

EVALUATION OF THE HARMONIC METHOD FOR PREDICTING BELGIAN COASTAL TIDES

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ABSTRACT

This written contribution should be considered as an extended abstract of a paper that will be published elsewhere. Preliminary results are presented of an evaluation of a particular model approach to predict the ocean tides at the Belgian Coast.

1 THE HARMONIC COMPUTATION OF THE TIDES

The purpose of this research is to predict the "tidal curves" at a given location where measurements are available, i.e. : to predict the evolution of the local level of the sea surface as a function of time.

As the tides are caused by the relative motion of the moon and the sun with respect to the earth, it can be assumed that the periodicities of this motion can be found back in the tidal effects on earth. Moreover the ocean tides are affected by the shape of the seas in which they occur. Due to shallow water effects "compound" tides are generated which have frequencies composed of "astronomical" frequencies. Therefore the "harmonic" method of tidal modeling considers the tidal variation of the local waterlevel as a superposition of components ("tidal constituents" or "tidal waves") having frequencies generating from the lunar and solar motion relative to the earth, as well as frequencies which are linear combinations of these astronomical frequencies. The latter components are called "shallow water tides".

The amplitudes and phase angles of these components remain to be determined by analysis of observations of the local waterlevel variation during a certain period. Mostly it takes one year of observations to determine these so-called "harmonic constants".

An analysis of such a period cannot resolve the effects of the "nodal cycle" in the moons orbit, which has a period of about 18.6 years. This phenomenon causes a modulation on the harmonic constants which are analysed from different years of observations. Different methods exist to account for this so called "nodal modulation" by the application of "nodal corrections" on the analysed harmonic constants.

Finally we remark that different harmonic models of the local tides can be set up : these formulations are determined by the set of frequencies of the components which are assumed to build up the tidal variation.

2 FORMULATION OF THE MODELS USED FOR THE EVALUTATION

The models which are used for the presented evaluation can be distinguished as follows

(a) Models implemented at the Hydraulics Laboratory of K.U.Leuven.

KUL1 : model with 60 constituents based upon Melchior et al., 1967;

KUL2 : model with 57 selected constituents;

both models use the formulation of Godin, 1972 for the nodal corrections.

(b) Models implemented at the Coastal Hydrographic Service.

VOR1 : model with 60 constituents based upon Melchior et al., 1967;

VOR2 : model with 57 selected constituents;

both models use the nodal corrections as published in Deutsches Hydrogr. Inst., 1967.

The 57 "selected" constituents emerge from an extended analysis of hourly observed water heights at Ostend during 1983. In this year the phase angle of the nodal cycle has a zero crossing. Although harmonic constants were determined for Nieuwpoort, Zeebrugge and Ostend, the evaluation computations were carried out for Ostend only.

3 EVALUATION COMPUTATIONS

Computations were carried out using the four models, mentioned above, and were compared with observed tidal heights at Ostend.

3.1 Computations of high-water and low-water heights and times

For three different sets of periods the high-water and low-water heights and times were computed and compared with observed data. The mean error and standard deviation are listed in tables 1 to 3.

The results for "IOS-Bidston" refer to the tide tables, produced by the Institute for Oceanographic Sciences (Bidston, U.K.), compared with the observations.

It appears that the tide tables produce the smallest mean difference with the observations but the standard deviations are comparable for all models.

3.2 Computations of tidal curves

For three different tidal types (neap tide, mean tide, spring tide) the tidal curves at Ostend were computed for periods of two days. During each of the periods a more or less constant wind was blowing over the southern North Sea. Three cases were selected for each tidal type :

- periods with a wind strength of 0 - 2 Bft
- periods with a wind strength of 3 - 4 Bft
- periods with a wind strength of 5 - 6 Bft.

For each period the computed 48 hourly heights were compared with hourly recordings at Ostend. The mean error and standard deviation are listed in tables 4 to 6.

Several conclusions can be drawn from these results.

- The mean difference is almost the same for all models.
- The standard deviation of the differences from the models KUL2 and VOR2 are smaller than those from the other models.
- The models KUL2 and VOR2 perform with quasi identical accuracy.
- All tidal types are simulated with almost the same relative accuracy, no matter what wind condition.
- The accuracy of the model computations increases with decreasing wind speed (for all tidal types).

4 CONCLUSIONS

A restricted number of comparisons of model simulations by means of the harmonic method, with observed data indicate the following properties of the harmonic computation method of the tides.

- The definition of a selected set of constituents doesn't affect the mean error (difference between model simulations and observations) but most often it improves (i.e. : diminishes) the variance of this error.
- The method of nodal correction of the harmonic constants doesn't affect the error statistics.
- The tidal type (spring, mean or neap tide) which is simulated has no influence on the error statistics.
- The mean error and its variance increase with increasing meteorological activity (wind speed).

To confirm these conclusions more experiments may be carried out.

From this study it arises that, once an "optimum" set of constituents is chosen, the error statistics of a harmonic tidal model cannot be improved any more. An exception to this conclusion may be the systematical better performance of the method used by IOS-Bidston as far as the mean error is concerned (see tables 1 to 3). This method contains a correction procedure on the heights and times of high waters and low waters. A possible improvement of tidal curve simulations may be accomplished by fitting computed curves to the "corrected" extrema according to the procedure used by IOS-Bidston.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

- Godin, G., 1972. The Analysis of Tides. Liverpool University Press, Liverpool.
- Deutsches Hydrographisches Institut, 1967. Tafeln der Astronomischen Argumente $V_0 + v$ und der Korrekturen j, v zum Gebrauch bei der harmonischen Analyse und Vorausberechnung der Gezeiten für die Jahre 1900 bis 1999. Bericht Nr. 2276, Hamburg.
- Melchior, P., Pâquet, P. and Van Cauwenberghe, C., 1967. Analyse harmonique de vingt années d'enregistrements de marées océaniques à Ostende. Bulletin de l'Académie royale de Belgique (Classe des Sciences), Serie B, No. 20, pp. 123-130.

FIRST QUALITY CONTROL ON TIDAL PREDICTIONS

HW/LW(heights and times) for OSTEND

Periods : from 22/4/75 to 30/4/75

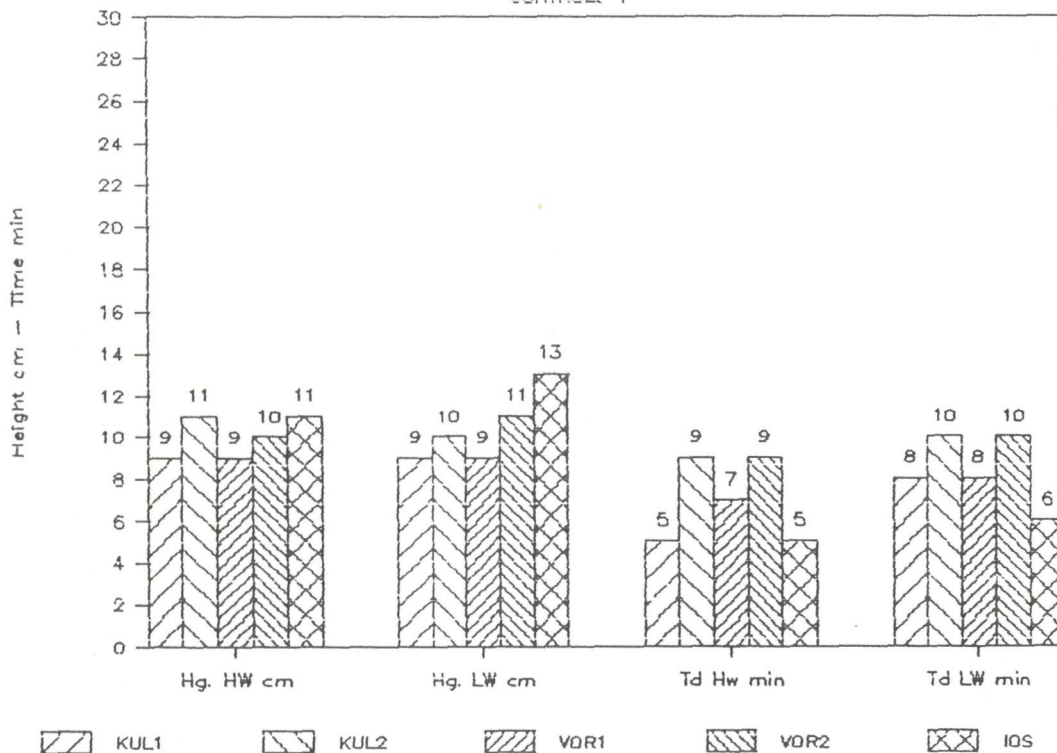
02/5/75 04/5/75

10/6/75 18/6/75

01/7/75 09/7/75

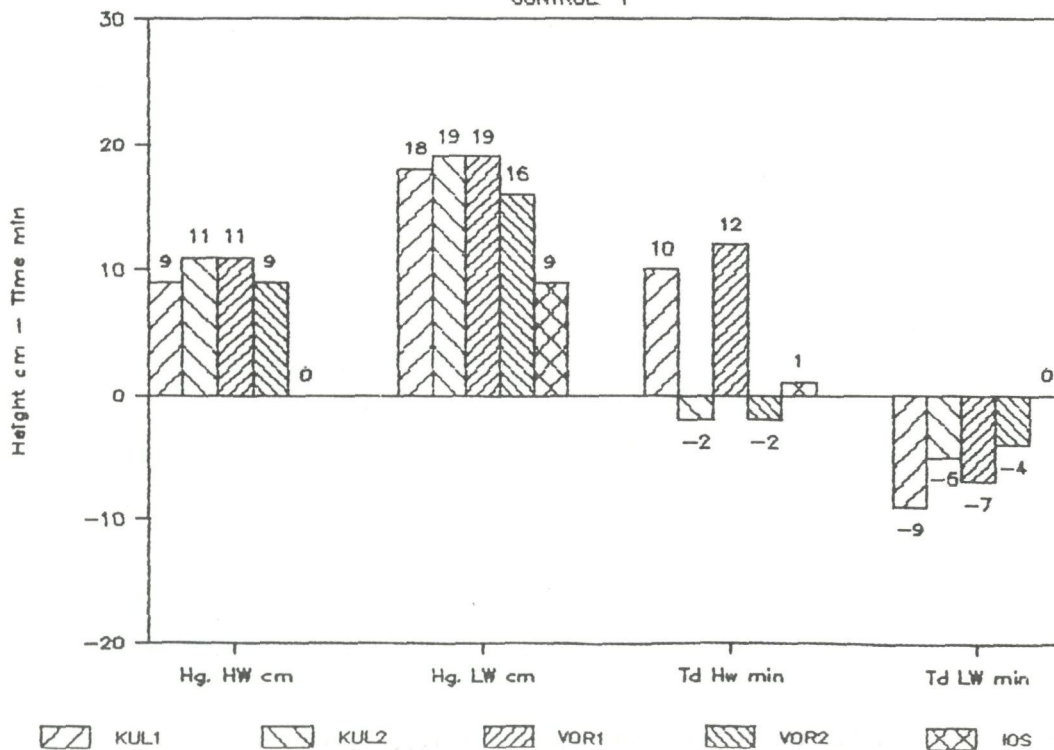
STANDARD DEVIATION

CONTROL 1



MEAN ERROR

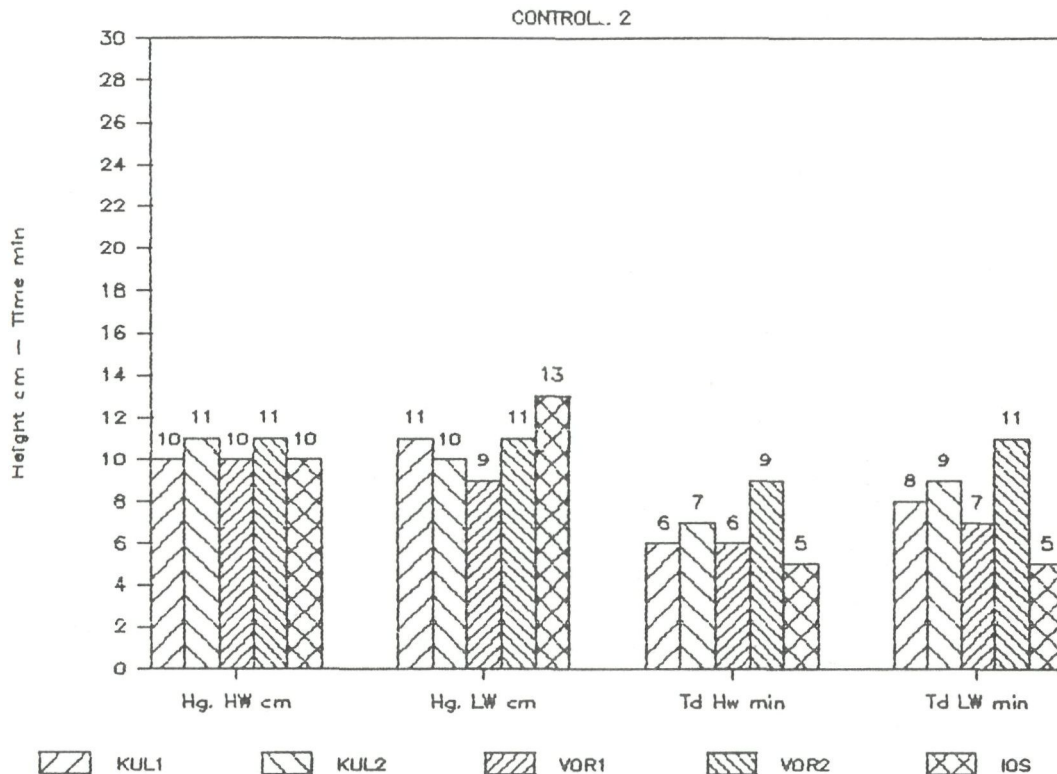
CONTROL 1



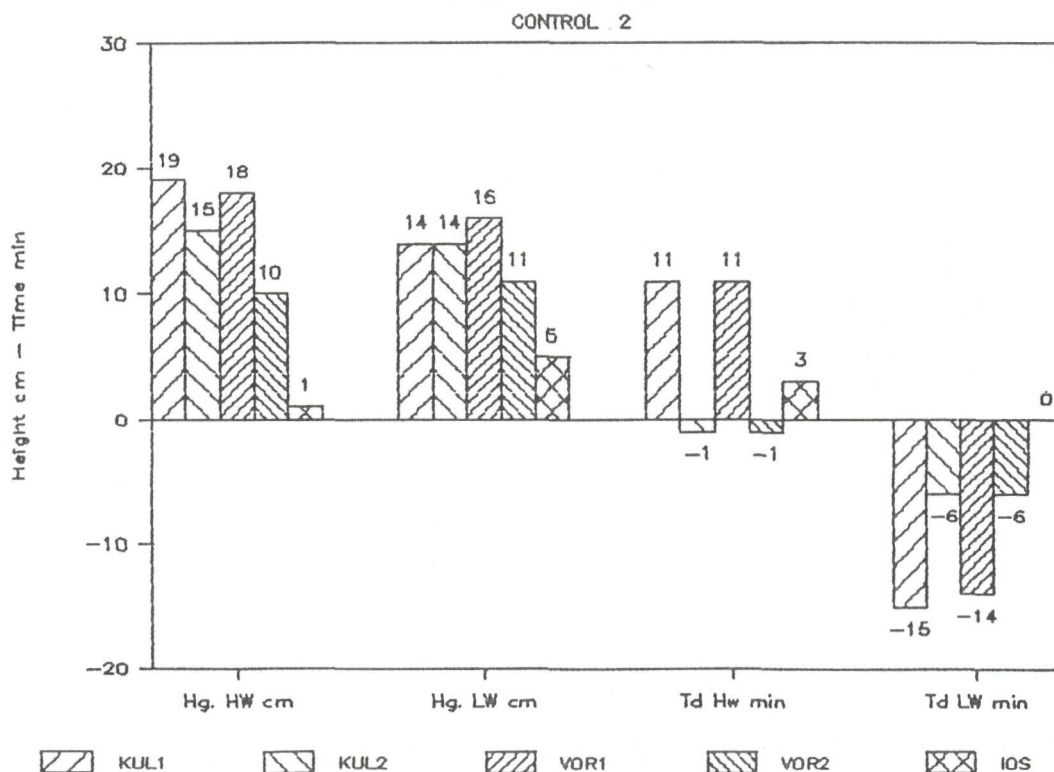
SECOND QUALITY CONTROL ON TIDAL PREDICTIONS

HW/LW(heights and times) for OSTEND
 Periods : from 13/06/75 to 20/06/75
 27/07/75 02/08/75
 06/08/75 14/08/75
 03/09/75 08/09/75

STANDARD DEVIATION



MEAN ERROR

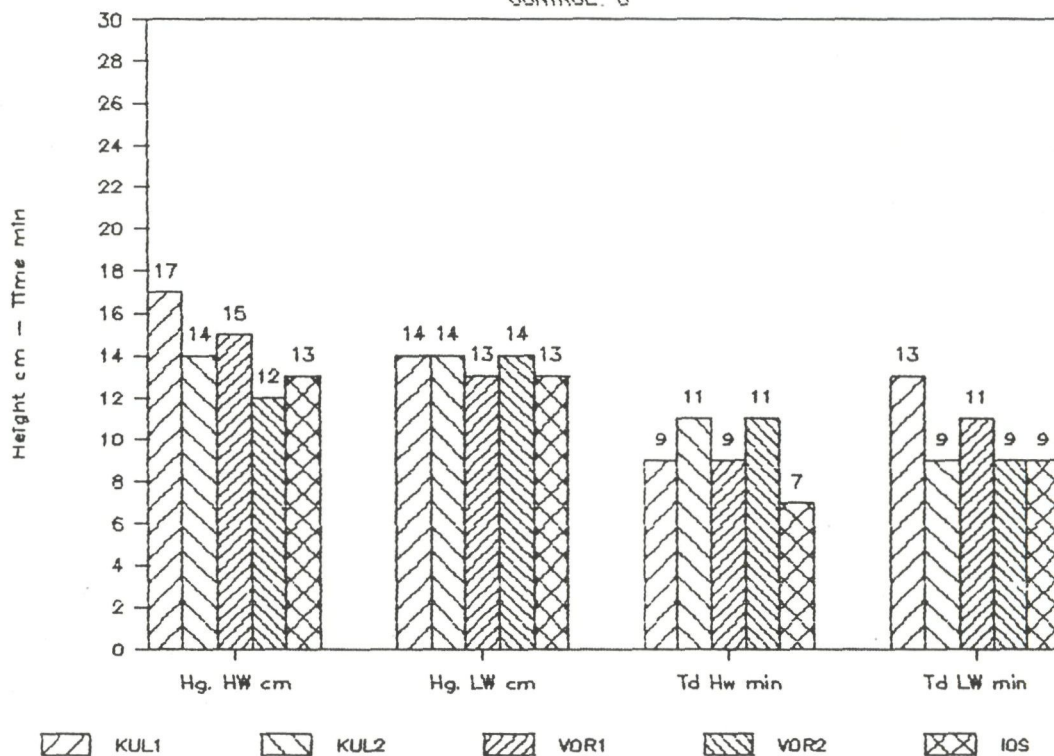


THIRD QUALITY CONTROL ON TIDAL PREDICTIONS

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Period : from 15/09/86 to 15/10/86

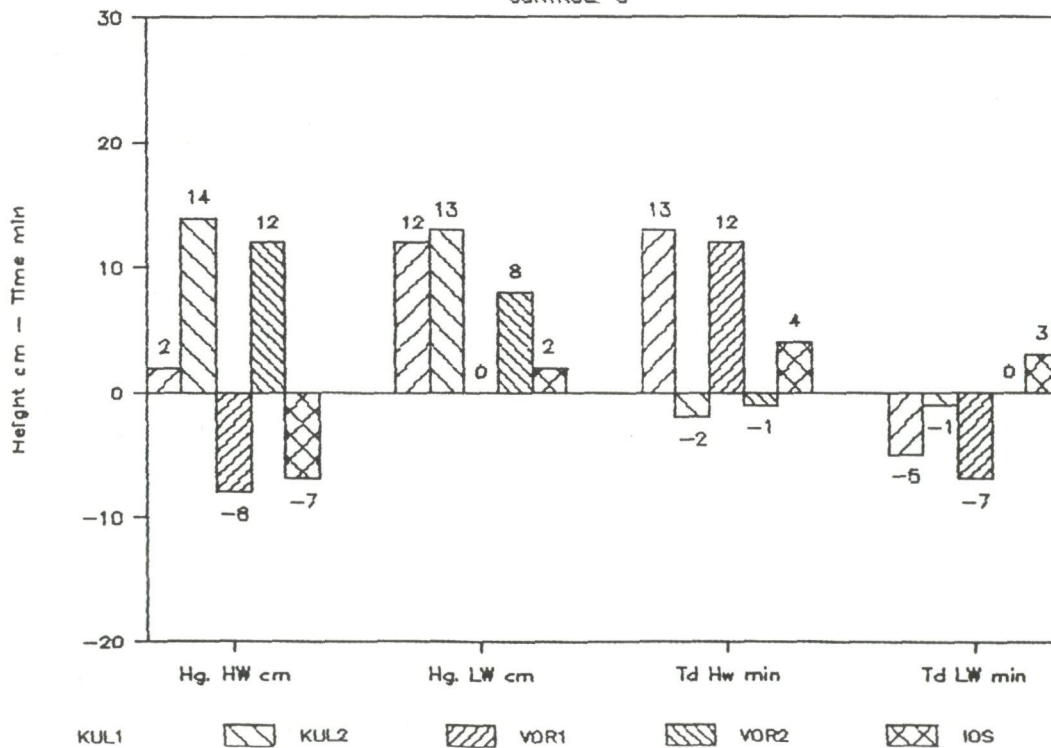
STANDARD DEVIATION

CONTROL 3



MEAN ERROR

CONTROL 3



QUALITY CONTROL ON TIDAL PREDICTIONS

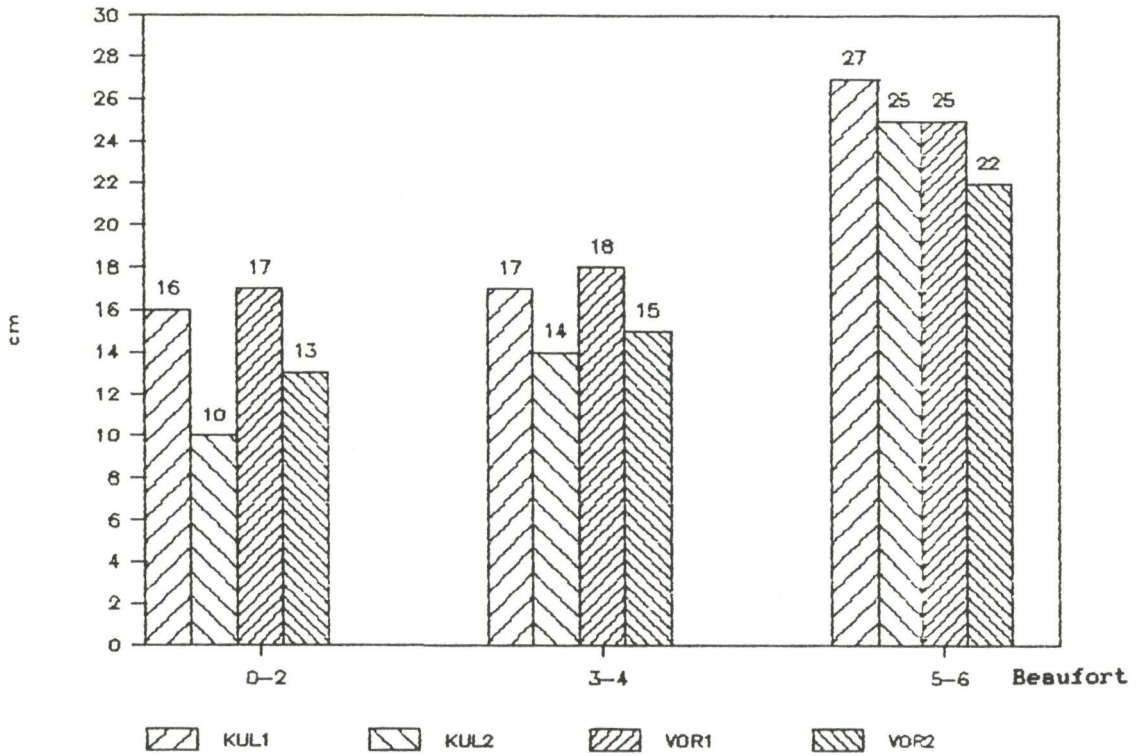
3 types of weather

(hourly heights) for OSTEND

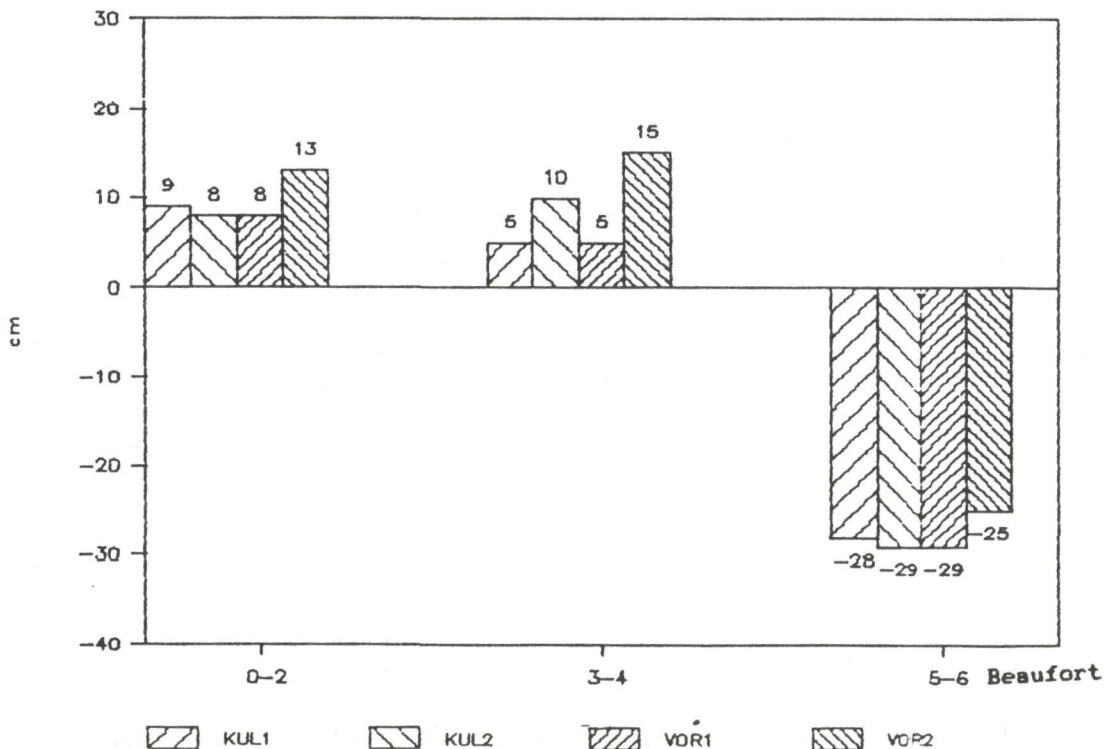
Tidal type : SPRINGTIDE

Periods : 08-09/03/85 windstrength 0-2
01-02/02/87 3-4
21-22/11/87 5-6

STANDARD DEVIATION SPRING TIDE



MEAN ERROR SPRING TIDE



QUALITY CONTROL ON TIDAL PREDICTIONS

3 types of weather

(hourly heights) for OSTEND

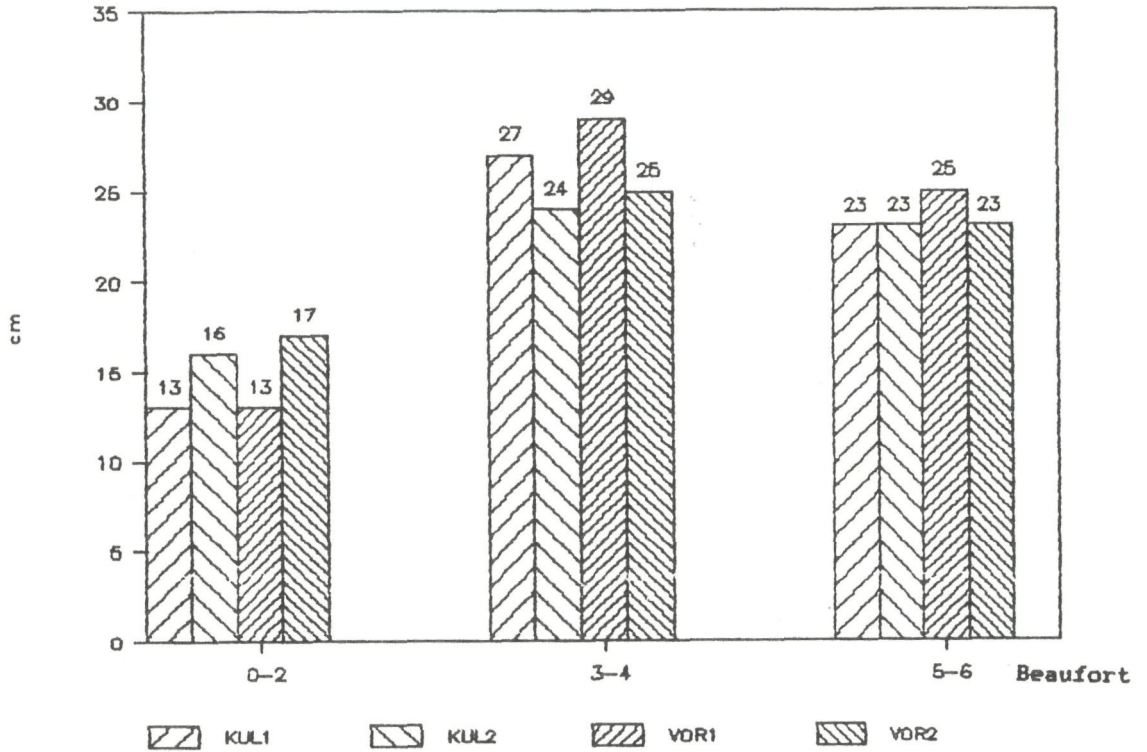
Tidal type : MEAN TIDE

Periods : 11-12/09/85 windstrength 0-2

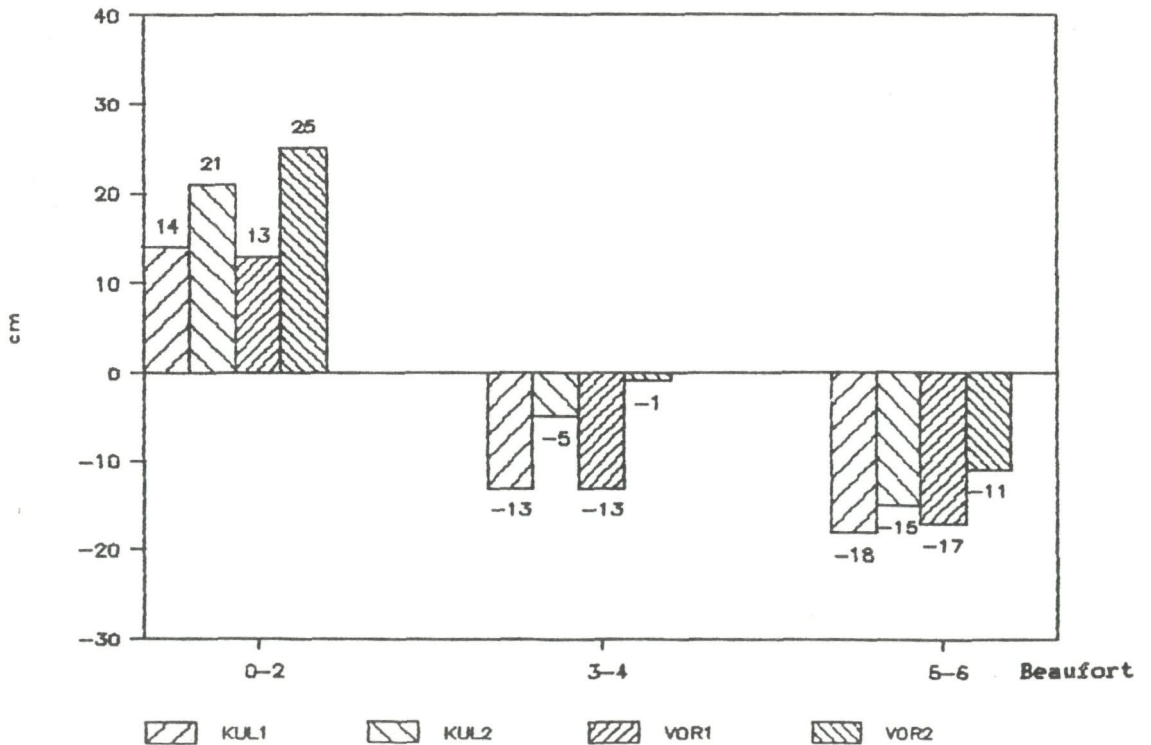
17-18/10/87 3-4

17-18/11/87 5-6

STANDARD DEVIATION MEAN TIDE



MEAN ERROR MEAN TIDE



QUALITY CONTROL ON TIDAL PREDICTIONS

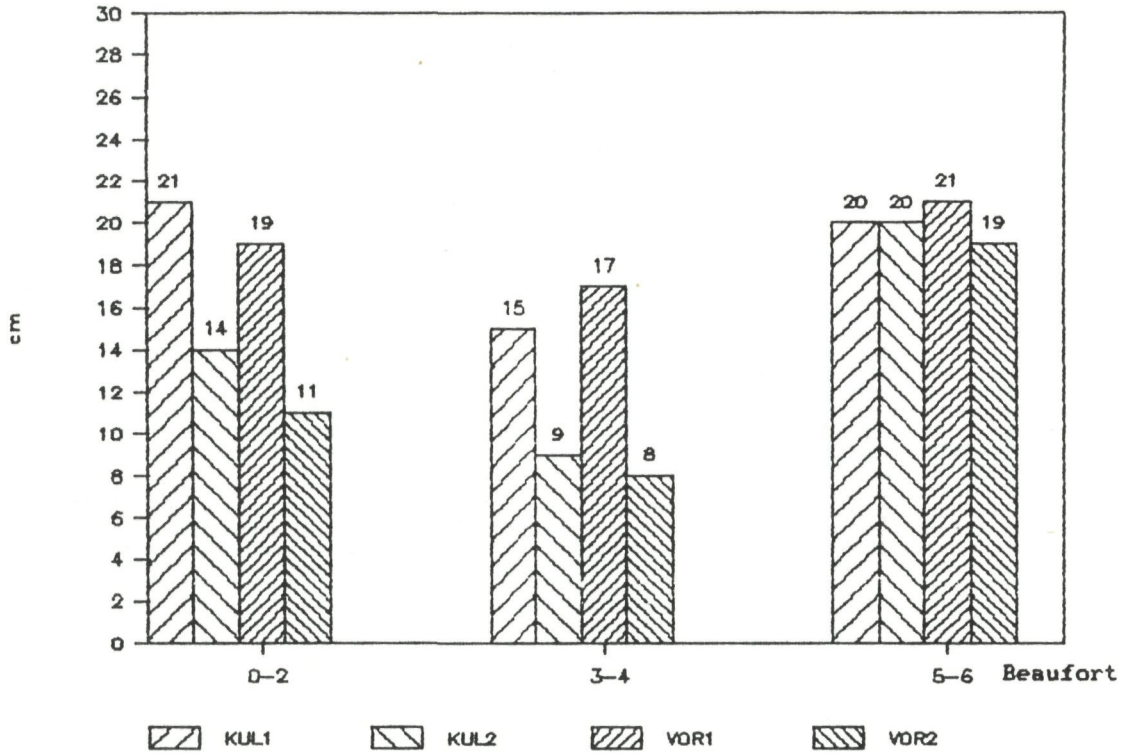
3 types of weather

(hourly heights) for OSTEND

Tidal type : NEAP TIDE

Periods : 02-03/09/87 windstrength 0-2
01-02/10/87 3-4
14-15/11/87 5-6

STANDARD DEVIATION NEAP TIDE



MEAN ERROR NEAP TIDE

