KFKI aktuell

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Editorial

Key fields of research in the coastal zone

Integrated coastal zone management, water framework directive, community models, information systems, metadata, risk and decision support systems – a series of catchphrases characterising current research activities in the coastal zone, which may be extended arbitrarily.

How do the themes of the KFKI projects reported in the following pages fit into such a framework. These are primarily concerned with physical processes and interactions in nature, innovative measurement methods, data analysis and mathematical modelling. As such, these provide the basic essentials for construction planning and maintenance tasks in the fields of coastal protection, maritime engineering and harbour construction. This aspect, which essentially relates to natural science and engineering science, is one of many technical-sectoral aspects of the coastal zone primarily followed by the KFKI. At the same time there is a need to transparently document a knowledge of research activities and research results in coastal engineering in order to guarantee the most efficient allocation of budget funds possible with regard to both researchers and users.

In a functioning integrated coastal zone management system, which may be interpreted as an instrument for solving utilisation conflicts, additional aspects must be included e.g. relating to the fields of ecology, agriculture and tourism. In order to guarantee the necessary communication between all those involved in this process an information infrastructure is required which supports horizontal and vertical information flow and permits the technical integration of data from different disciplines. A contribution to the development of such networks, which are also an important instrument for fulfilling the reporting obligations demanded by the water framework directive, is currently provided by the KFKI research project NOKIS ++ (http://nokis.baw.de).

Sufficient facts and analyses form an essential basis for responsible decisions. A recognised tool for this purpose is mathematical modelling. Flow, wave and transport processes are nowadays coupled in morphodynamic models for investigating bed evolution. The fact that morphodynamic processes are not yet fully understood in detail means that further research is necessary in this field. This not only applies to the further development and validation of models, which may also include biological processes, but also to the acquisition and processing of the necessary basic data. Both aspects will constitute important key fields in future KFKI research.

The balance and synthesis report published by the KFKI to mark its 25th anniversary as well as the KFKI research programme may be ordered through the KFKI office (http://kfki-sekretariat@baw.de) or may be viewed on the homepage of the Project Sponsor Jülich (PTJ) (http://www.fz-juelich.de) under the heading “BMBF Programme: System Erde”.

The current status of research and development projects presently in progress is documented on the homepage of the KFKI (hhtp;//kfki.baw.de) under the heading “KFKI Projekte”. All completed projects including related publications are also archived in this database. In addition, an opportunity for discussion is offered by lectures on the projects presented at the yearly seminar on coastal research.

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WAVESCAN

Automatic recording and modelling of surf zones on the basis of digital image sequences

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1. Introduction

The numerical simulation of waves and currents has made enormous strides in recent decades. It is nowadays possible to compute the evolution of wave spectra over very large areas (Mittendorf & Zielke, 2004) or to simulate the transformation of individual waves over smaller areas along the coast or in harbours by means of computer models (Schröter et al. 1995). In order to calibrate and validate the numerical algorithms data from laboratory tests as well as field data are necessary. Field data in particular are mainly restricted to point measurements using buoys, pressure transducers or wave gauges. In view of the high spatial and temporal resolution of the numerical models, however, point measurements are no longer sufficient.

In the WAVESCAN project measuring techniques with high area coverage are coupled with modelling methods. For this purpose a photogrammetric method has been developed which permits the determination of temporal and spatial high-resolution surface models of the surf zone. These data may be used to drive and validate a numerical model for simulating physical processes in the surf zone. For this purpose an existing Boussinesq model was extended to meet the corresponding requirements.

2. Measurement campaigns

The basic data for the project were collected during two measurement campaigns in August 2002 and May 2003 on the north beach of the island of Norderney. The groin field D1/E1 represents the study area (see Fig. 1).
In cooperation with the Lower Saxony Water Management and Coastal Defence Agency in Norden (NLWK Norden) the beach topography as well as the underwater topography were surveyed and point wave measurements were performed by the "KÜSTE" Research Division using potentiometer gauges, pressure transducers and buoys. Four digital video cameras were used for photogrammetric data recording of the water surface. The recordings were made from the roofs of two high-rise buildings in the direct proximity of the groin field (white circles in Fig. 1). Synchronous triggering of the cameras was realised by means of an external trigger. During the measurement campaigns significant wave heights of up to one metre with a frequency of 8 Hz were recorded over a period of up to 20 minutes.

Fig. 1: Study area (Source:"NLWK Norden")

3. Photogrammetric evaluation

The three-dimensional movement of the water surface was determined using the photogrammetric stereo data with the aid of digital image mapping. A modification of the Vertical Line Locus (VLL) was used for the geometrical limitation of the search area. The image mapping for the first stereo image pair at time step [i] was performed with the aid of manually measured starting points. This results in a large number of newly determined object points. Due to the slight wave movement between consecutive time steps the object points of time step [i] may be used as starting points for the subsequent time step [i + 1]. In order to reduce the computational effort required for image mapping only a certain well-distributed set of object points were used as new starting points.

A coarse grid of new starting points was selected from the object points of the preceding time step. The result of image mapping of the stereo image pair [i + 1] may be used in a similar manner for the stereo image pair [i + 2] and so on (Santel et al.,2004).

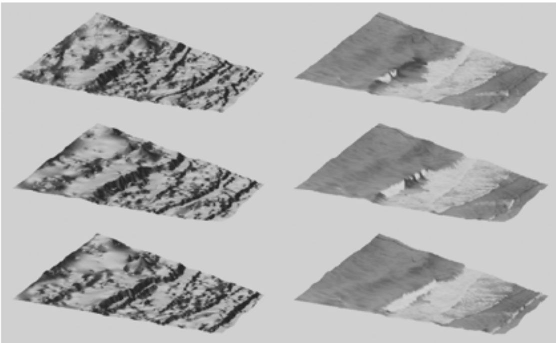

Fig. 2: Sequence of water surface structures with ?t = 1s

The left part of Fig. 2 shows extracts from three generated water surfaces from an image sequence with a time step of 1 second from epoch to epoch. The position of the wave fronts in the surface models may be easily recognised and traced. The additionally generated orthophotos were superimposed on the determined surfaces (right half of Fig. 2). Random checks on the results of the digital image mapping were carried out using manual stereo evaluations and wave data measurements. The accuracy of the results lies within expectations. Problems arise in regions with poor texture. At some points the results of the image mapping are superimposed by high-frequency noise. Further matching of the image mapping algorithm is currently being undertaken to solve this problem.

4. Numerical model

The second major aspect of the project was to extend the Boussinesq model BOWAM2 developed at the Institute of Fluid Mechanics (IFS). In addition to the nonlinear transformation of waves implicitly included in the fundamental equations a realistic simulation of the surf zone also demands a consideration of energy dissipation due to wave breaking as well as wave run-up and overtopping on the beach and along the groins. Moreover, the generation of waves by driving the model using photogrammetric data was reconsidered.

The fundamental equations of the model are Boussinesq equations extended for deep-water applications, which approximate the linear dispersion relationship by means of a (4,4)-Pade approximation and are thus capable of simulating nonlinear transformations of the water surface up to a water depth to wavelength ratio of D/L ˜ 1.5 (Schröter 1995). The numerical solution is performed on an equidistant Cartesian grid using a 3rd order finite difference method.

The extension of the fundamental equations to include the wave-breaking process is achieved by including the law of internal friction with an eddy viscosity concept and the periodic drying and wetting of nodes during wave backrush is accounted for by the assumption of a thin, residual water film using the wet slope concept. The introduction of waves into the computational domain is realised by means of a mass source and receding waves are damped without reflection using sponge layers on the boundary. Although this approach increases the time required to find a solution due to the extension of the computational domain, it has the distinct advantages that waves of arbitrary frequency may be generated (which is only possible with limitations using reflection-free boundary conditions) and that only the surface elevation is required for controlling the model, which is very useful in the case of photogrammetric measurements as well as other data.

5. Results

Extensions to the numerical model were first verified by a large number of comparisons between theoretical solutions and the results of laboratory tests. Simulations of the groin field were subsequently carried out, whereby waves were introduced using the data from buoys installed on the seaward boundary.
An example of the latter is given in Fig. 3, which shows an instantaneous representation of the water surface. White areas of the figure indicate breaking waves.

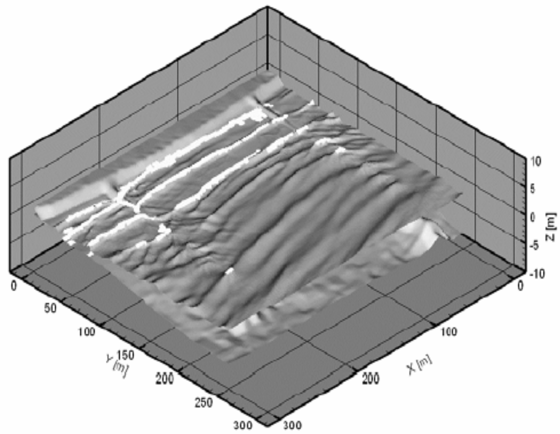

Fig. 3: Instantaneous representation of the simulated water surface

A comparison with photogrammetric results shows that the localisation of the breaker zone is reproduced well by the numerical model. Similarly, good agreement was obtained between the simulated results and spectral parameters derived from the time series of point recordings performed by the "Küste" research division. The generation of waves on the basis of point buoy measurements only permits a statistical reproduction of the wave climate in the groin field, however. In order to reproduce the water surface without phase errors measured values must be prescribed at nodes over the entire model boundary. This was demonstrated for a section of the groin field using photogrammetric data. This example shows that driving the model in this way functions in principle and will now be extended to larger areas over longer time periods.

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Mathematical modelling of wave run-up and overtopping

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Introduction

In order to determine run-up heights and overtopping rates on sea dkes and other coastal protection structures empirical formulae are mostly used according the method of Hunt (1959). This concerns matching functions based on the data obtained from physical model investigations of different representative wave climate states and mainly simple dike geometries. Especially for non-compliant dike geometries the applicability of these formulae is questionable or even impermissible. Physical model experiments for the entire diversity of dike geometries have not been carried out so far due to the large amount of work that this entails.

Using mathematical models on the other hand it is possible to investigate all conceivable geometries with regard to wave run-up and overtopping with a limited amount of effort. Richardson et al. (2001) have shown that an application is possible for almost vertical revetments (10:1). Efficient mathematical models based on the shallow water equations can rapidly simulate wave trains comprised of up to 1000 waves and have already been applied for variant investigations (Niemeyer & Kaiser, 1998). The determination of absolute values, however, is still fraught with uncertainties. The main aim of the research project “Optimisation of dike profiles “ was thus to check the applicability of available mathematical models of wave run-up and overtopping and to examine possible methods of optimising suitable models.

The models OTT-1D and OTT-2D (Dodd, 1998) of the project partner HR Wallingford and the model ODIFLOCS (van Gent, 1995) of the project partner DELFT HYDRAULICS were used. In the case of the latter, sensitivity investigations were primarily carried out in the initial phase of the project (Niemeyer et al., 2002). The data required for validating the models were made available by the Leichtweiss Institute (LWI) from tests carried out in the Large Wave Channel (GWK) and the wave channel at the Leichtweiss Institute (LWI) as well as by the Franzius Institute, Hanover from tests performed in a wave basin. These data originate from the KFKI projects “Loading of the landward slope of sea dikes due to wave overtopping” and “Oblique wave attack on sea dikes”.

Comparison with measured data

Fig. 1 shows a comparison of overtopping rates measured in the GWK with computed mean overtopping rates. The values obtained from both models correlate very well, with a systematic underestimation for increasing overtopping rates. It is found that the magnitude of the simulated mean overtopping rates is affected by changes in the model parameters for the roughness coefficients or the assumed minimum water depth (Niemeyer et al., 2002).

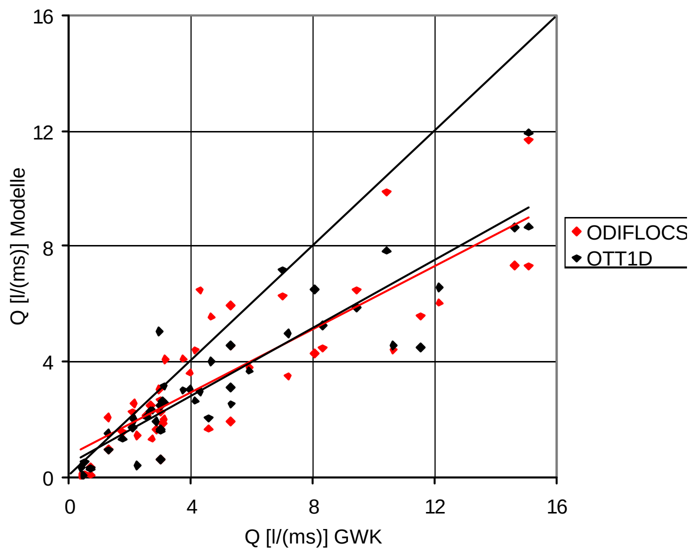

Fig. 1: Comparison between average overtopping rates measured in the GWK with those computed by the models OTT-1D and ODIFLOCS

Also the nature and position of the inflow boundary condition have a considerable bearing on the model results. Especially due to model-inherent numerical dispersion, it is found that the overtopping rates decrease with an increase in the modelled area for the same spatial model resolution. The general applicability of the shallow water equations for water depths above the shallow water limit is also questionable. It may be seen in Fig. 2 that the shallow water equations (OTT-1D) in this case no longer correctly simulate the time series of surface elevations (in contrast to a Boussinesq model).

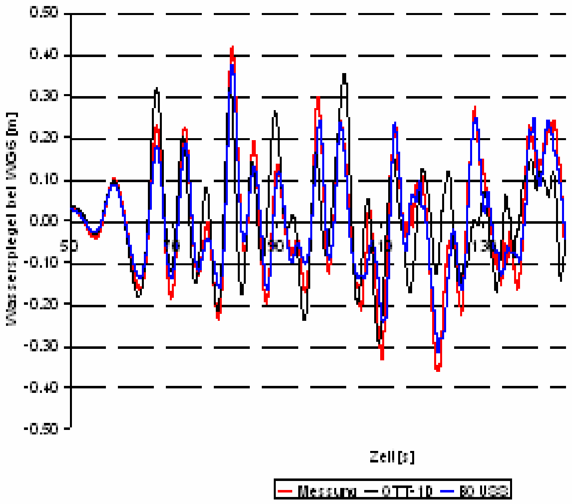

Fig. 2: Comparison between measured surface elevations (—) and those computed using OTT-1D (—) and a Boussinesq model (—)

As boundary information for the computer simulations it is possible to use surface elevations directly or a one-dimensional wave spectrum. The first possibility permits a direct comparison of run-up events under laboratory conditions in order to investigate the general suitability of the model type for the run-up and overtopping computation. In a practical application, of course, spectral information on the design wave climate would normally be available. As illustrated in Fig. 3, good results are also obtained if spectra are used as boundary information.

Summary

The model investigations have shown that the investigated models may be recommended for practical engineering applications. Besides the advantage of diverse applicability the quality of the model results for overtopping rates was superior to that given by empirical formulae.

Acknowledgements

This project was funded by the German Federal Ministry of Education and Research (BMBF) under the Project Number 03KIS032. We would like to thank the Leichtweiss Institute as well as the Franzius Institute for their excellent cooperation. We also extend our thanks to our European project partners DELFT HYDRAULICS and HR Wallingford for their valuable contribution.

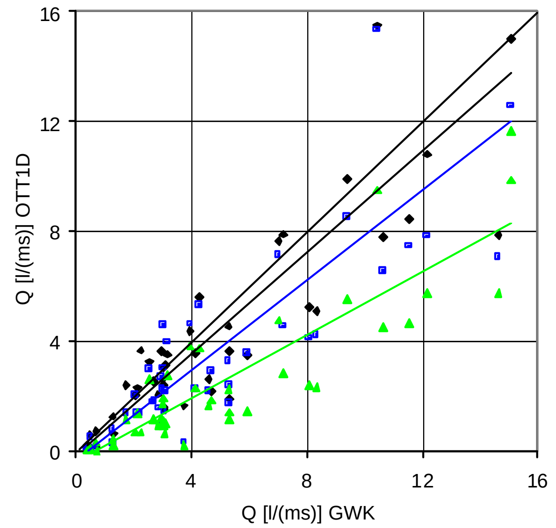

Fig. 3: Comparison between measured (large wave channel) overtopping rates with average overtopping rates computed by model OTT-1D using spectra as boundary information. (—) large distance between the boundary condition and the dike, (—) average distance, (—) small distance.

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Stationary 3-D flow measurement system for highly turbulent flow states under the influence of tides, currents and waves

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Abstract

The increased incidence of damage to various hydraulic structures underlines the necessity for a new measurement technique and suitable numerical methods in order to more precisely simulate operating states in advance and thus rule out critical loading from the very beginning. Although the use of numerical methods for describing such flow processes is possible, their prognostic capability is limited owing to a shortage of basic data for calibrating and validating numerical models with high temporal and spatial resolution. The essential boundary conditions for these operating states such as a free surface and moveable geometries have so far not been applied in a large-scale model with high resolution over particular areas, as is necessary for an application of this kind.

The aim of the project is thus to develop, construct and test in the hydraulics laboratory a stationary 3-D flow measurement system consisting of a Particle Image Velocimeter (PIV), a mechanical flow measurement system and a carrier system for highly-turbulent flow states. This also involves testing the measurement system on the study case of the Ems retractable tidal barrier as well as to use the measured flow velocities for verifying and calibrating a numerical model.

During the development phase of the numerical model successful simulations were carried out at the Franzius Institute of Hydraulic and Coastal Engineering by means of a moveable model of a rising gate. A comparison between the simulation results and measurements performed with an Acoustic Doppler Velocimeter (ADV) probe showed satisfactory agreement. Validation of the simulation results using the considerably higher-resolution spatial and temporal PIV measurements thus appears to be appropriate and very promising.
In particular, a comparison of the developing eddy structures is possible using the PIV measurements. With regard to the simulation of flow velocities on the landward side and at the Ems retractable tidal barrier, comparisons with the results of physical model tests were found to be satisfactory in qualitative terms. The simulation of several loading cases is currently in progress in order to more precisely assess the quality of the results.

A PIV permits the measurement of 2-D and 3-D flow velocities over a wide velocity range. By the selective, triggered exposure of a suitable plane within a flow profile by a laser beam specially matched to the problem concerned and by recording the generated image using one or two CCD cameras for a quasi 3-D representation it is possible to acquire a great deal of information regarding flow conditions in the form of temporally and spatially resolved velocity vectors from simultaneous photographs of a large number of points. The flow velocity is computed by evaluating the particle displacement during the interval between two exposure impulses. In order to guarantee the success of this method the particle concentration of the flow under investigation must be sufficiently high.

After linking-up and matching the individual components of the PIV system by the Hanover Laser Centre in cooperation with the project partners it was possible to achieve the necessary mechanical and control flexibility of the laser-supported overall system for adaptation to different boundary conditions such as turbidity, space requirements and observation field size at various measurement locations. On the basis of extensive software tests parameter sets were selected which take into account the constellation in prototype tests. A complex relationship is found between turbidity in the field, additional or natural seedings, and the laser intensity setting. A simple mathematical relationship between the intensity setting and turbidity does not exist. The measured data are site-specific and yield an individual parameter matrix in each case. As was shown by the prototype tests at the model scale, the particles present in natural watercourses are suitable for generating sufficiently good scattered light reflexes. Depending on the problem in question, the 3-D PIV measurement system in the 2-D or 3-D mode has proved to be suitable for the visualisation of flow fields, the generation of depth profiles and the representation of turbulence. Implementation of the system at locations with different flow conditions verified the high robustness and mobility of the overall system. The mechanical flexibility in the arrangement of components is a major advantage regarding adaptation to particular structural or geometrical boundary conditions. In the meantime joint tests are being carried out in parallel on the different systems in order to increase the database for the numerical flow model.

In addition to the PIV a robust, mechanical flow measurement system consisting of a body immersed in the flow under investigation has been developed at the Institute of Material Sciences, Non-Destructive Testing Methods Section. This system measures the flow velocity in the three spatial directions by sensing the deflection of a rod attached to a body immersed in the flow. This inexpensive measurement technique, which may also be implemented independently of the PIV sensor unit, is not only able to provide the PIV system with reference values but also serves as a means of extending the database for the numerical flow model by performing long-duration measurements at selected measuring points. Various models of the mechanical incident flow measurement system using different measurement technologies were constructed and evaluated under realistic conditions. Flow measurements compared with an ADV probe as a reference agreed very well with measured values in the principal flow direction for the selected system. The influence of multi-dimensional turbulent flows on the measurement system is currently being investigated.

In order to assess the various measurement systems under different realistic operating conditions a pillar of the Ems retractable tidal barrier was chosen under consideration of the required boundary conditions. This installation location is characterised by high flow velocities due to ebb and flood flows, large water level differences during a tidal period, varying salinity owing to the tide, suspended material load influencing water turbidity as well as different operating states during opening and closing of the barrier gates. In cooperation with the NLWK project team “Ems retractable tidal barrier” an installation location for the flow measurement system was chosen in the subsidiary opening 1 of the barrier opposite the operating cabin. In the meantime a rail system has been installed at this location so as to allow the carrier system with the measurement systems to be arbitrarily positioned at different immersion depths and distances from the pillar wall.

MUSE – statistical-probabilistic ranking of storm surges with very low probabilities of occurrence

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In 2002 the KFKI research project “Model-backed investigations of storm surges with very low probabilities of occurrence (MUSE)” was granted funding approval by the German Federal Ministry of Education and Research (BMBF) for a period of three years. This project is a joint project involving the Research Centre for Water Management and the Environment (fwu) at the University of Siegen, the German National Meteorological Service (DWD) and the Federal Maritime and Hydrographic Agency in Hamburg (BSH Hamburg).

The statistical ranking of extreme water levels with very low probabilities of occurrence ($< 10^{-3}$) cannot be estimated with certainty by a statistical analysis of the observed data. From a series of observations extending over about 100 years it is only possible to extrapolate over a period of 2 to 3 times the duration of this time series according to the laws of statistics.

The aim of the KFKI project MUSE is to derive additional information relating to highly infrequent extreme events in order to realise considerably longer extrapolation time spans. Simulations of physically consistent storm surge weather conditions and the modelling of corresponding wind set-up values or water levels are suitable for this purpose; this additional information may be included in the statistical-probabilistic data analysis and improve the quality of the results.

It should be noted, however, that this additional information may be included in the statistical analysis in a variety of ways. Under consideration of the results to be expected a debate of the statistical ranking of extreme storm surges based on different mathematical approaches is posed on a much broader footing; in this respect, individual approaches make no claim to “correctness”.

The problem of statistical ranking of extreme water levels always arises when an event occurs which is significantly larger than previously observed events or when it is intended to deduce an event with a very low probability of occurrence.

The occurrence of an extreme value often alters the results of statistical ranking considerably. This effect was evident during the extreme high water event in the Elbe estuary in 2002, which partly cast doubt on the statistical methods used. This uncertainty in the ranking of such extreme values, which also applies to the Baltic Sea, results in the fact that a more detailed statistical analysis for solving coastal engineering problems is dispensed with in most cases. The extreme high water event of 1872 is a prime example of an event which “apparently” does not fit into the observed time series (Fig. 1).

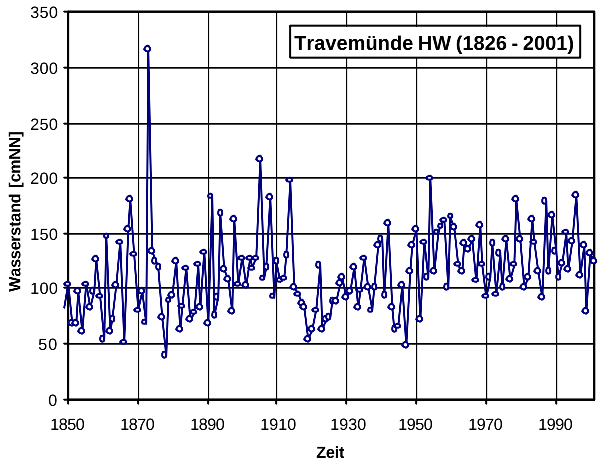

Fig. 1: HW time series recorded by the Travemünde tide gauge (Baltic Sea)

An examination of this situation leads to the following questions: are extraordinary extreme events (e.g. Travemünde 1872 or Elbe 2002) freak events or do they belong to the natural variability of a time series? Does a maximum high water exist that may be explained in physical terms? In the first instance it appears plausible that a highest possible water level theoretically exists with an exceedance probability of $P_ü = 0$, without having to specify its order of magnitude. For this reason a statistical-probabilistic method based on the general extreme value distribution (GUMBEL Type III) was developed in the research project. In this method an upper limiting value may be defined which is asymptotically approached by the distribution function. In order to investigate the variability of a time series a large number of Monte-Carlo simulations were implemented. With the aid of the latter it was possible to generate a large number of synthetic time series corresponding to the observed data series in terms of their structure. The intermediate results of the Monte-Carlo simulations so far indicate that although maximum extreme values ($P_ü<10^{-4,-5...}$) may be computed, they are in fact considerably lower than the upper limit of the distribution function.

This opens up the possibility of equating these values to the maximum water levels modelled by the BSH and hence obtain physically-justified additional information. Compared with the methods previously adopted the statistical-probabilistic evaluation of the observed data (Cuxhaven HThw) yield similar results. The fact that an extreme event with a value greatly exceeding those of previous observations may occur in a time series may also be modelled by Monte-Carlo simulations (Fig. 2). If an extreme modelled water level is added to the observed time series and the behaviour according to Fig. 1 is simulated with the inclusion of this value, it is found that the results of the developed method ProMUSE are less affected by this than the results of "classical" methods.

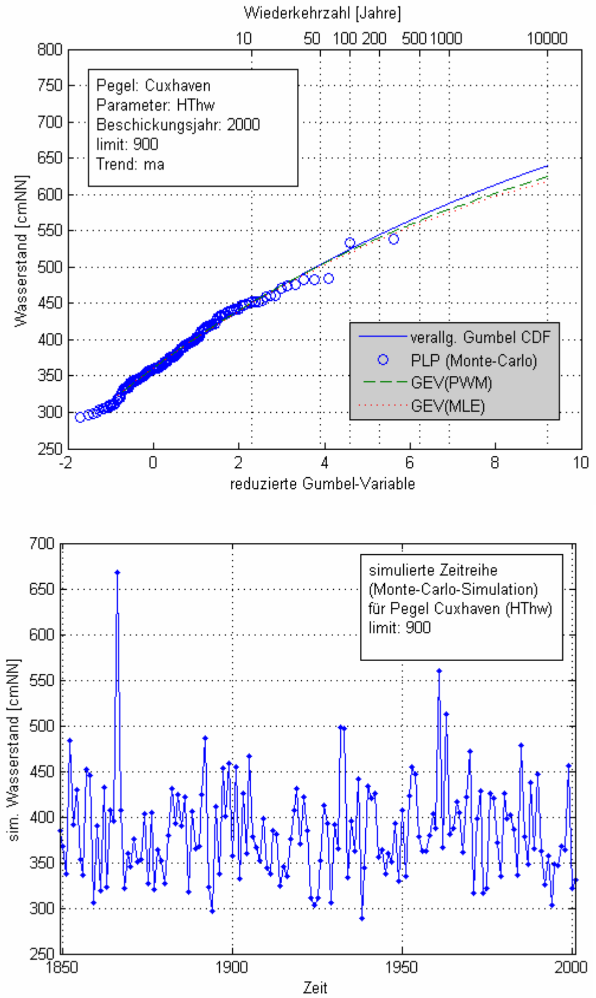

Fig. 2: Statistical analysis of the observed HThw data series at Cuxhaven and simulated HThw time series

Summing up, it is evident at the present stage of the investigations that the original aim of simulating storm surge weather conditions is successful and that a statistical-probabilistic method has also been developed which is capable of including the additional modelled data (DWD, BSH). The methods and results presented for the statistical ranking of extreme storm surges must still be further developed and verified.

MUSE – model investigations of extreme storm surges

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In 2002 the KFKI research project "Model-backed investigations of storm surges with very low probabilities of occurrence (MUSE)" was granted funding approval by the German Federal Ministry of Education and Research (BMBF) for a period of three years. This project is a joint project involving the Research Centre for Water Management and the Environment (fwu) at the University of Siegen, the German National Meteorological Service (DWD) and the Federal Maritime and Hydrographic Agency in Hamburg (BSH Hamburg).

Evoked by the storm depression Anatol in December 1999, as after the catastrophic storm surges in 1962 and 1976, a new debate was sparked off concerning the possible heights of extreme storm surges. The project MUSE (model-backed investigation of storm surges with very low probabilities of occurrence) is aimed at broadening the footing of such debates by supplementing the collective of high storm surges in the North Sea by realistic, yet so far non-occurrent storm surges. For this purpose the weather conditions for the storm surges of 1962, 1967, 1976, 1990, 1994 and 1999 according the Ensemble Prediction System (EPS) of the European Centre for Medium-Range Weather Forecasts (EZMW) were implemented and varied by shifting the starting point of the simulation. This yielded an average of 750 new potential weather forecasts per storm surge weather condition.

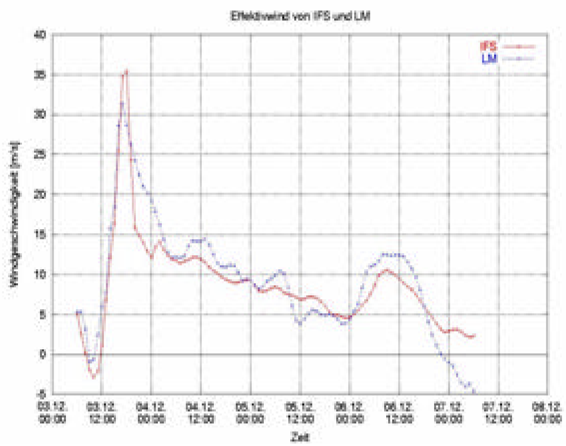

Fig. 1: Effective wind given by the IFS and the LM (EPS05-1999)

From statistical investigations it is known that WNW winds are responsible for the largest water level increases in Cuxhaven. As such, weather conditions were only classified as storm weather conditions for situations in which the projection of the wind speed averaged over the German Bight along this set-up direction (effective wind) is greater than 22m/s. Only 0.7 % of the variants fulfil this criterion on average per storm surge weather condition. The simulations performed using the EZMW model (Institute of Fluid Mechanics (IFS)) were only originally intended to serve as boundary values for the Local Model (LM) of the DWD. Due to the fact that differences arose in the computational results of the two meteorological models (Fig. 1) and that neither of the models could be rejected, a total of 59 weather conditions were obtained for further processing at the BSH.

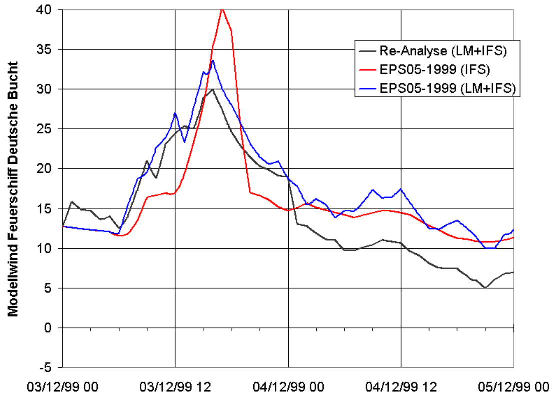

Fig. 2: Model wind given by EPS05-1999 (IFS), EPS05-1999 (LM-IFS) and reanalysis (LM+IFS) at the German Bight Lightship

A well-proven operational model chain for predicting water levels is available at the BSH. Further sorting was carried out using a two-dimensional barotropic model of the North Sea and the western part of the Baltic Sea. Only simulations in which the maximum water level in Cuxhaven exceeds 6m above MSL or in which the wind set-up exceeds 4.50 m (referred to the subsequent HW or LW of the precomputed model tide) were recomputed using the BSH three-dimensional, baroclinic, high-resolution model (approx. 2 km in the horizontal direction in the German Bight).

An EPS variation of the storm depression Anatol (1999) indeed yielded the highest water level in Cuxhaven. In this special case the simulations using IFS winds differ considerably from those using LM winds with regard to wind set-up (Fig. 3) as well as the maximum water level in Cuxhaven (Table 1).

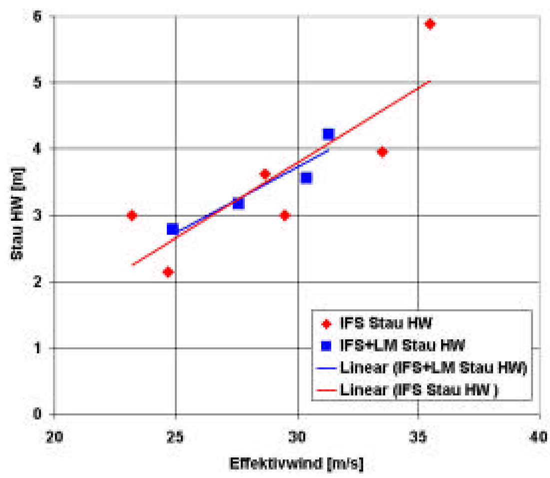

Fig. 3: Set-up at HW in Cuxhaven as a function of the maximum effective wind for the storm surge of 1999 (two-dimensional simulation)

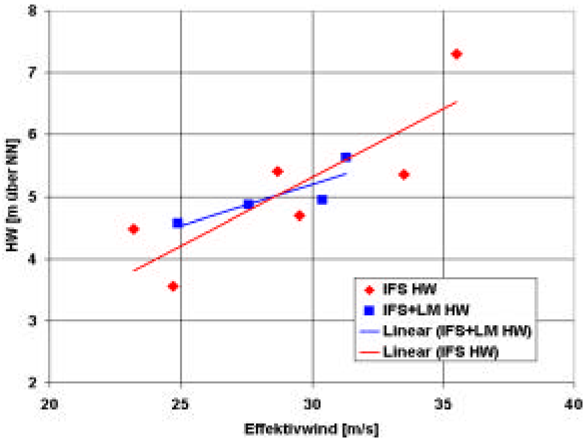

Fig. 4: Maximum effective winds and maximum water levels in Cuxhaven for the storm surge of 1999 (two-dimensional simulations)

Owing to a maximum water level of 7.30 m above MSL in Cuxhaven given by variant EPS05-1999 for the IFS winds, this variant was recomputed using the three-dimensional model. A slightly lower value of 7.27 m above MSL is obtained. Fig. 5 shows the spatial distribution of wind set-up in the German Bight. The increase compared with the reanalysis (Fig. 6) is due to a shift in the storm depression and higher air pressure gradients.

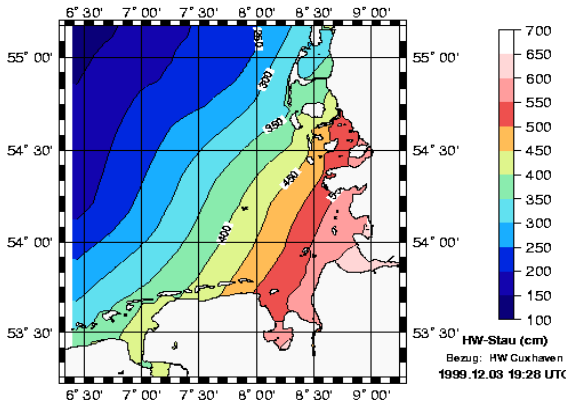

Fig. 5: Set-up at HW, EPS05-1999 (three-dimensional simulation)

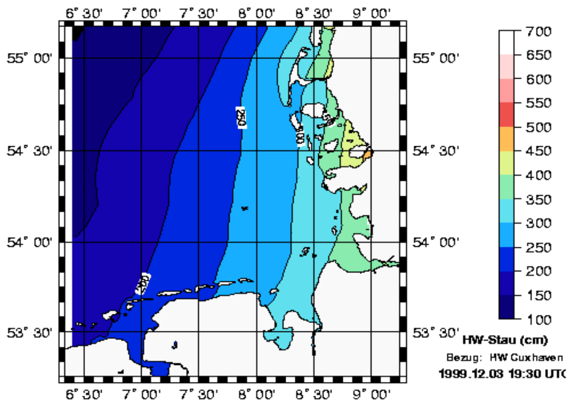

Fig. 6: Set-up at HW, reanalysis 1999 (three-dimensional simulation)

The effect of parametrisation on meteorological models is indicated by the difference between IFS and LM winds. Both versions may be justified on physical grounds. The formulation of the so-called wind shear stress coefficient is critical. In a sensitivity analysis based on different mathematical formulations the parametrisation implemented by the BSH in normal forecasting operations was found to agree best with the values observed in 1999.

The EPS weather conditions are physically meaningful variations of actual weather conditions. In order to even detect these very infrequent events (extreme storms and storm surges) a tremendous amount of computational effort is required. Despite a number of uncertainties which still exist in model computations, a more reliable method of estimating and satisfactorily justifying extreme water levels in physical terms is not available at the present time.

Level Changes in the Coastal Zone of the Baltic Sea

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Summary

Level displacements between the sea surface and the mainland play a decisive role in the modelling of natural processes in the coastal zone. Although these relative level changes may be derived from tide gauge measurements, they nevertheless represent the combined effect of changes in water level and vertical displacements of the coast. In the project presented, repeated level surveys were undertaken to determine landward level changes, thereby permitting a separation of the superimposed processes given by tide gauge measurements.

Along the German Baltic Sea coast eight precision level surveys have been carried out since 1869. Line direction benchmarks as well as level differences between these benchmarks are available for these measurement epochs. This data material exhibits inhomogeneity regarding the definition of the level system, the evaluation procedure (correction, compensation methods), line direction determination as well as documentation (point descriptions, information regarding measurement distances and measurement methodology).

Within the framework of the presented project the results of historical and up-to-date level surveys were combined for the first time in a single and extensively homogenised database. For this purpose measured data and additional information regarding the evaluation methods used (partly unpublished) were gathered, digitally recorded and processed, and repeated verifications of individual points were carried out within the scope of field surveys. This has resulted in the generation of files for different levelling lines and epochs containing measured level differences and level differences derived from level tables between the measurement points. For each levelling line a file containing relevant point information was also compiled. In the level data files identical points repeatedly surveyed during the different epochs were identified and referenced.

The repeated determination of the level of these points forms a basis for deriving relative temporal level changes. For this purpose a complex evaluation method was developed and implemented on the computer. Where available, the uncorrected level differences between measuring points were also taken into consideration in order to reduce the systematic effects resulting from specifications of the level systems and evaluation methods. The level change between two points in each case is determined as a linear trend in the temporal change of their level differences.

Secular level changes between the sea surface and the mainland were determined by processing a series of tide gauge measurements over many years. The spatial differences in these relative displacements may then be compared with the level changes along the coast computed from level surveys. These independently determined relative movements permit an estimation of the accuracy potential of the evaluated level surveys.

The methodology and results are presented in general terms in this paper. A determination of the spatial variations of height displacement rates based on level survey evaluations, their geophysical interpretation as well as their consistency with tide gauge measurements are discussed by way of example. Special mention is made of the implications of the latter regarding coastal protection.

KoDiBa – Development and implementation of methods for deriving consistent digital bathymetries

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Dr.-Ing. Frank Sellerhoff,
Dipl.-Ing. Nils Krönert,
smile consult GmbH, Hannover

Regular bathymetric surveys provide basic data for large-scale investigations of depth distribution and morphological changes along the German North Sea and Baltic Sea coast as well as for solving more complex problems e.g. by means of numerical models. Despite considerable advancements in measurement technology and a high expenditure of effort, it is generally not possible to survey all areas of interest in detail over a short space of time. This means that survey results are often only available over small areas and that data acquisition in neighbouring areas is carried out at different times. This situation is unlikely to change in the future.

On account of the above-mentioned situation the creation of digital terrain models on the basis of these survey data is at present extremely time-consuming and fraught with errors. This is especially the case if the area under investigation is subject to morphological changes. The time horizon of these changes, which may be several days, weeks or even months owing to the physical nature of the phenomenon, is a considerable hindrance to the creation of consistent and hence plausible terrain models.

The central objective of the KFKI project “development and implementation of methods for deriving consistent digital bathymetries – KoDiBa” is the development and prototype implementation of tools for overcoming the above-mentioned problems.

For this purpose it was necessary in the first instance to develop a suitable problem-matched data management system capable of handling not only the project-relevant data but also the metadata essential for the success of the project. This so-called “reversible data model” system permits the post-tracking of all changes to the basic data carried out during verification and plausibility checks, and was implemented with the aid of a relational database scheme. By keeping a record of all processing steps it is possible to regenerate the original state of the data at any time and to assess the archived data (also in the future) according to the current state of knowledge. The standardised management of the data and corresponding metadata combined with the method developed within the scope of the project forms the technological basis of KoDiBa.

The spatial and temporal ranges of applicability of the data measured at different times and different locations form a major part of the metainformation. Within the scope of the project suitable methods were developed for handling this problem, implemented in the prototype and tested using sample data from the project area (coastal zones of Borkum, Juist, Norderney). The computation of digital bathymetries may only be carried out in areas within the ranges of applicability of the available measurements.

The inclusion of time results in a 4-dimensional approach and requires the extension of known interpolation techniques or the development of new methods. These methods may be further improved by taking into consideration spatial and/or temporal structures. The developed spatial-temporal interpolation techniques permit the determination of a depth value at each point in time and at each location within the ranges of applicability.

In addition, the spatial-temporal interpolation techniques developed within the scope of KoDiBa as well as their prototype implementation in a bathymetry simulator offer new perspectives for the assessment and evaluation of bathymetric measurements. On the basis of selected examples it was possible, among other things, to make definite statements regarding depth and volume changes.

Application of the developed techniques for data verification, interpolation and analysis in other investigation areas as well as for other types of data such as e.g. sediment parameters, pollutants or other ecological parameters is conceivable.

NOKIS – Components of information systems in the coastal zone

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Dipl.-Geogr. Carsten Heidmann
BSH Hamburg

The North Sea and Baltic Sea Coastal Information System (NOKIS) was jointly developed by federal and state governmental departments between 2001 and 2004 within the framework of a KFKI research and development project (03KIS027). Staff members of the Regional State Office for Rural Areas in Husum (ALR Husum), the Regional Office of the Schleswig-Holstein Wadden Sea National Park in Tönning (NPA Tönning), the Federal Administration of Waterways and Navigation, Directorate Northwest in Aurich (WSD-NW Aurich), the Lower Saxony Water Management and Coastal Defence Agency in Norden (NLWK Norden), and the National Park Office of the Lower Saxony Wadden Sea in Wilhelmshaven (NLPV Wilhelmshaven) were all involved in the project from the very beginning as providers of metadata as well as direct users of the system. The information system is matched to questions relating to the coastal zone and is permanently operated and managed by the Federal Waterways Engineering and Research Institute in Hamburg (BAW Hamburg) under the web address http://nokis.baw.de.

In the participating departments metadata have been collected on the standardised documentation of existing data inventories and available cartographic material. These metadata, which provide on-the-spot support to routine daily work, are updated continuously. With the aid of descriptive information, which not only includes “who, what and how” but above all, details of “where and when”, targeted inquiries may be undertaken which permit spatial and temporal restrictions. The opportunities offered by this system are not only advantageous for local data management but are also for global information exchange via the NOKIS portal in the Internet once the metadata have been transferred to the BAW central server.

This information base is supplemented by a project database containing all completed and currently sponsored KFKI projects, thus providing users with online access to reports in digital form. Older documentations may be obtained on loan from the KFKI library under http://kfki.baw.de which is also integrated into NOKIS. This database, which is permanently managed for the Project Sponsor Jülich (PTJ), makes a formal contribution to the transparency of research in the coastal zone and additionally brings together the links to all Internet sites maintained by the individual projects.

Besides standardised metadata offering special searches for experts, a full-text indexing of digital sources is also implemented. By this means external websites as well as the above-mentioned digital reports are made accessible to NOKIS. Special mention is made here of the periodical “Die Küste”, for which abstracts of all articles and information on literature sources are compiled. These provide valuable references to grey literature dealing with the coastal zone.

On the basis of standardised metadata the attained status of NOKIS at the end of the project provides a current overview of data inventories, cartographic material and reports by the above-mentioned project partners concerned with the German coastal zone up to April 2004. After having processed the old data using tools developed jointly in the project for bringing the product to maturity, there still remains the ongoing task of appropriately reworking new data inventories and installing these on the central NOKIS server at the BAW.

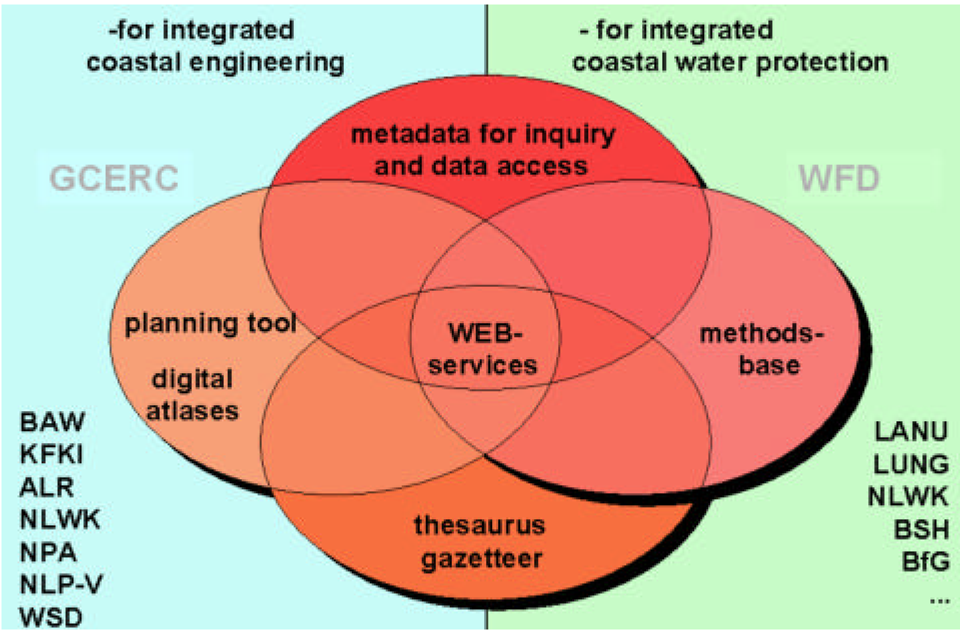
The aim of the project NOKIS++ (03KIS 049), which began in September, is to extend the North Sea and Baltic Sea Coastal Information System during the period 2004 to 2008 by including standardised Internet services. This is intended to intensify co-operation between engineers engaged in the fields of coastal protection, water resources management, nature conservation and waterways engineering as well as to promote information exchange with research institutions and support the necessary publicity work. NOKIS++ represents important data providers and information sources relating to the coastal zone together with the above-mentioned partners as well as the new partners: the State Agency for Nature and the Environment in Flintbek (LANU Flintbek), the State Agency for the Environment, Nature Conservation and Geology in Güstrow (LUNG Güstrow), the BSH and the Federal Institute of Hydrology (BfG).

In order to effectively support the various departments in the realisation of their planning and reporting tasks it is planned to implement practice-oriented methods for interdisciplinary data research, analysis and visualisation. The information infrastructure is based on the ISO 19115 and ISO 19119 standards for descriptive metadata and Internet services for data processing.

Existing structures, systems and resources in governmental administrations are purposefully implemented, appropriately supplemented and further developed in order to optimise the information flow in interdisciplinary teamwork. NOKIS++ is integrated into the German Federal Geodata Metainformation System (GeoMis.Bund), the German Environmental Information Network (GEIN) and the Environmental Data Catalogue (UDK).

NOKIS++ constitutes the framework for planning and management tasks in the coordination of integrated coastal hydrography and integrated coastal protection. The technological information infrastructure may be easily modified to accommodate new fields of application and may also be used for developing national strategies for an integrated coastal zone management system. The information infrastructure to be created for this purpose is based on the well-proven principle of decentralised data storage and stand-alone local nodes implemented in NOKIS, and on which the NOKIS software may be run locally, as well as metadata replication on a shared web portal. It is also intended to introduce standardised web services in order to support data utilisation according to the search – find – use principle.

Information-Infrastructures



Die KÜSTE

Contents of Issue 68

Issue 68 of the KÜSTE appeared in October 2004 with the following articles:

Online services

On the homepage of the KFKI http://kfki.baw.de under the heading "Die Küste" you will find summaries of individual articles in German and English, the corresponding list of contents as well as information on the literature used. By way of our Web Online Public Access Catalogue http://kfki.baw.de/OPAC we hope to be able to support you in your literature search. You will also find information regarding new additions to the KFKI library on our homepage http://kfki.baw.de/buecherei under the heading "Bücherei".

Sales and special offers

You may order the latest Issue 68 of the KÜSTE online in the KFKI office at a price of 22,- €. Older issues may also be supplied. **Issues 1–61** are available either as **a collective parcel at a special price of 130,- €** plus postage and packing or individually at a price of 5,- € per copy. The prices of issues 58 – 68 are listed on our homepage.

Information for authors

For authors wishing to submit articles for publication in the KÜSTE an obligatory format layout for preparing manuscripts is given on the KFKI homepage. In order to reduce production costs the reviewed articles will from now on be formatted by the authors themselves in the KÜSTE layout. For printing purposes the MS-Word document will be photographed directly by the publishers. With regard to figures, DIN-A4 photographs should also be submitted in order to guarantee high quality.

Looking ahead

The next issue of the KÜSTE is planned for summer 2005. The special edition "PROMORPH" will report on investigations carried out between 1.1.2000-31.12.2002 in the joint project "Forecasts of medium-term changes in coastal morphology"

Promotion of up-and-coming scientists

Young scientists may apply for **grants for conference trips** through the KFKI. As a rule, 50% of certified costs (participation fee, travelling costs, overnight accommodation) will be subsidised. In return you will be expected to write a short report on the conference visited, which will be published in the KÜSTE.

Your application for a travel grant must be sent to the KFKI as soon as an abstract has been submitted for a conference. The council meets twice a year to review the submitted applications. Applications that are submitted after the deadline will not be considered.

Internal News

On 1st June the KFKI office moved to the BAW in Hamburg. We should like to take this opportunity to warmly thank the retired Managing Director Dr.-Ing. Volker Barthel once again for his high commitment to the KFKI.

A new team commenced its work in Hamburg on 1st September. The new Managing Director Dr.-Ing. Rainer Lehfeldt is joined by the new office secretary Katrin Zabel, and Regina Herz, who has been in charge of the KFKI library since 2001.

Dr.-Ing. Rainer Lehfeldt

Katrin Zabel

Regina Herz

Events in 2005

04.-08.04.2005 5th International Conference on **Coastal Dynamics** 2005
ASCE, Barcelona
Website: http://www.coastaldynamics.org

13.-15.04.2005 **Coastal Engineering** 2005, Algarve, Portugal
Website: http://www.wessex.ac.uklconferences/2005/coasta/2005

18.-20.04.2005 **Comrisk** 2005, Kiel www.comrisk.org/html/conference.htm

19.-22.04.2005 **Coastlines, Structures and Breakwaters**, London
Website: http://www.icebreakwaters.coml Assembly-2005, Wien

25.-29.04.2005 **European Geoscience Union** EGU General Assembly-2005, Wien
Kontakt: molnar@ihw.baug.ethz.ch

15.-20.05.2005 World **Water & Environmental Resources** Congress 2005, Anchorage Convention Center, Anchorage, AK, USA
http://www.environmental-center.com/events/wwer2005/wwer2005.htm

25.-27.05.2005 Third Intemational Symposium on **Flood Defence,** Nijmegen, The Netherlands
Website: http://www.isfd3.nl/

27.-29.06.2005 Advances in **Marine Ecosystem Modelling** Research, Plymouth, UK
Website: http://www.amemr.info/

03.-07.07.2005 5th COPRI International Conference on Ocean Wave Measurement and Analysis, **WAVES 2005,** Madrid, Spain
Website: http://www.cedex.es/waves2005/

18.-21.07.2005 **Coastal Zone 05:** Balancing on the Edge, New Orleans, USA
Website: http://www.csc.noaa.gov/cz/

11.-16.09.2005 **XXXI IAHR** CONGRESS, Seoul, Korea
Website: http://www.iahr200S.or.kr

07.-09.09.2005 **Enviroinfo** 2005, Brno, Tschechische Republik
Website: http://www.enviroinfo2005.org

14.-17.09.2005 **HTG-Kongress** 2005 in Bremen
Website: http://www.htg-online.de/aktuell/akto.htm/

04.-06.10.2005 **INTERGEO** 2005, Düsseldorf Website:
http://www.intergeo.de/