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Example of the use of LatiPaS (and WorldTide)

Objective and used software

The objective of this study is to evaluate the use of the programs World Tide and LatiPaS for a practical case. The case used is the estuary of the Western Scheldt and the Scheldt river. The programs used are World Tide, a program based on a Matlab script by John D. Boon, emeritus professor of the University of Virginia (Virginia Institute of Marine Science). The used version is 1.0.0.0, in combination with Matlab 2012a. This program is able to analyse a tidal record with a large number of constituents (https://www.mathworks.com/matlabcentral/fileexchange/24217-world-tides).

The program LatiPaS has been developed by Gerrit Jan Schiereck of Delft University. This program is available from http://software.dicea.nl. This program is able to compute a waterlevel record given the tidal constituents of that station, as well as a computation of the tidal propagation in a tidal sea, estuary or river. Input are the tidal constituents at the boundary, and output are the waterlevels and velocities in all nodes and branches.

Used data

The case elaborated is the Western Scheldt estuary and the Scheldt river up to the weir of Gent (the Zeeschelde). The case is based on public data. The bathymetric information is taken from http://navionics.com. Tidal constituents for Vlissingen are based on a publication of Flanders Hydraulics (originally originating from the Xtide database). The comparison is done with tidal records along the Schelde from Rijkswaterstaat (http://getij.rws.nl) and http://waterinfo.be (the official website of a number of Flemish authorities).

Tidal constituents

From the http://getij.rws.nl a full (predicted) waterlevel record for the year 2018 for the station Vlissingen has been downloaded. This file has an interval of 10 minutes. The original file had Wintertime and Summertime, it has been corrected to only Wintertime. With this file and the program World Tide the constituents for Vlissingen were calculated. This was done both for 4 constituents as well as 37 constituents. This resulted in the following table. Note that the Xtide database consists of in total 94 constituents. The blank constituents in the Xtide columns are constituents with a description which could not be matched to a description in Word Tide.

World Tide gives also a graph comparing the “measured” data (which are in this case the Rijkswaterstaat predictions) compared with the values calculated with the Word Tide constituents. Also the residual values are shown.

The figures for both the 4 constituents as well as the 37 constituents are shown below.

Remarkable is that the observed tide during spring seems always higher than the calculated value. During neap tide it is reversed.

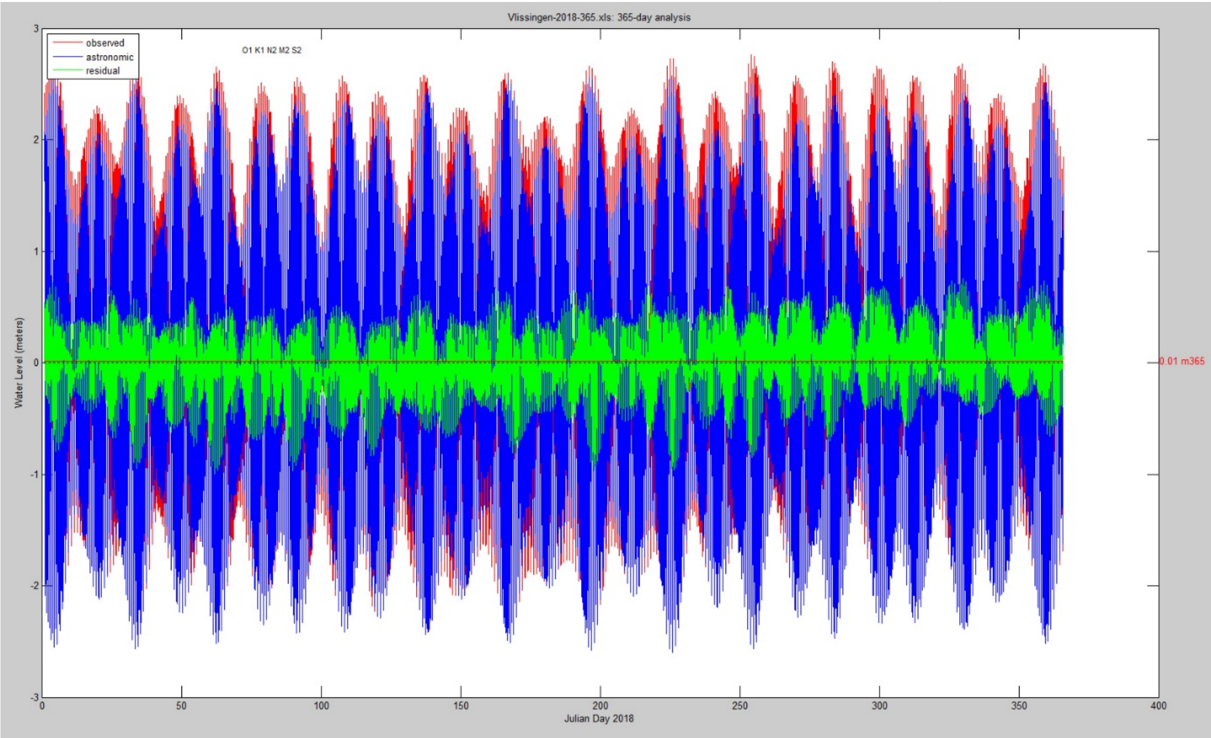
According the Xtide database the 2MN2 constituent (with a period of 12.2 days) is relevant with an amplitude of 14 cm. This constituent is missing in World Tide.

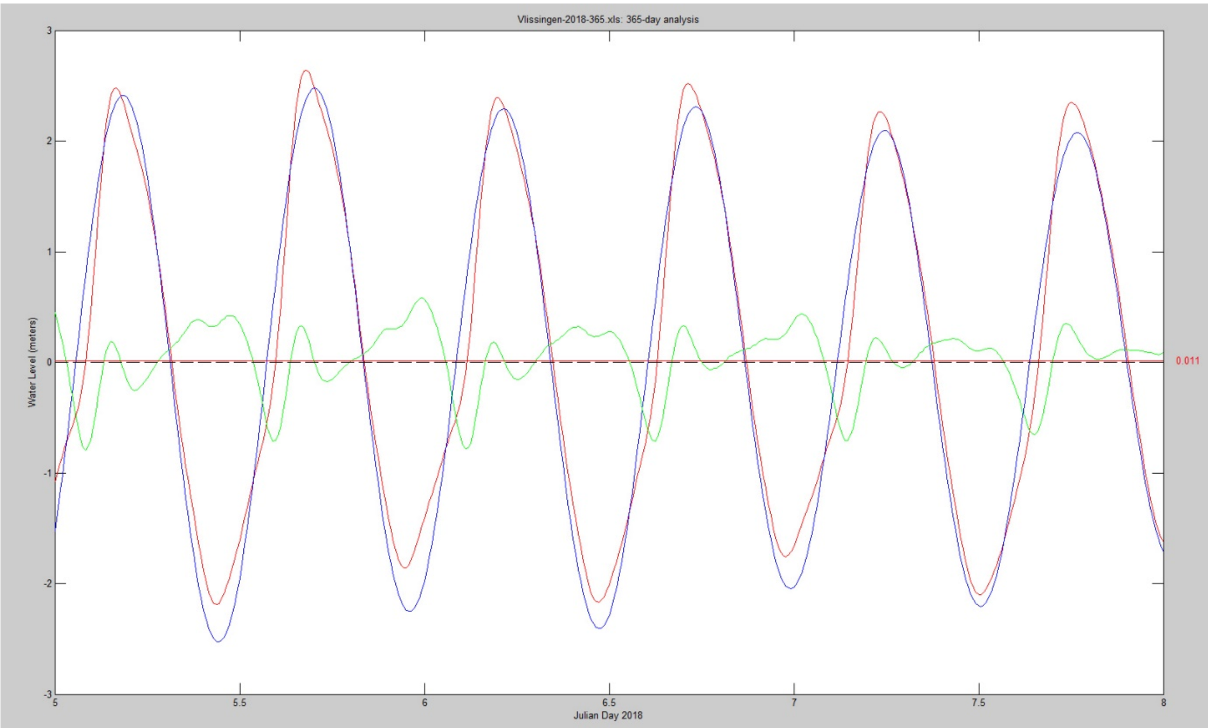
	Xtide		World Tide (4)		World Tide (37)	
	Amp	Phase	Amp	Phase	Amp	Phase
SA	0,07	216			0,00	0
SSA					0,00	0
Q1	0,04	143			0,03	358
RHO1					0,00	72
O1	0,11	198	0,10	154	0,10	145
M1	0,01	167,6			0,02	23
P1	0,03	1			0,03	3
S1	0,01	339			0,01	163
K1	0,07	12	0,07	3	0,07	3
J1					0,00	172
OO1					0,00	118
MNS2	0,03	140			0,03	311
2N2	0,04	347,7			0,04	166
MU2	0,13	165			0,13	51
N2	0,29	33	0,26	256	0,28	256
NU2	0,10	28			0,09	358
M2	1,75	60	1,73	5	1,73	4
LAM2	0,05	76,4			0,06	173
L2					0,11	12
T2	0,03	106			0,03	101
S2	0,48	117	0,46	118	0,47	118
R2					0,00	1
K2	0,14	118			0,14	280
2SM2	0,04	346			0,04	45
2MK3	0,03	166			0,03	46
M3					0,00	283
MK3	0,02	310			0,02	252
MN4	0,04	95			0,04	260
M4	0,13	120			0,13	7
MS4	0,09	180			0,09	123
S4	0,01	279,9			0,01	281
2MN6	0,04	82			0,05	190
M6	0,09	108			0,09	299
2MS6	0,09	160			0,09	46
S6					0,00	9
M8	0,03	113			0,03	249
3MS8	0,05	164			0,05	354

Tidal constituents for Vlissingen[i]

	Amp	Phase
Z0	0.320	
Sa	0,060	163
Ssa	0,028	313
Mm	0,059	12
Mf	0,033	99
Msf	0,090	44
K1	0,061	29
O1	0,091	223
P1	0,046	22
Q1	0,036	158
J1	0,008	199
M1	0,005	139
OO1	0,010	172
Rho1	0,010	113
Sigma1	0,008	356
Mu1	0,004	20
2Q1	0,010	88
Phi1	0,006	118
Chi1	0,005	198
Theta1	0,014	254
S01	0,014	250
MP1	0,006	306
S1	0,009	26
Phi1	0,008	48
M2	1,963	87
S2	0,477	150
N2	0,300	60
K2	0,156	153
V2	0,142	53

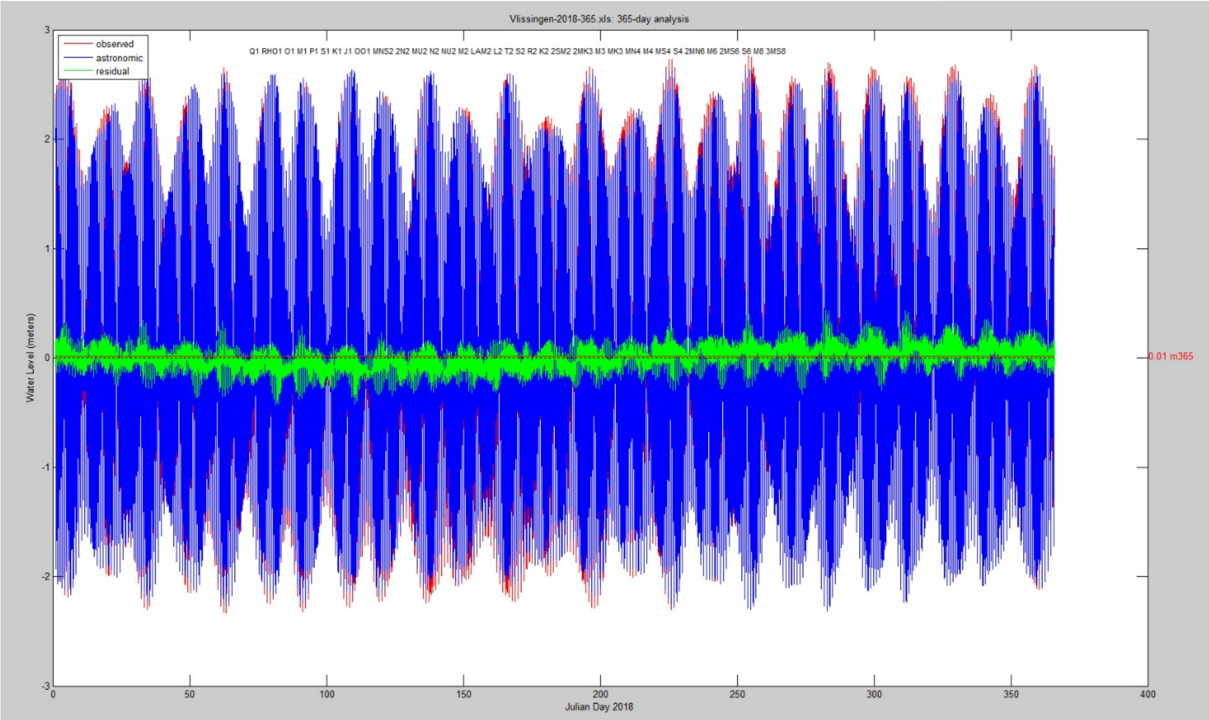
Tidal constituents for Antwerpen[ii]

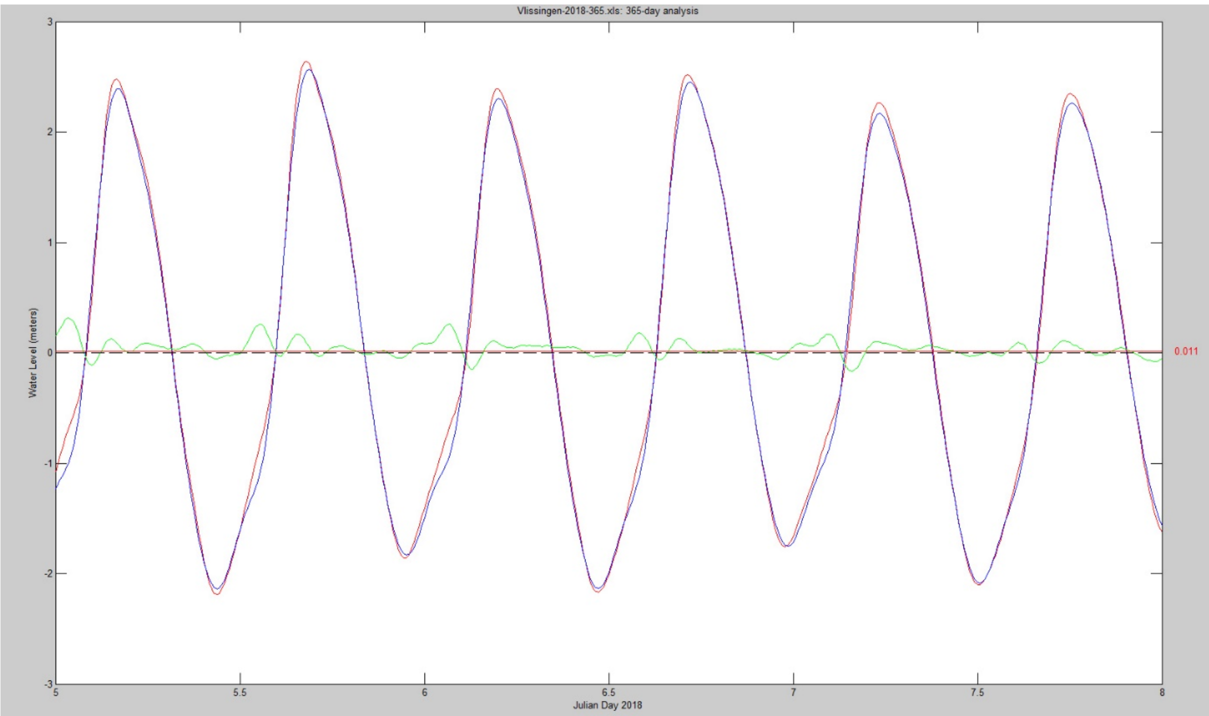




World Tide analysis of the tide in Vlissingen, using all data for 2018 and using 4 constituents. The top figure shows the full year, the lower figure January 5 – 8.

The RMS error is 0.265 m, the %R Variance is 96.09





World Tide analysis of the tide in Vlissingen, using all data for 2018 and using 37 constituents. The top figure shows the full year, the lower figure January 5 – 8.

The RMS error is 0.1.03m, the %R Variance is 99.41

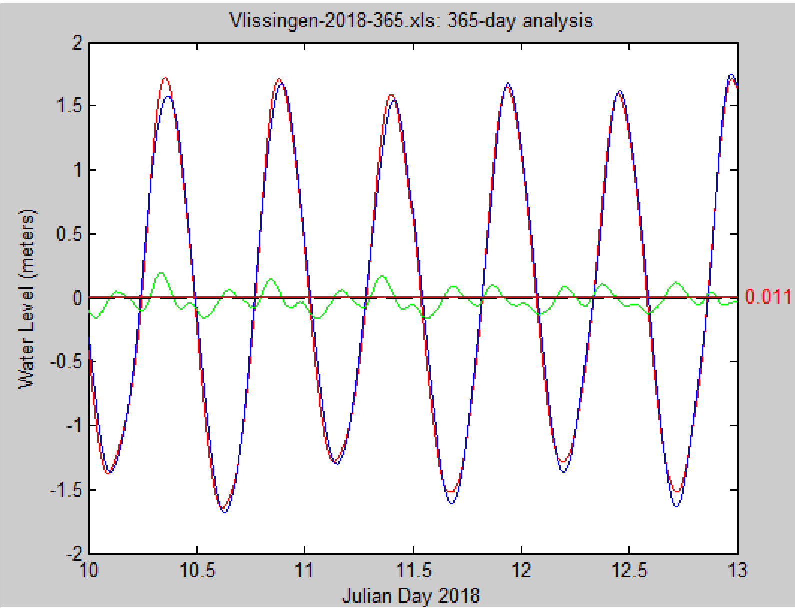
Determination of the tide using LatiPaS

With LatiPaS two calculations were made, one with the Xtide constituents (using the constituents from Xtide, the four main constituents, plus an automatic inclusion of N2, K2 and P1). The result is plotted on the next page (left or upper figure).

Then a calculation has been made using the constituents from World Tide (using the values from the analysis with 6 constituents). This resulted in the right (or upper) figure.

In the first case (comparison of LatiPaS, using Xtide constituents) the difference with the official Rijkswaterstaat predictions is small and can be explained by missing constituents. It shows that LatiPaS should not be used for real predictions or consultancy, but indeed for understanding the tidal system.

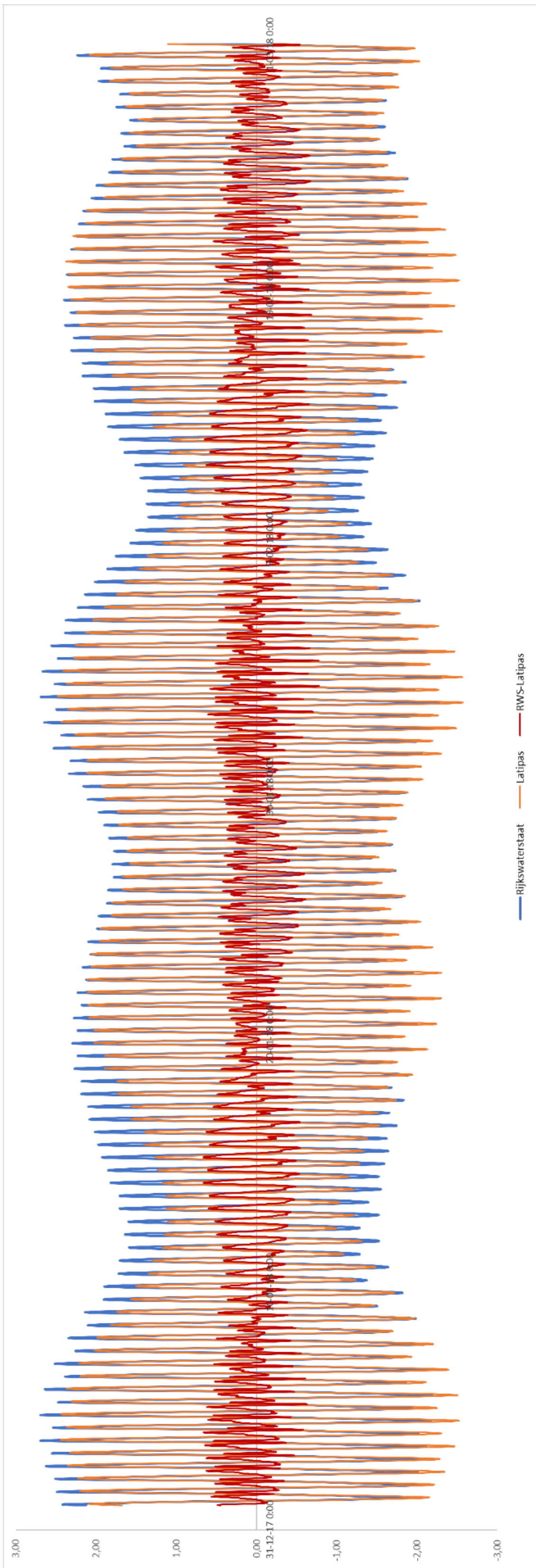
Strange is that the computation with the World Tide constituents gives a large difference. As can be seen on the graph of page 7 (which is an enlargement of the graph of page 6), the absolute value of the prediction is not very wrong, but the dates of neap and spring tide are completely wrong.



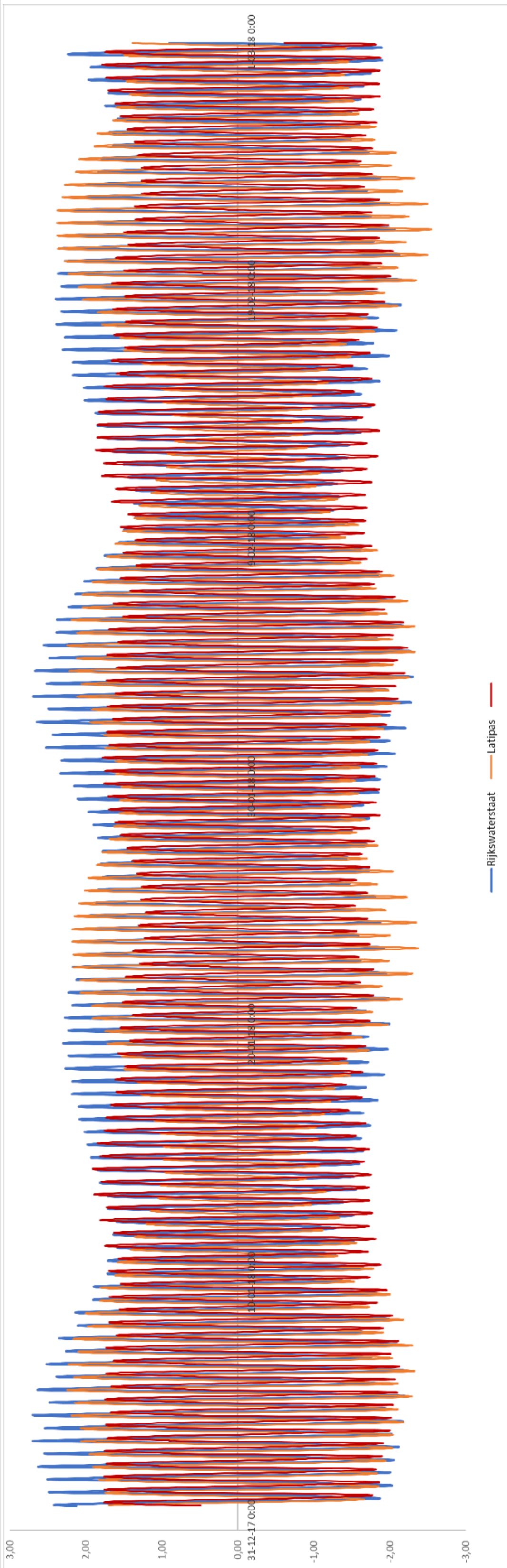
In the original dataset of Rijkswaterstaat, the first neap tide in January 2018 is in the afternoon of the 11th. When looking to the output of World Tide page 4), it shows that the first neap tide is indeed at the right date (see also the enlargement of the figure of page 4, left).

However, when computing this with LatiPaS, it gives complete different results.

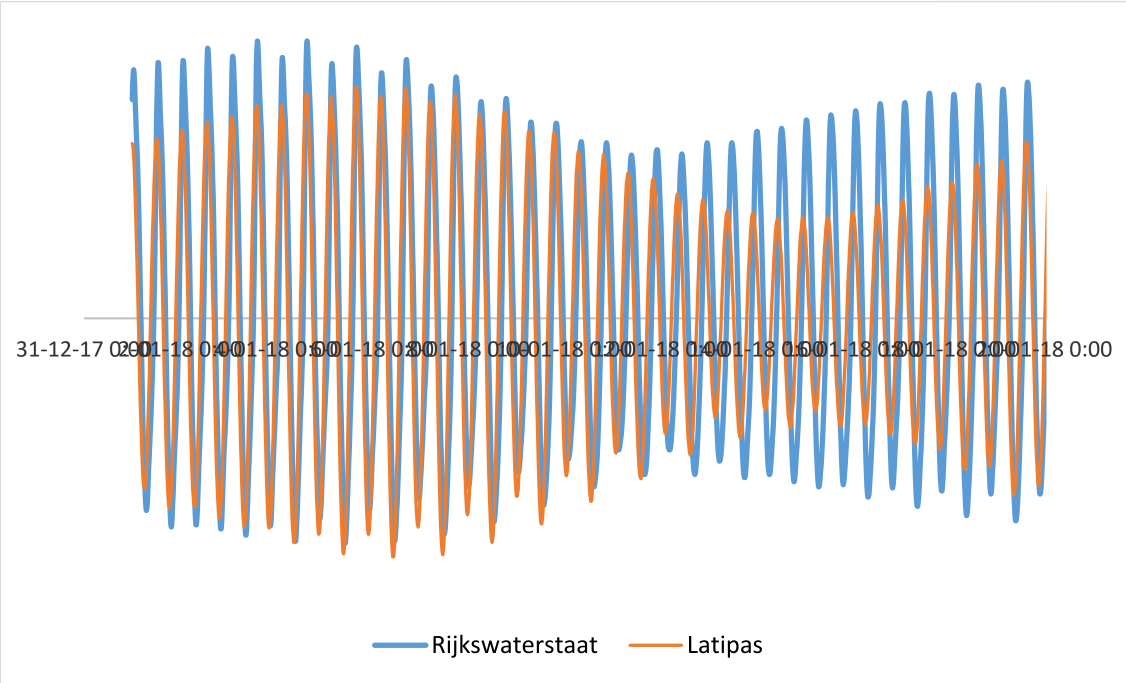
This needs further investigation.



3,00
2,00
1,00
0,00
-1,00
-2,00
-3,00
31-12-17 0:00
Rijkswaterstaat
Latipas
RWS-Latipas



3,00
2,00
1,00
0,00
-1,00
-2,00
-3,00
31-12-17 0:00
Rijkswaterstaat
Latipas



Tidal wave in the Westerschelde

Using information from Navionics a schematization of the Westerschelde has been made. The tidal constituents are from the above tables. Note that in Belgium refence datum is TAW, which is 2.33 m below NAP (approx.. MSL at sea). All computations are carried using NAP as reference.

This has resulted in the following information:

node name	node nr	branch nr	Bottom	Bottom NAP	Width	Length	Level of storage	Storage Width
Vlissingen	1							
Terneuzen	2	1	-30	-33	1130	21590	-10,0	2270
Hansweert	3	2	-30	-33	1130	17200	-6,7	2350
Walsoorden	4	3	-10	-13	850	6280	-7,9	1000
Baalhoek	5	4	-20	-23	850	2420	-2,9	2000
Bath	6	5	-15	-18	500	9280	-8,1	1000
Prosperpolder	7	6	-18	-19	730	5400		
Liefkenshoek	8	7	-15	-16	670	7800		
Kallosluis	9	8	-12	-13	560	6040		
Antwerpen	10	9	-10	-11	530	9480		
Hemiksem	11	10	-8	-9	420	11250		
Wintam	12	11	-10	-11	325	2680		
Temse	13	12	-7	-7	350	6900		
Tielrode	14	13	-6	-7	220	3700		
St Amands	15	14	-4	-7	120	6560		
Dendermonde	16	15	-4	-7	120	11220		
Schoonaarde	17	16		-6	75	10720		
Bergenmeersen	18	17	-2,5	-5	70	8690		
Wetteren	19	18		-4	70	3470		
Melle (splitsing)	20	19	-1,5	-4	60	7100		
Gent (Vlaamse Kaai)	21	20		-1	30	7740		

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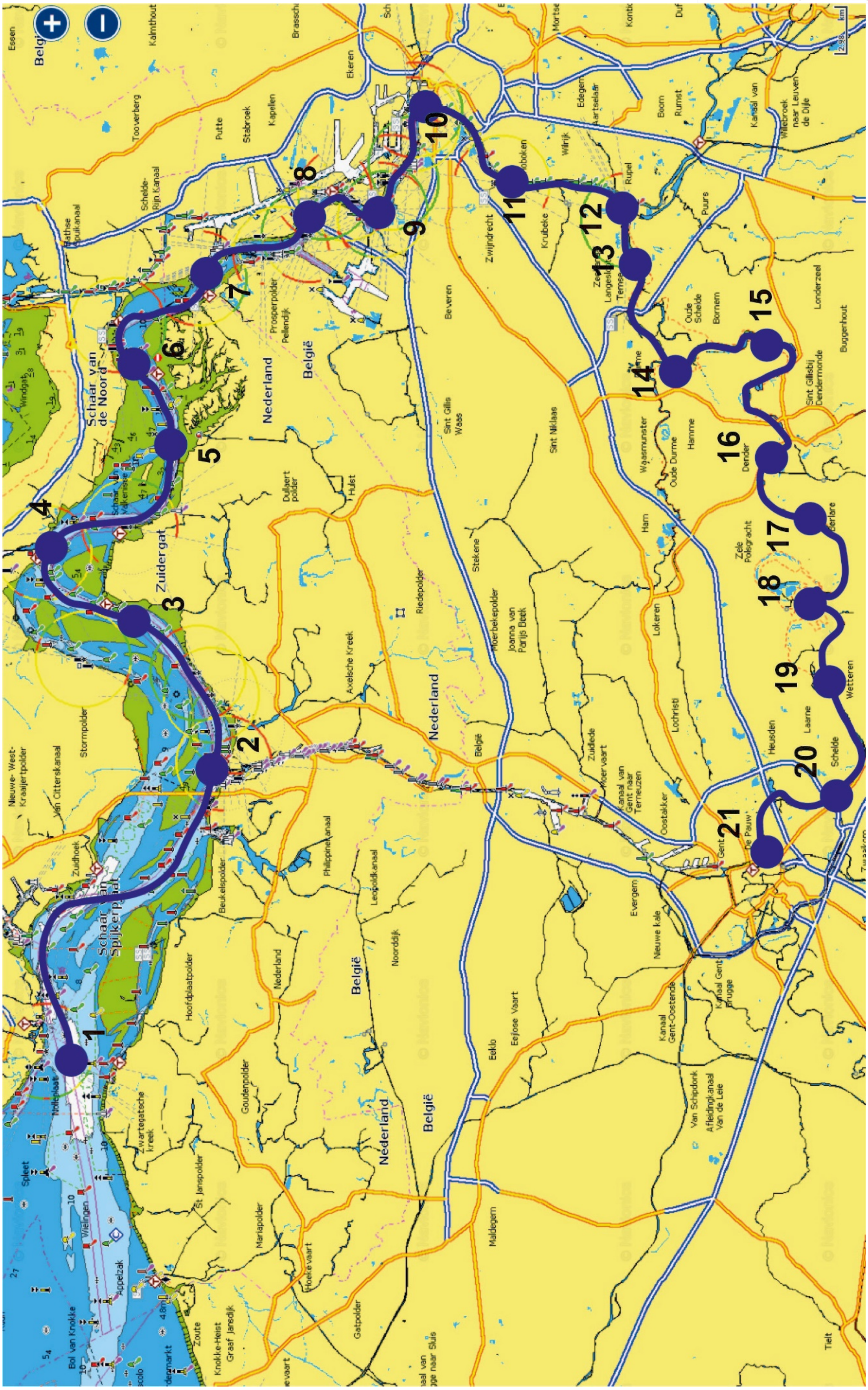
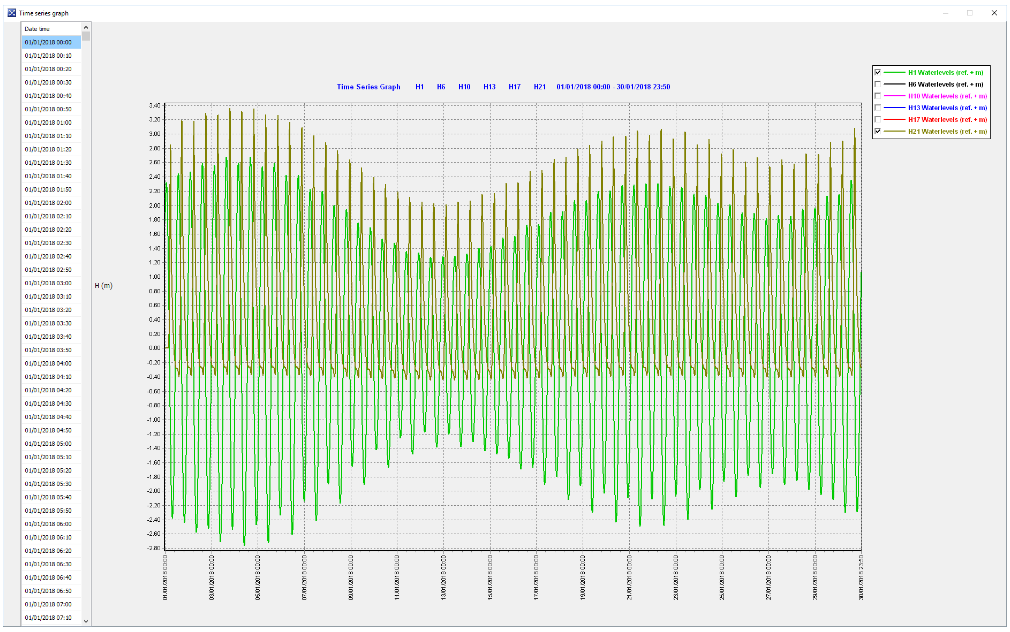
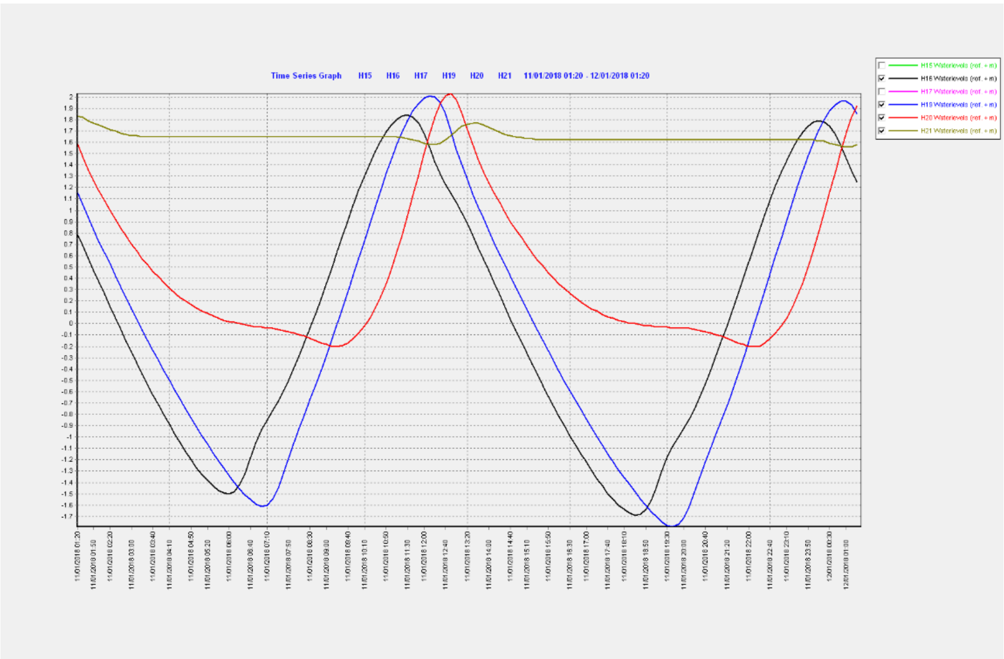


A computation has been made using the full model with a closed end. This has resulted in a qualitative quite acceptable result, although quantitatively it is not precise. The main problem is that the phase of the tide is not correct, and also the amplification factor is not correct. The phase problem is due to the fact that the waterdepth (=celerity of the wave) is not correct, because the depth of the Westerschelde is far from uniform; there are deep and shallow sections. Also the storage area cannot be entered in Latipas in the correct way (for the Westerschelde it is a rather complex function of the waterlevel). To improve the performance some resistance and depth data are adapted (model Schelde3).





However, some special peculiarities of the estuary/river system are surprisingly correctly modelled. For example when looking to the waterlevel in Gent (node 21) one see high water, but low waters do not occur any more. The second picture (during neap with slightly different settings) shows this even better.

Also a calculation has been made using only the sections towards Anwerpen, and introducing two boundaries (both in Antwerpen as well in Vlissingen). This gives good results.

A last calculation type was made using the boundary at Antwerpen and calculate the remaining part to Gent. Tis is the model Zeeschelde. Here the phase-lag is modelled quite will, but the change in amplitude is wrong. The amplitude decreases along the river, while in reality the amplitude is still increasing (until node 13, or 4 in the Zeeschelde model) .

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[i] Vanlede, J.; De Mulder, T.; Mostaert F. (2008). Harmonische voorspelling van waterstanden te Vlissingen, ter aanvulling van de OMES databank. WL Rapporten, 713/22. Waterbouwkundig Laboratorium, Borgerhout, België

[ii] Claesens, J. (1979), Het getij in de Schelde, Ministerie van Openbare Werken, Antwerpse Zeediensten,