

IHO TWLWG

Task H1

Compare predictions from a common set of tidal observations

UKHO Report

Introduction

UKHO received a set of hourly tidal observations for the US port of Boston, covering the period 01 Jan 2010 – 31 December 2010. We additionally requested an additional month's data (01 – 31 Jan 2011) due to the fact that our analysis procedures require 378 days for a full "year" analysis. The dataset received also contained the NOAA predictions and subsequent residuals for the whole period of observation.

Method

1. The raw data is first investigated for any spikes or data drop outs or anything else which may make its analysis difficult or even impossible. No major problems existed with this dataset.
2. We then convert the observed hourly heights into file structures which simply lists the hourly data in differing ways in readiness for the analysis procedure: an example is shown below. The data is rounded to 2 decimal places:-

```
001 10 1          0200      0281 0364 0421 0431 0401 0343 0272 0194 0133 0121 0169
ddd yy 1=am, 2=pm 0000hrs 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100
etc.
001102          0240 0325 0412 0481 0499 0470 0409 0329 0232 0145 0093 0101
002101          0158 0226 0315 0400 0457 0465 0427 0371 0289 0205 0143 0135
002102          0193 0264 0356 0444 0505 0519 0484 0424 0334 0235 0148 0096
003101          0105 0163 0240 0328 0414 0459 0458 0417 0358 0270 0191 0133
003102          0125 0182 0253 0349 0436 0491 0506 0468 0405 0314 0220 0140
004101          0095 0120 0184 0259 0348 0430 0472 0463 0418 0343 0258 0179
004102          0115 0112 0169 0243 0330 0414 0472 0480 0442 0375 0294 0206
005101          0130 0093 0126 0189 0265 0351 0427 0464 0449 0399 0333 0247
005102          0166 0112 0118 0172 0240 0319 0398 0449 0450 0412 0351 0276
006101          0193 0123 0098 0134 0191 0265 0351 0419 0449 0431 0385 0324
006102          0241 0167 0115 0130 0173 0237 0313 0388 0431 0429 0394 0339
007101          0270 0194 0133 0113 0149 0201 0275 0353 0412 0439 0422 0382
007102          0318 0238 0170 0127 0129 0168 0222 0293 0356 0398 0402 0372
008101          0323 0257 0193 0139 0127 0162 0214 0281 0354 0407 0434 0419
008102          0375 0316 0246 0185 0142 0140 0179 0227 0292 0350 0397 0398
009101          0374 0328 0269 0210 0158 0142 0175 0221 0281 0349 0401 0425
009102          0408 0369 0309 0247 0181 0133 0136 0166 0205 0265 0325 0371
010101          0379 0359 0318 0266 0206 0158 0148 0180 0222 0280 0344 0396
010102          0415 0399 0362 0306 0237 0174 0129 0130 0161 0200 0260 0320
011101          0360 0370 0355 0318 0264 0205 0161 0150 0181 0224 0286 0349
011102          0396 0416 0402 0364 0299 0230 0171 0129 0127 0155 0203 0267
```

3. The data is then loaded into our analysis software, which performs the analysis using a grouping method of 30-day periods as a number of different series. So Series "1a" uses the first 30 days of data, Series "2a" looks at the latter 15 days used in Series "1a" and the next 15 days, Series "3a" uses the last 15 days of Series "2a" and the next 15 days, and so on.
4. So the Series used are 1a, 2a and 3a; then 1b, 2b and 3b, and so on up to 1h, 2h and 3h.
5. The data is therefore analysed in 30 day chunks over a total period of 378 days.
6. A checklist is maintained following the result of each 30 day 'mini-analysis' which monitors the consistency of the four major constituents, M2, S2, K1 and O1), as well

as the Mean Level (Ao), to ensure that there are no major discrepancies in phase angle or amplitude as the analysis progresses.

7. The overall results are then provided as a vector mean of each constituent identified in the analysis.
 - In this case a total of 140 constituents were identified in the analysis, but of that total some constituents are deemed as “suspect” due to inconsistencies in their results between the Series during analysis. Some had amplitudes of zero to 3 decimal places.
8. Therefore 86 constituents were used in the prediction of tides at Boston.

Other meta-data

We also computed mean tidal levels for the port, as follows:-

Mean Higher High Water (MHHW):	4.327m 1534 UT
Mean Lower High Water (MLHW):	4.075m 0342 UT
Mean Higher Low Water (MHLW):	1.529m 0932 UT
Mean Lower Low Water (MLLW):	1.328m 2143 UT
Mean High Water Springs (MHWS):	4.423m 0342 UT [1607 UT]
Mean High Water Neaps (MHWN):	3.962m 0344 UT
Mean Low Water Neaps (MLWN):	1.591m 0957 UT
Mean Low Water Springs (MLWS):	1.185m 0955 UT [2220 UT]

Mean Sea Level: 2.814m

Chart Datum

Comment: the raw tidal observations appear to be related to an arbitrary zero (i.e. a datum which is not Chart Datum). In the US we understand Chart Datum to be ‘the level of Mean Lower Low Water, MLLW’. Therefore ‘Mean [Sea] Level’ was computed as 2.814m (NOAA = 2.815m, SANHO = 2.815m).

So in order to adjust the zero of the predictions to a CD of MLLW (i.e. MLLW = 0.000m), 1.328m would need to be removed from the MSL value [1.328m is our computed level for MLLW].

Results

The tidal predictions were generated using the above mentioned set of harmonic constituents, and the results of those predictions compared against the observed data supplied by NOAA.

The results are contained in an Excel spreadsheet, but are summarised below:-

O-C statistic	NOAA	UKHO
Average Difference	0.000	0.005
Standard Dev	0.129	0.134
Max difference	1.679	1.739
Min difference	-0.746	-0.723

The results are very close and give confidence to the procedures used in the analysis of the raw data.

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Boston 2010

Time Zone:- UTC Units:- Metres

Mean of 1 yearly values between Principal Central Date of 10 July 2010

Ao		2.814
Sa	334.2	0.033
Ssa	344.0	0.024
Msf	56.6	0.022
Q1	169.6	0.018
O1	185.5	0.113
MS1	307.4	0.007
M1	186.1	0.006
pi1	192.1	0.004
P1	199.4	0.044
K1	204.4	0.140
J1	216.0	0.008
2N2	65.7	0.034
mu2	99.5	0.010
SNK2	83.5	0.006
NA2	311.6	0.009
N2	76.1	0.328
nu2	89.9	0.068
OP2	142.1	0.009
MA2	71.1	0.015
M2	109.2	1.385
MB2	59.3	0.007
lam2	59.0	0.004
L2	153.5	0.082
T2	130.2	0.020
S2	146.5	0.209
R2	30.4	0.005
K2	148.4	0.059
MQ3	145.4	0.002
MO3	197.3	0.006

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2MS3	233.1	0.002
2MP3	182.4	0.002
M3	136.7	0.004
MP3	253.4	0.002
MK3	229.8	0.005
3MK4	44.3	0.003
3MS4	65.6	0.004
MN4	9.3	0.013
Mnu4	9.0	0.002
MA4	263.9	0.001
M4	27.5	0.023
3MN4	160.6	0.004
MS4	63.3	0.009
MK4	62.4	0.002
3MK5	63.6	0.001
M5	302.5	0.001
3MO5	112.0	0.002
4MK6	274.3	0.003
M2N6	239.2	0.001
4MS6	29.2	0.003
2MN6	240.3	0.019
2Mnu6	258.1	0.007
3MSK6	93.5	0.002
MA6	193.6	0.001
M6	281.2	0.031
3MKS6	56.7	0.001
MSN6	286.6	0.003
4MN6	138.0	0.008
MNK6	193.2	0.001
2(MS)K6	123.5	0.001
2MT6	330.2	0.001
2MS6	330.9	0.011
2MK6	336.8	0.004

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M7	204.5	0.001
2(MN)8	186.7	0.002
3MN8	208.5	0.006
3Mnu8	204.6	0.002
M8	245.6	0.006
2MSN8	130.5	0.003
2MNK8	268.8	0.002
3MS8	294.9	0.004
3MNK9	108.5	0.001
3M2N10	337.1	0.002
4MN10	145.1	0.003
M10	192.6	0.003
3MSN10	117.0	0.001
4MK10	220.3	0.001
6MSK12	205.6	0.000
M12	116.5	0.001
4MSN12	294.7	0.001
5MS12	143.2	0.001
6MS14	83.6	0.000
MSnu2	306.1	0.012
2SM2	3.1	0.011
SP3	24.7	0.001
S3	180.3	0.002
SK4	112.6	0.001

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2SM6	102.4	0.001
MSK6	2.9	0.002