Kuratorium für Forschung im Küsteningenieurwesen

KFKI aktuell

Editorial

The case for cooperative modelling

The task of research carried out by the German Coastal Engineering Research Council (KFKI) is to address pressing problems relating to the coastal zone and to set into motion the research and development work necessary to solve these problems. Within the framework of the research activities of the KFKI, scientific institutes are frequently concerned with the description, analysis, diagnosis and prognosis of the physical processes and interactions between the dynamics of coastal waters and the installations and structures necessary to safeguard the economic utilisation of the coastline. At the present time, attention is being increasingly focused on the sediment balance and sediment management as well the morphological development of coastal zones that differ greatly in terms of their character and hydrodynamic loading. The urgency of individual problems, which presently exist e.g. in the Ems and Elbe estuaries, is likely to be exacerbated by the possible effects of climate change. Via complex paths, the effects of an accelerated rise in mean sea level alone may result in highly detrimental changes which must be investigated and assessed in order to determine realistic margins regarding climate development. By this means it is possible to draw up plans for upcoming projects and investments in coastal waters within the framework of alternative considerations, also including sustainable long-term climate-proof measures. This not only concerns the question of adaptive coastal protection. It also involves the correct choice of scientifically founded and ecologically acceptable reactions to gradual changes that could have a negative impact on the different spheres of life and economic sectors along our coasts and estuaries.

The optimum planning of future measures compatible with anticipated climatic changes relies on a proper understanding of the overall system, which may be gained from detailed investigations of the historical, present and probable future development phases of a waterway system. In this connection the author poses the question as to which methods should be applied to further improve our understanding of the system in order to tackle the upcoming tasks, and above all, the way in which important decisions regarding future measures may be derived from the latter within the framework of a cooperative process that guarantees sustainability.

In order to thoroughly realise the long-term objective of a detailed understanding of the system, it must firstly be accepted that an investigation of the complex natural processes along the sandy coasts, on the intertidal flats and in the estuaries is a very demanding task that can hardly be accomplished nowadays by individual persons due to the requirement of wide-area coverage combined with high quality. This task demands an interdisciplinary as well as a transdisciplinary working approach in order to take account of questions arising from practice at an early stage. In order to fundamentally broaden our current scientifically-founded knowledge of natural processes it is necessary to combine our existing wealth of knowledge gained from experience with the methods and computational techniques applied in different scientific fields.

In order to tackle complex problems scientists increasingly rely on the development and implementation of mathematical methods, preferably in the form of simulation models. These models attempt to describe the underlying physical processes in terms of their temporal and spatial distribution in as much detail and with the highest coverage possible, including the best possible description of the model topography and the boundary values that influence the system. Independent of the attained development stage, however, a model always remains a substitute system for the real natural system. An important aim of the modeller is thus to make the uncertainties of a model transparent and to investigate the causes of these uncertainties. For example, a morphodynamic simulation model is unable to exactly compute the spatial and temporal distribution of erosion rates present in nature owing to the fact that the model is incapable of correctly reproducing the flow- and wave-induced distributions of shear stresses and turbulent fluctuations. Moreover, there are numerous additional factors inherent in the system that lead to model uncertainties.

As a consequence of this, scientific methods even based on highly-developed simulation models are only able to yield prognoses of the probability of a particular system behaviour. Nevertheless, in view of the ever-increasing demands placed on mathematical modelling, an effort must be made to achieve the greatest possible agreement and also complementarity (in the sense of complementary properties and characteristics) between nature and the simulation model. This leads to the requirement of concrete quality characteristics that must be satisfied by a model. Whether a particular simulation method is equally as good as or even superior to an alternative method can only be judged once the circle of users have tried out different mathematical models and compared and critically examined their basic underlying concepts and results. Mathematical models are complex tools that are deployed by experts. Assessments must therefore be made according to agreed, generally accepted and documented criteria. In this context it is especially important to identify the assumptions made in conceptual models. In the final instance, this permits the assignment of a comprehensible range of validity to an obtained model result

In order to ensure a wide range of decisions regarding the measures to be adopted, different simulation models that make use of completely different software should therefore be developed and applied by a circle of users (not by individual persons) (multi-model approach) so as to interpret differences which may result from the dissimilarity between the conceptual models and implementation of the simulation methods.

The simulation methods must be further developed beyond their present-day status by a large number of steps, even though these may often be small. This can be achieved very effectively if work is carried out on the basis of integrated modelling. Integrated modelling systems are characterised by a software architecture that permits the integration of special expertise and software modules provided by different researchers or development groups into an overall system either functionally or via standardised interfaces. This approach should ensure interchangeability of core components of the modelling system. It should also support the multi-model approach, as for example, standardised post-processing of the simulation data as far as possible in order to permit a comparison of the simulation results based on a standardised characteristic value system.

To finally underline the foregoing with special emphasis: the multi-model approach in conjunction with the creation of cooperative application and development environments is gaining increasing importance because decisions regarding courses of action in the coastal zone increasingly rely on model results. This approach is certain to broaden our understanding of the way in which a particular waterway system functions internally. The identification of model uncertainties and the further scientifically-founded concretisation of probabilities offered by this approach are also expected to play a key role in the decision-making process.

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INTBEM A - Analysis of soil mechanics processes for the functional optimisation of dyke elements (03KIS061)

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How safe are our dykes? And what action should be taken if our dykes prove to be unsafe?

These are questions repeatedly asked in connection with global warming that must be answered. The reason for posing these questions is that the future rise in sea level is expected to be greater than assumed in previous dyke dimensioning and also the fact that storm surges are likely to be more severe than in the past.

The questions initially posed are thus directly related to an anticipated change in dyke loading rather than an expression of doubt that existing dykes are unable to resist the loads we have been familiar with up to now. This is an important statement because it firstly implies that the present safety of dykes cannot be reasonably doubted, provided these are properly maintained. Secondly, our attention is directed to the loads that dykes are likely to experience in the future. It thus appears reasonable to first consider the question as to how these loads will alter as a result of water level and climate changes.

The research project "Integrated design of sea and estuary dykes (INTBEM)", gratefully funded by the KFKI since 2006, is thus comprised of two directly related subprojects, namely the project "Mathematical modelling of the hydrodynamic loading of dykes (INTBEM B)", the results of which are reported by Hanz-Dieter Niemeyer in the next contribution, and the project "Analysis of soil mechanics processes for the functional optimisation of dyke elements (INTBEM A)". By combining the results of these two projects we hope to derive reliable data concerning the safety of dykes in relation to the external loads to be expected in the future. In the event that the determined level of safety is insufficient, our results will provide a basis for target-oriented upgrading measures apart from the raising of dyke crest heights.

Based on the experience gained since 1962, it is concluded that dyke failure above all, if not exclusively, may always be expected when the dyke is overtopped. The water running off the inner embankment can erode the embankment cover layer. Alternatively, the embankment may slip as a whole because the loads resulting from overtopping can no longer be sustained due to a combination of soil waterlogging and the often dramatic loss of strength associated with the latter.

All of this is well known and has in fact served as a basis for specifying dyke heights since 1962: the height of dykes should be such that wave overtopping remains below a very conservative limiting value, i.e. 3 % of all waves are permitted to attain the dyke crest and run off down the inner embankment. In other design specifications for dyke heights, the overtopping rate is limited to 2 l/sm. If it intended to retain this concept of preventive coastal protection, the dykes must be raised if a rise in sea level is expected, because wave overtopping is directly related to water levels.

Now, the raising of dykes is no easy matter and not cheap. I don't wish to and cannot expound on the details of the problems associated with the latter here. They were and still are, however, the problems that instigated the research project I wish to report on in this contribution.

Instead of raising the dykes we wish to determine the resistance of the inner embankment against overtopping in terms of numbers, and compare these with the external loads to be expected if the forecasts regarding sea level rise materialise. This will indicate the overtopping rates that an existing dyke can sustain without the need to question its safety. If these turn out to be lower than the forecasted overtopping rates, the question as to the safety of the dyke concerned can be positively answered with regard to a rise in sea level. If not, it will be necessary to consider the best course of action. Raising of the dyke is then only one of several options. An alternative measure that is often simpler and equally as effective is to strengthen the inner embankment.

Within the framework of the research project INTBEM we have investigated the mechanisms that lead to cracks in the dyke revetment as a result of soil shrinkage, how the formation of cracks affects the infiltration of rainwater as well as overtopping water, and what consequences this has regarding soil strength and hence dyke stability. The results pertaining to this question lead to a design criterion for the thickness of the embankment cover layer such that the amount of water that infiltrates into the dyke is limited to such an extent that it may be drained off via the dyke support, mostly with the inclusion of a drainage conduit in the dyke core.

Moreover, we have developed a method for determining the erosion caused by wave overtopping which is dependent on the specific erosion resistance of the soil and the protective action of the sward.

Finally, we have investigated the damage mechanism by which slipping of the revetment on the inner embankment occurs. Based on the latter, a quality requirement is derived for the compaction of the embankment as well for the sward.

By means of these methods it is possible to state the safety of an existing dyke in terms of numbers, provided the extent of sea level rise and the overtopping rates derived from this are stipulated. Based on the INTEM B results it is thus possible to determine the average overtopping water volumes to be expected in the future for each dyke section. By this means it will be possible to check the magnitude of the infiltration rate, and whether this can be drained off via the dyke core drainage system. If this is not the case, the revetment layer must be thickened. The necessity of this, however, is only likely in a limited number of cases. It then remains to check whether the forecasted erosion rate is acceptable. A final check is then necessary to ascertain whether the revetment layer is sufficiently compacted and hence strong enough to sustain the increased loading due to wave overtopping. If this is not the case, it by no means inevitably necessary to raise the dyke height. It is still possible to increase the strength of the dyke revetment by repeated compaction.

INTBEM B - Mathematical modelling of the hydrodynamic loading of dykes (03KIS062)

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Introduction

Within the framework of the KFKI research project INTBEM ("Integrated design of sea and estuary dykes"; 03KIS061 und 03KIS062) financed by the BMBF [German Federal Ministry of Education and Research], the hydrodynamic loading of dykes was computed in the subproject INTBEM B - 03KIS062 using the mathematical model OTT-1D. The model is able to quantify wave runup and overtopping as well as runup and runoff velocities on the outer dyke embankment and the mean layer thicknesses of the overspill on the dyke crest. In order to verify the ability of the model to correctly reproduce natural conditions a wide range of investigations were carried out on the modelling of simple and complex geometries with the aid of different wave channel data and the results compared with those obtained from empirical calculations.

Mathematical modelling

The modelling of hydrodynamic loading was carried out using the mathematical model OTT-1D developed by HR Wallingford (Dodd, 1998 and Dodd et al., 1998). This model is able to simulate the complete overtopping of a structure. This is essentially due to the ability to treat several water masses independently in the computations (runup tongue, overspill water, water body in the lee). The shallow water equations form the physical basis of the model. These have been used for a long time in coastal engineering for computing horizontal sea currents. The advantage of these equations is that their application is computationally uncomplicated due to the implementation of standardised, stable and quickly solvable numerical schemes. OTT-1D is a phase-resolving model which solves the shallow water equations explicitly using finite volume methods, and yields a map of the wave field. The wave-dependent transformational configuration is described with high temporal and spatial resolution.

Within the framework of the investigations the model was modified for the purpose of stable application at large model and prototype scales. Furthermore, it is also possible to determine the hydrodynamic loading on the inner dyke embankment by means of the modified version of the model. For this purpose different arbitrary roughness sections can be implemented in the model. These modifications create the preconditions for a general application of the mathematical model for dykes and revetments with natural shapes.

For verifying the model a series of wave channel data from the Leichtweiss Institute in Brunswick as well as from the Large Wave Channel in Hanover were available. These included simple dyke geometries as well as complex revetments such as those found on Baltrum and Norderney. Moreover, field measurements from Petten in the Netherlands were also included in the analysis (Berkenbrink et al. 2008).

Results

1. By means of the mathematical model OTT-1D it is possible to efficiently model the hydrodynamic loading of dyke and revetment embankments with high stability. Both simple and complex geometries are simulated well by the model. A comparison of the

model results with measurements shows good agreement with low scatter.

2. Within the framework of the KFKI research project "Wave overtopping loads on inner dyke embankments", detailed large-scale investigations of wave runup, wave runoff and wave overtopping were carried out. These data sets were used to verify the model with regard to layer thicknesses, velocities and wave overtopping for a simple dyke geometry. Very good agreement is obtained between measured and computed data for all hydrodynamic parameters. The results of small-scale hydraulic model experiments performed in Hanover for investigating the scatter of average wave overtopping rates were used for carrying out a sensitivity analysis (Kanis 2008).

3. Data sets from small- and large-scale investigations of the revetments on Norderney and Baltrum were available for the verification of complex geometries. By means of these data sets it was confirmed that the model is also capable of reliably simulating wave overtopping for complex geometries.

4. All of the computed results were compared with the results given by diverse empirical formulae. On the one hand, the equations based on the physical model experiments were used for this purpose, and on the other, the general equations given in the EurOtop Manual (2007). With the exception of a special non-transferable empirical adaptation function, the discrepancy and scatter of the model results were found to be less than those of the results obtained from the empirical equations.

5. Validation of the model using all data sets has shown that OTT-1D is universally applicable. A calibration equation has been developed which is valid for all data sets. Using the modified version of the model in combination with the calibration equation, it is possible to simulate realistic wave overtopping behaviour for arbitrary profiles.

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Fluid mud – extension of a numerical morphodynamic simulation model for simulating the dynamics of fluid mud along the German North Sea coast and its adjoining estuaries and tidal rivers (03KIS065)

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In situ measurements and rheological analyses of fluid mud

Owing to the rapid development of ship sizes in international maritime shipping and the continuous increase in draughts in recent decades, the maintenance of sufficient water depths in the approaches to seaports along the German North Sea coast is an important location factor in terms of competitiveness. In order to meet this demand it is essential to undertake ongoing dredging and sustained maintenance of seaport approaches on a permanent basis. Of the approx. 45 million m³ of material dredged annually in Germany in recent years, about 90% of this amount was from the North Sea coastal zone and its adjoining estuaries and tidal rivers. Especially in the freshwater and saltwater mixing zone (brackish water zone), a special, partly organic fine sediment permanently accumulates due to the large-scale hydrodynamic situation. This forms flocs in the water body with a very low settling velocity, which also varies according to the local sediment concentration and local flow conditions. On account of the latter, these flocs tend to settle especially in low-velocity zones and at the turn of the tide. The sediment concentration in the near-bed zone can become so high as to create fluid mud, which exhibits completely different flow characteristics compared with the overlying water.

The proportion of dredged material comprised of fluid mud is not exactly known. An indication of this is however given by dredging work in the port of Emden, where 4 million m³ of material consisting mainly of fluid mud was dredged annually from the port prior to the establishment of the present-day in situ maintenance strategy.

In order to minimise the maintenance costs for estuaries, the dynamics of fluid mud must be calculable. The hydrodynamic situation in the so-called partially-mixed estuaries along the North Sea coast is characterised by complex interactions between tidally-induced currents with density and stratification effects that transpire on very different spatial scales. The most dominant influence on water movement is the tidally-induced translation of the water body as a whole, which results from the cyclical variation of water levels on the seaward boundary of the estuary. Another important factor is the mixing of freshwater from the upper reaches with saltwater from the open sea and the resulting stratification effects, which range from local scales to large-scale baroclinic circulation.

With regard to sediment transport in the estuary the baroclinic circulation has resulted in a turbidity zone which is fed by sediment from the sea as well as from the upper reaches. The position of the turbidity zone, in which layers of fluid mud may form, is dependent

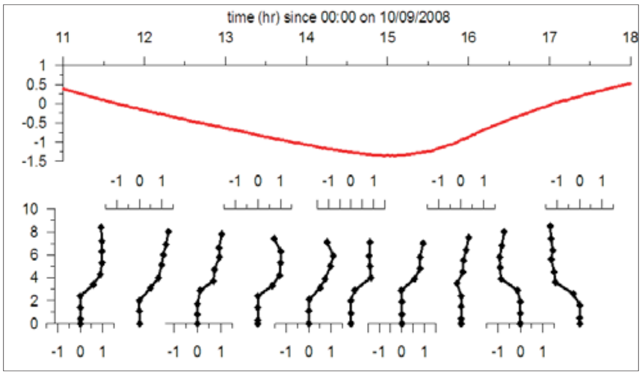

Figure 2:
Vertical velocity profiles measured over a tidal cycle in the Ems near Soltbor

among other things on the freshwater discharge in the upper reaches.

The mechanical properties of fluid mud are highly dependent on the type of bacterial metabolic processes that occur within the mud. The initially dominant aerobic metabolic processes gradually transform into anaerobic processes with increasing oxygen deficiency. Basically speaking, fluid mud exhibits viscoplastic material behaviour, i.e. it is capable of flowing according to a complex rheology, which is marked by shear liquefaction as well as thixotropy. With regard to navigability, fluid mud also possesses a flow boundary. In the long term (i.e. over several weeks and longer) it is essential to consider the above-mentioned mechanical properties in direct relationship to biological aspects, as these are significantly influenced by the metabolic products of the micro-organisms present. A decrease in oxygen concentrations due to aerobic metabolic processes as well as

Figure 1:
The Franzius Institute survey dinghy "Otto"

reduced turbulent mixing within the fluid mud eventually results in a changeover to anaerobic metabolism. Due to the metabolic products this is accompanied by a considerable increase in the mechanical strength of the fluid mud, which in turn favours its permanent consolidation. The anaerobic processes also result in an increase in the methane content of the consolidated fluid mud, which means that the effective density of the material considered remains relatively low even at this stage.

In order to model the above-mentioned processes it is necessary among other things to parameterise the structurally viscous properties of fluid mud, as these must be taken into account in the form of a nonlinear viscous term in the momentum equation for the suspension. The presented parameterisation based on the concept of equilibrium flow curves and additional parameters for describing the time-dependent structural strength permits the numerical reproduction of temporal shear tests carried out with a rheometer. The paper provides an overview of the most recent field measurements and rheometric analyses carried out in the field of fluid mud research at the Franzius Institute.

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OPTEL - Wind setup investigations and the development of an operational model of the tidal reaches of the Elbe (03KIS069-03KIS072)

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Aims of the project

Owing to tidal effects, seagoing vessels from the North Sea bound for Hamburg along the Elbe estuary require detailed spatial and temporal water level predictions. Reliable water level predictions are also very important for construction projects, power plant operation, water resources management and disaster control in the event of storm surges. Detailed information regarding tidally-dependent flow conditions is also important for certain manoeuvres in the port itself (e.g. docking of vessels, turning of very large ships). Within the framework of OPTEL it is intended to investigate whether it is possible to develop an operational water level and flow prediction model of the Elbe using existing hydrodynamic-numerical models with the computing power of modern-day computers. The proposed model should also be capable of accounting for extreme wind conditions and/or extreme freshwater discharge conditions in the upper reaches. It is planned to couple the proposed model with the models of the North Sea and German Bight, which have been routinely deployed over a number of years at the BSH. It is also intended to investigate whether it is possible to extend the forecasting period for water level developments e.g. in the Port of Hamburg.The partners involved in this project include the BAW (German Federal Waterways Engineering and Research Institute, Hamburg), the BSH, the HPA (Hamburg Port Authority) and the DWD (German National Meteorological Service). The BSH has developed and deployed operational numerical models of the North Sea, Baltic Sea and the German Bight for many years for predicting water levels, flow velocities and other physical parameters. In a joint project the BSH has extended this system to include an Elbe model, which is interactively coupled to the existing North Sea model. The BAW also has many years of experience regarding the numerical modelling of the Elbe, Jade-Weser and Ems estuaries for scenario and hindcasting investigations. It is intended to extend the modelling methods developed so far in order to realise an operational forecasting model for the tidal reaches of the Elbe by coupling the latter to the BSH North Sea model. Moreover, the BSH and the HPA have many years of experience regarding the analysis and empirical forecasting of water levels in the German Bight and the tidal reaches of the Elbe. The HPA has specified time periods for validating the models, and is currently carrying out comparisons with empirical methods for computing wind setup. The wind direction and wind speed data given by the numerical forecasting models of the DWD serve as essential input data for predicting water levels. The DWD has gained international reputation regarding the development, interpretation and implementation of short- and medium-term numerical weather forecasting models as well as extension models and downscaling methods. Downscaling is necessary in the case of the Elbe model because its horizontal resolution (initially 90 m, possibly 45 m later) will be considerably higher than that of atmospheric models. The DWD is therefore developing a method by which the wind stress acting on the water surface of the Elbe may be derived from the coarser atmospheric models COSMO-EU and COSMO-DE.

A further aim of the project is to establish operational running of the new Elbe model. Among other things, the purpose of this is to ensure that full advantage of the model results is taken in the long term. This will be carried out in connection with the operational forecasting model of the North and Baltic Sea, which has been deployed for many years at the BSH. Parallel to OPTEL, a new form of statistics for evaluating the model results (Model Output Statistics, MOS) is currently being developed at the BSH. By means of the latter it is hoped to reduce systematic errors and to refine the model results in a post-processing step in which the model results are coupled with measured data. It is anticipated that MOS methods will also play a role within the utilisation framework of the future Elbe model for the purpose of water levels predictions.

Once the operational deployment of the Elbe model has been established, the current forecasting data of all technical authorities of the Federal Waterways and Navigation Administration as well as the competent state authorities will be available for access on a BSH server. The experience gained during the development and pre-operational deployment of the operational model of the tidal reaches of the Elbe as well as the IT methods may be applied to other estuaries following completion of the project.

Current status of project work

The project began in April 2008 and will end in March 2011. Development of the models at the BAW and the BSH has now reached a stage as to permit hindcasting runs with the models. The DWD has now handed over the coefficient data sets for downscaling computations to the modellers at the BAW and the BSH, even though refinement work is still necessary. The time periods for validation have been specified by the HPA, and a wide range of measurements have been compiled for this purpose. For these time periods the BAW and BSH have already run the BSH North Sea model in order to compute boundary values for the Elbe models. The HPA has investigated different empirical methods for computing the development of wind setup between Cuxhaven and Hamburg. These investigations indicate that the formulation of wind setup involves complex relationships.

OPTEL - downscaling of wind fields from local models to the tidal reaches of the Elbe (03KIS070)

Wind fields over the Elbe

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In the OPTEL project, a method has been developed which permits the determination of high-resolution 3-D wind fields over the Elbe.

At the present time, only the coarsely resolved 3-D wind fields given by the COSMO-EU and COSME-DE forecasting models of the German Meteorological Service are available for the planned operational water level prediction model. The COSMO-EU model has a mesh width of about 7 km and is capable of computing forecasts over a maximum period of 78 hours in advance. Owing to the coarse mesh width, only a few grid points of COSMO-EU lie over the Elbe (see Figure 1). For this reason, a part of the Elbe is not accounted for as a water surface in the model. This means that the influence of the Elbe on wind speeds is not taken into consideration, and that wind speeds over the Elbe are to a large extent underestimated.

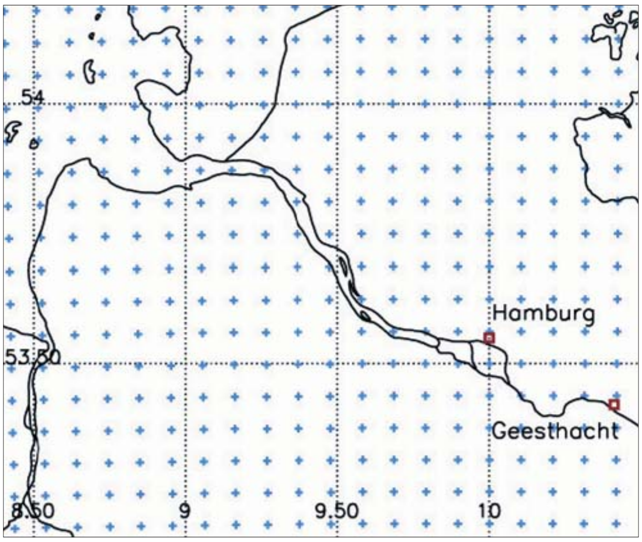

Figure 1:
COSMO-EU mesh points in the vicinity of the Elbe (blue crosses).

Although the second model COSMO-DE has a smaller mesh width of about 2.8 km, the maximum forecasting period of this model is only 18 hours. Because the Elbe is only covered by a small number of mesh points in this model as well, it is also necessary to derive wind fields for the Elbe with a greater spatial resolution than the existing model wind fields.

In order to compute wind fields with a higher spatial resolution, correction factors were determined with the aid of the model WAsP (Wind Atlas Analysis and Application Program) using a grid with mesh widths of 250 m for the wind speeds computed by COSMO-EU and COSMO-DE at a height of 10 m above ground level or tidal datum (=NN: Normal Null).

For this purpose different wind fields were first computed with WAsP by prescribing different boundary conditions:

1. Topography and roughness fields which are available as boundary conditions in COSMO-EU (COSMO-EU boundary fields).
2. Topography and roughness fields which are available as boundary conditions in COSMO-DE (COSMO-DE boundary fields).
3. Boundary fields compiled from topographical grid data and official topographical charts, which are referred to as OPTEL boundary fields in the following.

The correction factors are finally computed from the ratios of the wind speeds determined using the COSMO-DE boundary fields on the one hand and the OPTEL boundary fields on the other. Wind fields over the Elbe on the high-resolution grid are then obtained by multiplying the forecasted COSMO wind fields with the correction factors.

The right-hand box in Figure 2 shows an example of the correction factors for wind directions between 285 ° and 315 °. The left-hand box shows the average wind field computed using the COSMO-DE boundary fields while the middle box shows the average wind field computed using the OPTEL boundary fields. In the wind field determined using the OPTEL boundary fields a reduction in wind speeds in the lee of islands and sandbanks in the Elbe is clearly noticeable.

In this example the correction factors lie between 0.8 and 1.2 on average, and attain maximum values of up to 1.6 along the southern bank of the Elbe. Across land the values fall to a minimum of

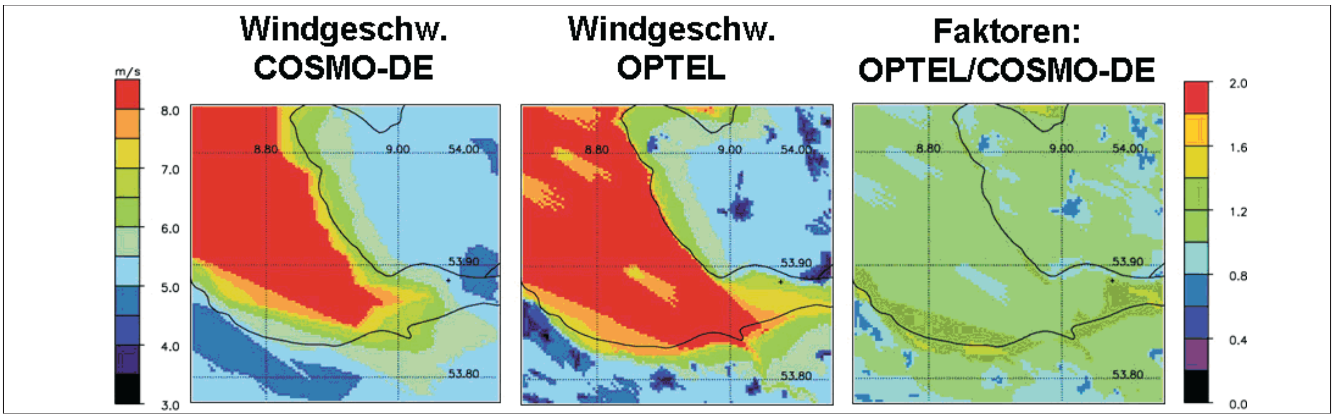

Figure 2:
Average wind speeds at the mouth of the Elbe for wind directions between 285° and 315°, as computed by the program WAsP with the boundary fields COSMO-DE (left-hand figure) and OPTEL (middle figure). The corresponding wind climate was determined from wind measurements at Scharhörn between 1998 and 2007. The correction factors were determined from the relationship between the COSMO-DE and OPTEL wind speed fields (right-hand figure). Black lines: banks of the Elbe.

about 0.6 in municipal areas or areas covered by woodland.

Correction factors are available over the length of the Elbe from the estuary mouth to Bleckede, for additional wind direction intervals, and also for comparing COSMO-EU wind fields with OPTEL wind fields.

OPTEL – Studies of surge development in the tidal reaches of the Elbe (03KIS072)

Empirical studies of surge development in the tidal reaches of the Elbe

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Thomas Strotmann

Hamburg Port Authority

Within the framework of the KFKI project OPTEL (Wind setup investigations and the development of an operational model of the tidal reaches of the Elbe) the Hamburg Port Authority (HPA) is engaged in the empirical-statistical analysis of storm surges.

In order to obtain a basic estimation of the quality of the results of existing transferral methods, three different empirical-statistical approaches for forecasting storm surges in the Elbe estuary were initially examined. In order to realise improved comparability of the results, this study was restricted to the peak values and times of occurrence of storm surges. These values reflect the dominant factors that influence tidal surges, e.g. freshwater discharge in the upper reaches, astronomical tide levels, wind, and also external surges. Of special interest for the Hamburg storm surge warning service WADI (HPA operational unit) is the transferability of the storm surge peak water levels at Cuxhaven to Hamburg Saint Pauli and their times of occurrence.

A comparison of the three methods considered – for about 150 events defined as storm surges in OPTEL – provides information regarding the standard error and which particular method is most suitable for further consideration. As may be seen in Figure 1, a major proportion of the results differ within a margin of ± 20 cm. This represents the tolerance range of the WADI forecasts at the time of occurrence of the peak water level at Cuxhaven. Nevertheless, a number of partly severe outliers are apparent, which clearly indicates that it is not possible to transfer all storm surge peak water levels with the required reliability based on the factors of influence considered so far.

Based on the standard error shown in Fig. 1, however, it is apparent that the setup method in terms of the sum of all events yields better results regarding the transferral of peak water levels from Cuxhaven to Hamburg than the other two methods. This observation led to more detailed investigations concerning the development of the surge wave at the tide gauges along the tidal reach of the Elbe as far as Hamburg. The results of these analyses indicate that it is possible to achieve a satisfactory linear transferral of the storm surge peak water levels to Hamburg based on the time of occurrence of high water at Brokdorf (see Fig. 2).

The standard error of the predicted water levels from Brokdorf to Hamburg is less than 10 cm. Because this point in time is too late for initiating disaster control measures, however, further investigations are now focussed on events at the mouth of the Elbe in order to improve the water level predictions at Brokdorf. The fact that steady winds from a direction of 285° in the German Bight are especially responsible for high water levels is well known from earlier investigations. In OPTEL, special attention is now being placed on wind action over the estuary reach between Cuxhaven and Brokdorf in a time window surrounding the time of occurrence of storm surge peak water levels at Cuxhaven. By taking into account the local wind recording stations at Scharhörn, Cuxhaven and

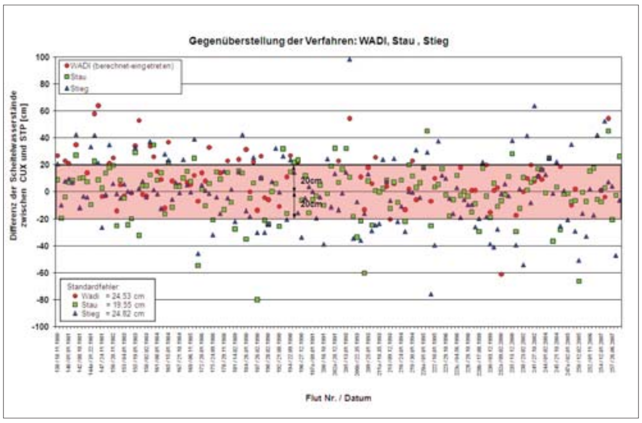
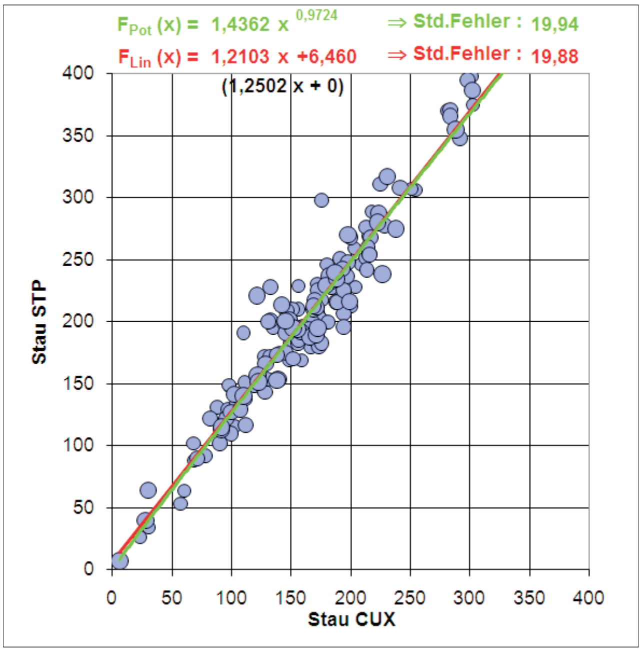


Figure 1:
Comparison of the results obtained by the different methods



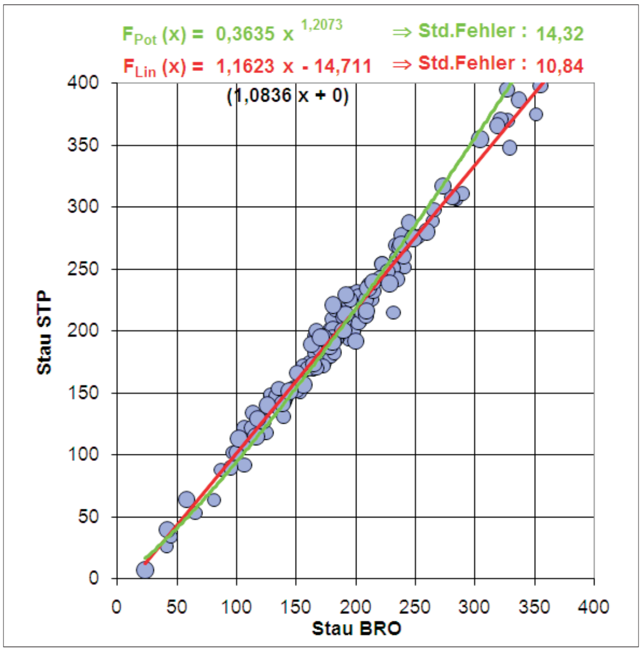


Figure 2:
Comparative representation of scatter diagrams for the transferral of water levels from Cuxhaven to Saint Pauli (left) and from Brokdorf to Saint Pauli (right)

Brunsbüttel it is hoped to gain a better understanding of the hydrodynamic processes governing water discharge characteristics at the estuary mouth. Investigations in the past have mainly concentrated on the most effective wind setup directions at these wind recording stations. The results so far suggest that west-south-west winds (250°-265°) in particular have a predominant influence on setup development between Cuxhaven and Brokdorf.

Referring to Fig. 1, a further important task is the consideration of individual storm surges – especially those that feature as outliers in the results obtained by the different methods. In this respect, special parameters must be defined for describing the development of storm surges which permit the cataloguing of storm surges and the dominating factors that influence them. If the outliers cannot be described by these parameters, these are the result of special circumstances that must additionally be taken into consideration. In this context, exemption rules should be formulated for the outliers, which could support the WADI in particular regarding the prediction of storm surge water levels in Hamburg.

AMSeL – Determination of mean sea level (MSL) and the analysis of highly-resolved tidal water levels along the German North Sea coast (trend investigations of tidal chains and residence periods that pose a danger to the coastline): MSL + North Sea trends (03KIS068)

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Dr.-Ing. Torsten Frank

Thomas Wahl

University of Siegen Research Centre for Water Management and the Environment (fwu)

Introduction / Objectives

Today, as in the past, the tidal conditions and development of water levels along the German North Sea coast are defined by various parameters (extreme water levels, peak values, MHW levels, MLW levels etc.) and evaluated on the basis of many years of observations. These evaluations range from statistical time series analyses to trend analyses. In contrast to the latter, the chronology of the tide, as marked by a temporal sequence of extreme peak water levels and the resulting residence periods of particular water levels, has not been investigated sufficiently. Moreover, an investigation of the so-called mean sea level (MSL) has hardly any tradition in Germany, even though this is a fundamental component of enormous importance regarding the future estimation of storm surge risks, international climate studies, scenarios of sea level rise, comparisons of observations with corresponding model results as well as satellite altimetry.

In the research project AMSeL these problems are taken up and investigated in order to ascertain the extent to which possible trends affect the concatenation of a series of consecutive extreme tides and whether an increase in very long periods of elevated low water levels is to be expected on the incoming tide. This would not only hinder inland drainage but would also redirect the main loading of wave attack to protected coastal sections previously subjected to only slight loading. In this context, there also remains the question as to whether individual high storm surge peak water levels or rather chains of extreme storm surges represent the governing load regarding coastal protection along representative sections of the coastline.

For the purpose of the MSL analysis, methods and methodologies were first investigated in order to generate homogeneous data sets from up-to-date high-resolution tidal curves and historical time series of peak water levels on the one hand, and on the other hand, to examine different parametric and non-parametric functions for determining trends in the compiled MSL time series.

In order to attain the most substantive results possible within the framework of AMSel, high-resolution temporal water levels as well as hourly and peak values were evaluated at a large number of representative tide gauges in the North Sea (see Fig. 1).

Data basis

During the course of the project to date a total of 1358 years of data records at 18 tide gauges (Fig. 1) have been lumped together; albeit with different temporal resolution and differing quality. A large amount of time was required to compile the data, check for data gaps and inconsistencies between different data records as well as to assess and re-examine the quality of the data recorded at the individual gauges.

Decisive gauges within the overall investigation set were identified in collaboration with the group accompanying the project. For the purpose of detailed investigations a considerable amount of effort has been spent on the high-resolution digitalisation of the data records at these gauges going back several years; these evaluations are still in progress.

Another important aspect in this respect is to guarantee consistency with the KFKI project IKÜS as soon as it becomes necessary to carry out partial evaluations of absolute referenced values rather than independently relative values or values referred to gauge datum.

MSL – Methods and sample results

Initially, MSL (i.e. mean tide level) time series are generated from highly-resolved data collected in recent years while time series of half-tide levels are generated from recordings of peak values further back in time. These are combined in order to obtain the longest and most reliable MSL time series possible. A precondition for this is to check the stationarity of the evaluated k-factor (LASSEN 1989). If non-stationarity is present, a match function of the nth order is used to correct the time series of the half-tide levels (WAHL, JENSEN and FRANK 2008, MUDERSBACH and JENSEN 2008).

The obtained MSL time series are further evaluated sequentially using both parametric (linear, quadratic and exponential functions) and non-parametric methods (sliding average and sliding linear trends over n years in each case as well as Singular System

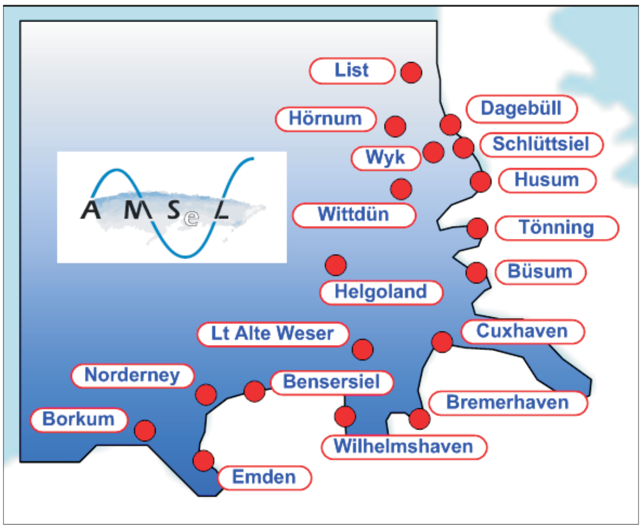

Figure 1:
Overview of the tide gauges deployed in the project

Analysis, SSA). Within this framework a new approach known as Monte Carlo Autoregressive Padding (MCAP) was developed.

Residence times / tidal chains

From an evaluation of the MSL as the still-water level and as a basis for all further considerations, an evaluation of residence times and tidal chains should provide an insight into the behaviour of water levels as well as the range of water level changes within a single tide or over a number of tides. For this purpose the investigations involve the exceedence periods of different water levels or the so-called emersion curves as well as permanent water level lines, residence times of water levels at particular heights as well as tidal chains or successions of elevated high water or low water levels (LÜDERS 1974, FÜHRBÖTER 1979, FRANK 2007).

In this case also, different evaluation methods yield different highly-resolved water level information ranging from peak values to minute-to-minute values. This is also reflected in preparatory investigations designed to estimate the effects of a change in the temporal resolution from e.g. minute to hourly values. The major point of concern at the present time is to determine different characterisation and parameterisation concepts for evaluating residence times in order to correlate the results at one gauge, referred to neighbouring gauges, with other tidal parameters (e.g. peak levels) as well as the temporal changes at the gauge location itself. For this purpose an analysis of e.g. the centrality with respect to modular values and the treatment of residence time histograms as a bimodal distribution should be considered.

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KLIWAS - Effects of climate change on waterways and shipping – development of adaptation options

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German Federal Institute of Hydrology

The research programme

Based on currently available climate projections, it seems highly probable that these will have far-reaching effects on waterways, shipping, ports and harbours, and the economic infrastructure along inland waterways. Nevertheless, there are still many uncertainties regarding (1) the severity of climate change, (2) its consequences in the hydrological system of coastal and inland waters, (3) the sensitivity of river quality and ecology as well as the effects on inland shipping and other waterway users. The increased concern expressed by politicians, the German Federal Waterways and Navigation Administration (WSV) and waterway users following the publication of the IPCC Report in 2007 was the major incentive for initiating the BMVBS (German Federal Ministry of Transport, Building and Urban Development) research programme KLIWAS. Those concerned expect reliable forecasts based on research as to whether and when it is necessary to implement adaptation measures in order to guarantee the continued use of waterways and harbours. The span of forecasts regarding the effects of climate change vary considerably according to the applied regionalisation procedures. The DWD (German National Meteorological Service) project "Compilation of input data sets for a generic effect model to estimate the consequences of climate change" (ZWEK, BECKER et al. 2008) demonstrates this for precipitation and air temperatures. The extent to which the span

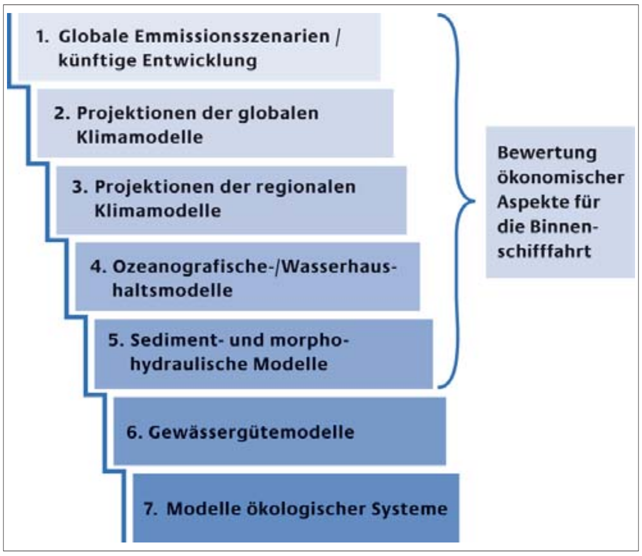

Figure 1:
KLIWAS model chain

diverges by introducing the additional working step concerned with hydrological parameters in the projection period up to 2100 is demonstrated by the initial results of the KLIWAS pilot project "Hydrology and inland shipping" based on the example of the Rhine, which has been in progress since 2007. In this study it was possible to make use of data from the EU project ENSEMBLES, which implements a wide range of global and regional models. An evaluation scheme by which different sources of uncertainty within the model chain shown in Fig. 1 may be assessed according to their relative importance in the range of discharge projections has been recently published (KRAHE et al. 2009). In accordance with the latter, a consideration of the results obtained from a single model with varying boundary conditions is insufficient for scientifically-founded policy counselling. It is far more appropriate to adopt a multi-model approach. This is a major task of the research programme KLIWAS, which places special emphasis on inland and coastal shipping.

The research programme is scheduled until 2013 and consists of 5 main projects involving 30 subprojects and a coordinating body. The research programme will be jointly undertaken by the following Governmental Research Institutes: the German National Meteorological Service (DWD), the German Federal Maritime and Hydrographic Agency (BSH), the German Federal Institute of Hydrology (BfG) and the German Federal Waterways Engineering and Research Institute (BAW). The strategy adopted in KLIWAS consists of the following three consecutive steps: 1. Determination and analysis of a range of climate and discharge projections by means of different global and regional climate models; 2. Assessment of the extent to which the traffic carrier "waterway" and the additional functions of rivers and coastal waters ("ecosystem services") are affected; 3. Analysis of sensitivity/level of impact, presentation of possible options for action and the consequential "vulnerability" of the sector. The keynote themes of the programme are outlined in the contribution. A central aspect will be a short presentation of the projects in the coastal/marine environment: for the North Sea and Baltic Sea the BSH and the DWD will generate time series of oceanographic and meteorological variables for the present-day reference climate and for different climate projections by means of long-term numerical simulations. In the proximity of the coast as well as in the Ems, Weser and Elbe estuaries, supplementary hydronumerical computations will be carried out by the BAW and the BfG. Based on the foregoing, the BAW will undertake an analysis of the vulnerability of hydraulic structures and facilities along the North Sea coast as a consequence of climate change and will develop adaptation options for the utilisation of waterways and harbours as well as for coastal protection measures. In the offshore zone the BSH will demonstrate the effects of climate change on maritime shipping and marine resources (such as e.g. the fishing industry).

The influence of climate-related changes on the balance of estuarine suspended material as well as the transport behaviour of contaminated sediment will be investigated at the BfG as a basis for updating dredged material management. In conjunction with the latter, the possible changes in river quality and hygiene will also be determined. On the basis of hydrodynamic loading as well as the results concerning suspended material and sediment transport, the BfG will then derive possible projections regarding changes in the foreshore vegetation of the Ems, Weser and Elbe estuaries and propose foreshore management adaptation options.

Besides forecasts of the impact of climate-related changes in the marine environment to be expected in the future, a detailed evaluation of the data available at the German Federal Waterways and Navigation Administration (e.g. tidal water levels) is also being undertaken. The results of already completed KFKI projects, such as e.g. the projects IKÜS and AMSeL, may be directly incorporated into the KLIWAS programme. In terms of networking, the KLIWAS partners are also represented in other research groups, e.g. KLIMZUG, and intend to extend networking during the course of their research activities.

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XtremRisK - Extreme storm surges along exposed coastlines and at the entrances to estuaries – risk evaluation and risk management in an era of climate change

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Introduction

Storm surges have repeatedly caused damage along German coastlines in the past. It is anticipated that the threat to coastal areas will increase considerably in the medium and long-term due to climate change. For this reason the most pressing task at the present time with respect to coastal protection is to estimate the increase in extreme storm surges regarding their frequency, intensity and duration, in order to avert possible catastrophies in populated areas along the coastline.

For this reason the joint project "XtremRisK" funded by the German Federal Ministry of Education and Research (BMBF) was initiated in October 2008. The aim of this project is to undertake a more detailed

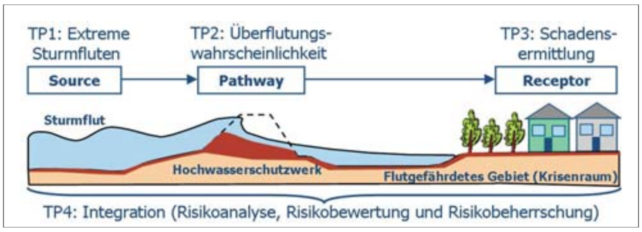

Figure 1:
Source-pathway-receptor concept and subprojects within XtremRisK

investigation of the effects of storm surges along the coast considering the example of the island of Sylt, and in an estuarine environment considering the example of Hamburg. The project partners include the Leichtweiß Institute of Hydraulic Engineering (LWI) at the Technical University of Brunswick, the Research Centre for Water Management and the Environment (fwu) at the University of Siegen, the Institute of Hydraulic Engineering at the Technical University of Hamburg-Harburg, and the Hamburg State Agency for Roads, Bridges and Inland Waters (LSBG).

The project is subdivided into four subprojects, which deal with risk sources (extreme storm surges), risk pathways (failure of flood protection structure), risk receptors (flooding and damage assessment), and risk evaluation (conflation of the partial results), respectively. The LWI bears responsibility for the management of the overall project.

It is anticipated that the results of the project will broaden our knowledge of extreme storm surge events. As such, the project will make an important contribution towards a determination of the risks of extreme storm surges in an era of climate change and hence provide a basis for identifying the courses of action necessary to counteract these risks. Further information may be found on the project homepage at www.xtremrisk.de.

The contribution deals with the presentation of the overall project and the most important objectives as well as a presentation of the initial results of the subprojects, as summarised in the following.

Subproject 1 makes use of two complementary methods in order to estimate physically possible extreme storm surge scenarios as well as to determine their corresponding probabilities of occurrence. The partners at the LSBG thereby apply an empirical method which takes account of the individual components of a storm surge (astronomical tide, wind setup, seiches, etc. and their interaction) explicitly, whereas the partners at the fwu apply a statistical approach in order to determine the joint probabilities of extreme events based on different storm surge parameters including waves.

In subproject 2, characteristic sub-area were selected in Hamburg and on the island of Sylt. A complete overview and a detailed description of the flood protection structures were compiled for these sub-areas. A classification of the individual sub-sections was then carried out in order to permit a subsequent probabilistic analysis of the flood protection structures. For this purpose an analysis of the required failure mechanisms and a compilation of the necessary limit state equations are currently being undertaken. The aim of this subproject is to determine the overall flooding probabilities for all selected sub-sections comprising the pilot sub-areas on Sylt and in Hamburg.

Subproject 3 consists of 2 parts. The first of these concerns the determination of relevant water levels and the wave climate in Hamburg under extreme conditions. The numerical model Kalypso coupled to the Delft University SWAN Model will be applied for this purpose. The results of subproject 1 will provide the basis for both models. In addition, damage assessment as a result of flooding, e.g. due to breaching of dykes, will also be undertaken in subproject 3. The numerical model FloReTo will be applied for this purpose. This model, which is currently capable of determining direct tangible losses, will be extended during the course of the project to also evaluate indirect economic and intangible losses.

Because the merging of all risk elements in subproject 4 relies on the results of the other subprojects as input data, this subproject was started nine months later. For this reason an analysis of so-called intangible losses (i.e. losses which cannot or are difficult to quantify in monetary terms) is currently being investigated for both pilot areas with the aid of socio-economic methods. In the next step it is planned to couple economic (tangible) losses with intangible losses in order to integrate these losses into a risk analysis. The aim of this subproject is to assess the overall risk for the pilot areas under consideration of tangible and intangible losses.

The current state of research in the subprojects and the follow-up working steps will be presented and discussed at the seminar.

Information systems for determining sediment dynamics based on spatial data pertaining to the EMS Estuary (WSV) and the Port of Hamburg

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Bodo Heyenga

Nino Ohle

Hamburg Port Authority (HPA)

Dr.–Ing. Frank Sellerhoff

smile consult GmbH

Depth-soundings are carried out within the framework of waterway maintenance and harbour management on a routine basis. The concept of a practical study, as discussed in detail in the following, was and still is the application of post-processed depth-sounding data primarily as an optimisation basis for reducing maintenance costs. The anthropogenically-influenced nature of the respective subsystems waterways and harbours is characterised in both examples by significant intensive sedimentation behaviour. By analysing depth soundings using the methods developed partly in the KFKI research project KoDiBa it is possible to discuss questions concerning sedimentation rates, existing relationships regarding upstream discharge, time of the year and other parameters with improved quality.

The following contribution focuses on the development and characteristics of two information systems by which depth soundings may be analysed with greater transparency, especially in qualitative terms. This is expected to result in an improved understanding of morphological processes.

Practical relevance

Port Authorities as well as Waterways and Shipping Administrations are obliged under private or public law to regularly monitor the bed levels of shipping channels in order to guarantee the necessary navigation depth. This is generally carried out using different methods such as profile depth-sounding, multibeam echo-sounding or combined methods (multisensors) which e.g. are able to record density or impedance jumps parallel to the bed. Depending on the authority commissioned to carry out maintenance work, a high degree of mutual interaction often exists between cause and effect. A large number of high-quality data records covering many years are available.

The consideration of morphological data in the same spatial context of a control volume, but at different times, yields an interpretable parameter regarding sediment characteristics and availability (owing to morphological dynamics) as well as the intensity of maintenance and locality characteristics. This is an important basis for both theoretical and operative methods.

Investigations carried out by the WSA Emden: the MorphoIS-Ems application

A special situation exists in the lower Ems due to adaptation of the shipping channel where necessary to permit the seaward transit of large ocean-going liners from the Emden shipyards, which primarily necessitates repeated dredging lasting several weeks at a time. Although the strategy is clearly "Damming up (by means of the Ems barrier) comes before dredging", the reduced amount of dredging as a consequence of this nevertheless leads to a significant increase in sedimentation and sediment intrusion rates following the transit of large vessels. In order to effectively and sustainably counter this cost-intensive and also ecologically disadvantageous situation the German Federal Waterways Engineering and Research Institute is currently working on solutions that require a detailed understanding of the system, which must be especially well-adapted in the case of the Ems.

The depth-sounding division of the WSA Emden monitors the existing navigation depth in the lower and outer Ems by profile soundings at a frequency of 33 kHz. Routine longitudinal soundings parallel to the shipping channel axis guarantee that the required shipping channel depth is permanently maintained. In sedimentological terms the lower Ems is characterised by a high content of fine sediment in suspension. When the turbidity is very high, this has a noticeable effect on the quality of depth soundings.

In a first step, the implementation of the KoDiBa functionality in the form of an information system coupled to a database containing depth soundings as well as the corresponding metadata permits quantitative prognoses which may also be described qualitatively using the meta-information. For the lower Ems, sedimentation rates were calculated in one-kilometre long river reaches over a period of several years. Using the meta-information "time of depth sounding", it is possible to arbitrarily select and process individual items of data or sets of data that clearly lie outside the long dredging periods. In a further step this yielded time series of sedimentation rates along the individual kilometre stretches of the lower Ems, which in quantitative terms, were partly as much as several decimetres per month. By comparing the latter with hydraulically similar reaches, periods of increased upstream discharge and the quantities of dredged material, it is hoped to improve and speed up the follow-up assessment of the results. The results obtained are expected to improve the sensitivity of the BAW numerical model forecasts and provide additional reference points regarding the sedimentation process.

Investigations carried out by the HPA: the HPA Sedira application

The application Sedira developed by the HPA is also aimed at improving our understanding of the overall system as well as our knowledge of sediment dynamics. In addition, it is hoped to provide answers to questions arising from discussions between different technical departments of the HPA such as e.g. the maintenance of water depths and the deposition of dredged material under different hydrological and anthropogenic boundary conditions.

Moreover, an important precondition for the development of Sedira is the on-going continuation of earlier investigations of sedimentation conditions in the dock basins of the Port of Hamburg, as carried out by Christansen and Haar (1996 and 1991) as well as Christiansen and Kamps (1985).These studies deal with the development of methods for evaluating analogue depth soundings carried out between 1977 and 1995. With the development of the Sedira system, these methods and analysis techniques have been adapted and refined in order to evaluate the spatially-distributed digital depth soundings recorded in more recent years.

The present-day methods and data implemented in the Sedira application thus permit more detailed analyses, which are expected to result in an improved estimation of sedimentation rates by including additional data such as, e.g. the coordinates of dredging fields, the quantities of dredged material, constructional modifications, hydrological boundary conditions or the results of hydronumerical simulations. An evaluation and interpretation of the results based on the experiences gained in the field of hydraulic engineering are expected to lead to spatially-differentiated forecasts of the sedimentation dynamics in the harbour basins, which will in turn constitute the basis for improved optimisation strategies regarding dredged material management and sediment management in the Port of Hamburg.

Procedural basis of the MorphoIS-Ems and Sedira applications

In order to deal with the questions arising from the above-mentioned projects, the two applications Sedira and MorphoIS-Ems were developed by smile consult GmbH. In basic terms, both applications rely on the results obtained from the KFKI research project KoDiBa (Sellerhoff, 2005). At that time, the main aim was to develop methods for generating consistent digital bathymetries. With regard to the problem presently under investigation, the model concept of a time series formulated in the project to describe the topographical evolution at a particular location with time was taken up and extended. Among other things, the extensions have a bearing on the consideration of anthropogenic interventions which affect the topography, such as e.g. dredging operations or the redisposition of dredged material.

The answer to these questions places high demands on the underlying data basis and a detailed description of the latter by means of metadata. A precise knowledge of both the spatial extension, which may be described using suitable envelope polygons, as well as the temporal extension is indispensable for the follow-up analysis of the time series. Both applications make use of the infrastructure for describing the required data and metadata, which is based on the relational database management system MySQL.

In a first step, time series which describe the temporal evolution of the bed will be generated for different control volumes. The time series generated in this way will be analysed in a further step. An analysis of the characteristics of these time series opens up the possibility of e.g. determining rates of change or the volume of sediment influx.

Whereas the algorithms used to determine the undisturbed time periods and average rates of change are similar in both applications, the methods of solution for determining the time series in each application are fundamentally different owing to the very different boundary conditions. The lower Ems is a relatively natural system, which, due to high turbidity, is monitored sparsely to some extent although regularly within the framework of depth-sounding surveys to ensure traffic safety. Information is transferred from upstream reaches of the estuary to reaches further downstream. In this case the data is evaluated on the basis of full one-kilometre stretches of the navigation channel. In contrast to this, a

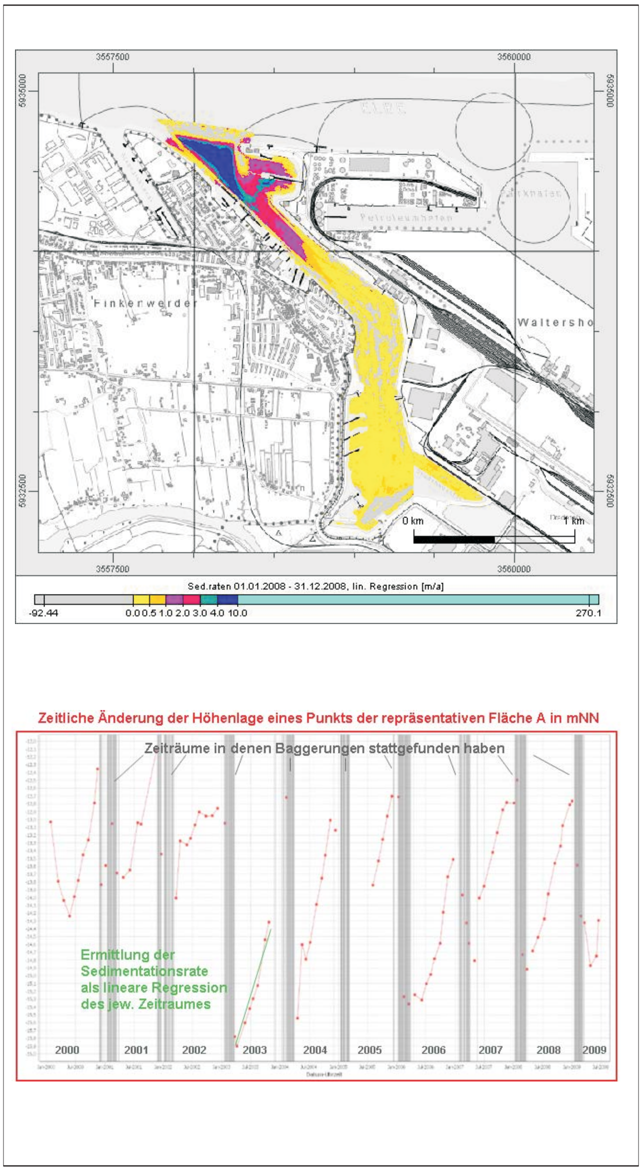

Figure 1:
Areal sedimentation rates and their temporal development

harbour basin represents a more or less anthropogenic system. Owing to the continuous utilisation of berths, periodical maintenance by dredging, and different physical processes such as, e.g. primary and secondary eddy currents at the entrances to harbour basins, it is necessary in this case to model and account for locally varying behaviour within the control sections by means of a large number of small control volumes (discretisation).

Summary

The experiences gained so far using the above-mentioned systems not only provide a deeper insight into the governing processes but also permit the visualisation and balancing of changes. During the course of investigations regarding the underlying causes of changes, it will also be necessary within the framework of further developments to not only analyse the time series of changes but at the same time take into consideration other parameters such as upstream discharge, tidal characteristics, salinity, temperature etc. and describe dependencies and interactions by means of correlations.

The rigorous analysis of depth-soundings and meta-data as well as synoptic data sets for the extended description of digital terrain models carried out within the framework of the KFKI project KoDiBa yielded the starting point for the information systems MorphoIS-Ems and Sedira. These information systems are currently being used to resolve morphological problems in the Elbe and Ems estuaries, and on the basis of previous results, have resulted in a deeper understanding of the system. This will in turn provide a starting point for the optimisation of surveying and dredging activities, maintenance work and the solution of ecological problems. Swiftness, interactivity and expandability constitute important prerequisites for practical work.

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New large-scale facilities for coastal research

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Lower Saxony Ministry of Science and Culture

The Lower Saxony Ministry of Science and Culture (MWK) and the German Research Foundation (DFG) are jointly financing two innovative large-scale research facilities at a cost of about 2.4 million Euros at the Leibniz University of Hanover.

With the acquisition of a 3-D wave generator for a wave basin as well as a new measurement system, the research group headed by Professor Torsten Schlurmann at the Franzius Institute of Hydraulic and Coastal Engineering will be able to further strengthen the position of the university in the field of coastal engineering research. The existing 2-D wave channel, which has been successfully operated by coastal engineers in Hanover for about 20 years, still remains the largest laboratory facility of its type worldwide.

According to Lutz Stratmann, the Lower Saxony Minister of Science and Culture, "The financing of this project by the State of Lower Saxony in collaboration with the German Research Foundation underlines the uniqueness of coastal engineering in Hanover in a national context".

And as expressed by Professor Schlurmann, "We are extremely pleased about the approval of the new facilities. These facilities will help us to become top players in the fields of Coastal Engineering Research and Marine Technology, and we already plan to engage in joint research projects with our colleagues at the GKSS-Research Centre in Geesthacht and other establishments affiliated to the German Marine Research Consortium".

The large-scale research facilities will enable the scientists to simulate and analyse the behaviour of three-dimensional short-crested waves and flow behaviour along the coastline and the associated complex interactions with marine structures such as breakwaters, harbours and wind-power installations for the very first time in a physical model.

The installations are also expected to make an important contribution to tsunami research. The researchers also intend to carry out analyses of wave runup and wave overtopping for coastal and harbour protection structures and further develop concepts for the dimensioning of sea dykes and quay walls. It is also planned to investigate the design and operation of offshore wind-power installations in the North Sea and Baltic Sea under realistic wave and sea-current loading. In addition, the researchers wish to gain a deeper insight into the effects of climate change on hydro-systems and infrastructures in coastal zones by simulating climate change scenarios for sandy coasts endangered by erosion.

The implementation of the new large-scale research facilities will also be of advantage to students, e.g. registered in the new Master Degree course "Water Resources, Environmental and Coastal Engineering", which is the first study course of this type to be launched in Germany. "The demand for Civil Engineers with this special profile is greater than ever, both nationally and internationally", according to Schlurmann. He anticipates a considerably expanded task and deployment spectrum for coastal engineers in the future. "Climate change will result in a rise in sea level, and the living and economic conditions along the coast will undergo lasting change."

Events

January 7-8, 2010	**40. IWASA - Internationales Wasserbausymposium Aachen**, Technologiezentrum (AGIT) am Europaplatz, Aachen, Germany info: www.iww.rwth-aachen.de
March 11, 2010	**39. Mitgliederversammlung der Gesellschaft der Förderer des Franzius-Instituts e.V. und Vortragsveranstaltung des Franzius-Instituts für Wasserbau und Küsteningenieurwesen**, Franzius Institut, Hannover, Germany info: www.fi.uni-hannover.de > Institut > Veranstaltungen
March 17-18, 2010	**Dresdner Wasserbaukolloquium "Wasserbau und Umwelt - Anforderungen, Methoden, Lösungen"**, Internationales Congress Center Dresden, Germany info: tu-dresden.de/die_tu_dresden/fakultaeten/fakultaet_bauingenieurwesen/iwd/kolloquien/kolloquium2010
June 30 to July 5, 2010	**32nd International Conference on Coastal Engineering (ICCE 2010)**, Shanghai, China info: http://www.icce2010.cn/

Imprint

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