Compare predictions from a common set of tidal observations

1. Attached is the comparison from the UK. See also documents TWLWG4/4/9A-Add1 and Add2
2. TWLWG4 is invited to note the information provided and take any action it considers appropriate.

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.