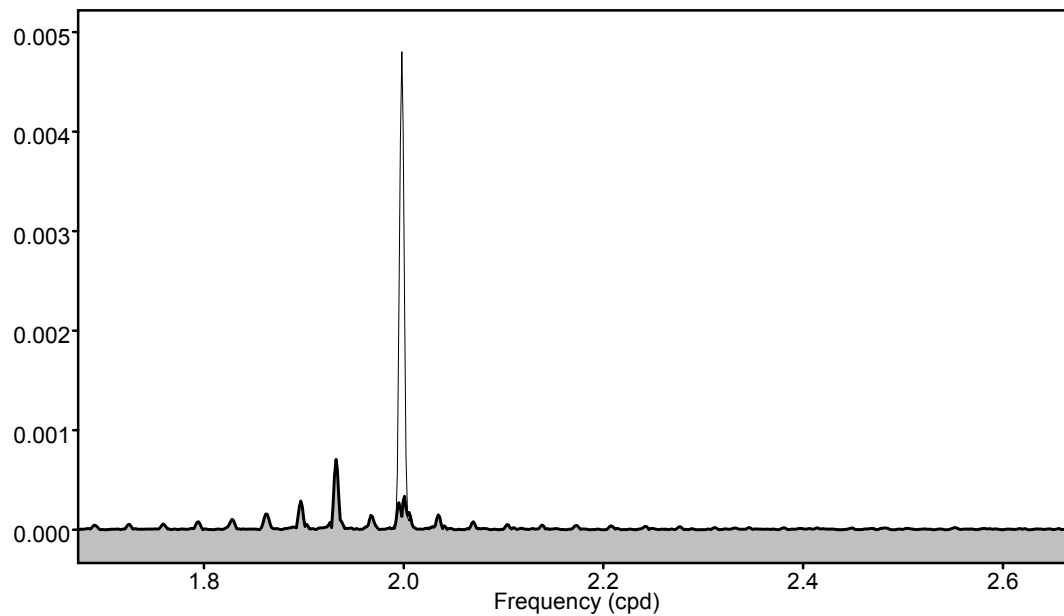


Fig. 1: Difference between MT80tw and PREDICT before and after correction of wave 984 sign in TAMURAHW.DAT.

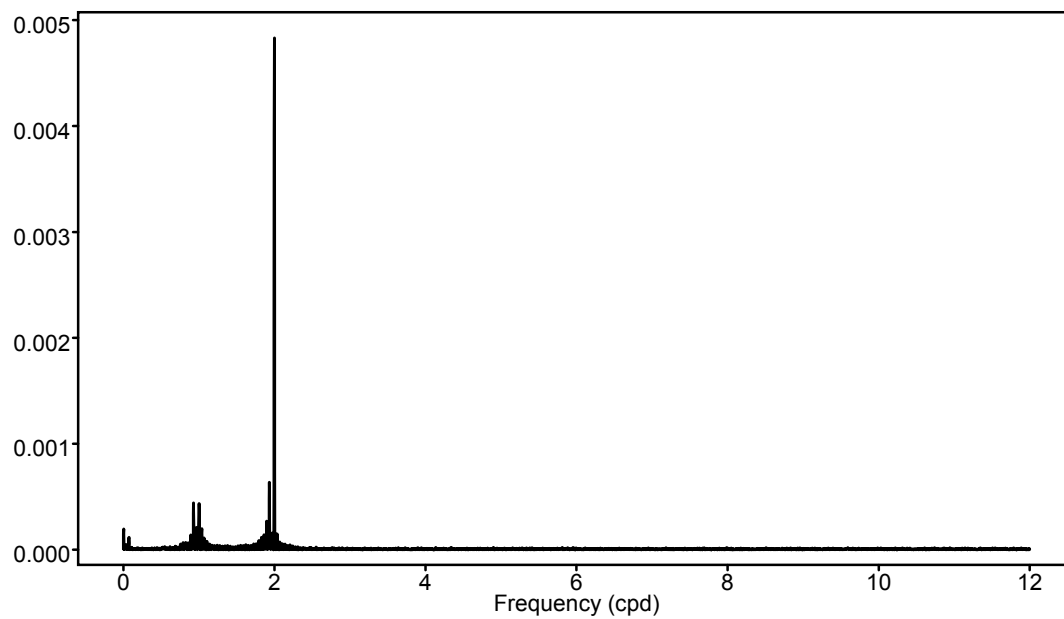


Fig 2: Spectrum of the Venus terms in Tamura development