News of the German Coastal Engineering Research Council

KFKI aktuell

ICCE 2008 – a successful conference held in Hamburg

From August 31 to September 5, 2008, the International Conference on Coastal Engineering ICCE was held in Hamburg's CCH for the second time since 1978. 917 participants from 45 countries experienced an unforgettable coastal engineering event. Topics ranging from coastal processes, coastal and harbour structures, ports and waterways to environmental aspects, risk and development of the coastal zone were covered in 517 presentations. With 266 participants, Germany provided the largest delegation followed by the United States (98) and Japan (95). Coastal engineering is gaining increasing importance if nothing else through the effects of climatic change. Moreover, questions concerning the risk and effects of hurricanes and tsunamis are the focus of attention among experts and in the public because of recent events in the USA and South-East Asia.

These facts were impressively emphasized by the keynote lecture "Coasts – the riskiest places on earth" given by Dr. Wolfgang Kron (Munich Re Group). He illustrated his point by showing that the risks in the coastal zone will grow in the future not only due to an increasing population density and utilization of the coast but also because of augmented threats deriving from naturally occurring extreme events. Therefore, coastal engineering research is actually of great importance for the sustainable use of our coastal zone by industry, tourism, ecology, fisheries, marine traffic etc.

78 German papers and 15 posters were presented. These had to pass through a stringent review process by 17 experts with only one German participant. It must also be emphasized that only 50 % of all submitted contributions passed the review and were permitted to be presented. This again underlines the high scientific standard of the ICCE as compared to many other conferences.

For those who are interested, all abstracts of papers presented can be downloaded from the conference homepage ***http://icce2008.hamburg.baw.de.***

Printed proceedings will likely be published in April 2009 and will be available through the library of GCERC (KFKI).

The breaks were an excellent opportunity for exchanges between participants and a visit of the trade show with 34 exhibitors from construction industry, building materials, consulting, measurement technology, scientific publishing and coastal and harbour authorities. At this point, we would like to explicitly thank all exhibitors for their commitment. A special "thank you" goes also to all sponsors of the conference. Without their support an event of this size and importance could not have been realized.

The conference was also well suited to inspire students, young scientists and engineers as well as administration trainees in the field of coastal engineering. Many of the auxiliary personnel were students from the universities RWTH in Aachen, Hannover and Hamburg-Harburg as well as trainees from the Federal authorities and Hamburg Port Authority.

The Wednesday afternoon at the ICCE is traditionally set aside for professional excursions. This year's destinations were the Port of Hamburg with the container terminals of HHLA and Eurogate, the Airbus Factory , flood protection works in Hitzacker and the ship lift in Scharnebeck, "Blanker Hans" and dike museum in Büsum as well as the holm (Hallig) "Langeness" and the Eider storm surge barrier.

A festive banquet in the culture and trade storehouse in the "Hamburger Speicherstadt" concluded the ICCE 2008.

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Behaviour and Properties of Fluid Mud (03 KIS 051)

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The open tidal harbours of Emden, Bremerhaven and Brunsbuettel at the German North-Sea Coast, are situated in the brackish zone of the tidal rivers Ems, Weser and Elbe (Fig. 1). In these zones the intermixture of the fresh water discharge with saline North-Sea water causes high concentrations of fine cohesive sediments. In harbour reaches with low current intensity fluid mud layers can accumulate to a thickness of several meters. The annual sedimentation rates in those harbours are higher by an order of magnitude than e.g. in Bremen and Hamburg, both located upstream of a significant seawater influence. A major reason for this accumulation of solid material is the superposition of tidal and density currents.

A research project was initiated (German Ministry of Education and Research, BMBF, grant number: 03KIS051) to explore the sedimentary and rheological properties of fluid mud in various brackish water harbours at the German North-Sea Coast.

The analysis of dual frequency echo soundings (210 kHz and 15 kHz) demonstrates that the fluid mud volumes in the outer harbours of Emden, Bremerhaven and Brunsbuettel have been nearly constant over a period of years. Bars at the harbour entrance are the key reason for the creation of fluid mud in the adjacent trough.

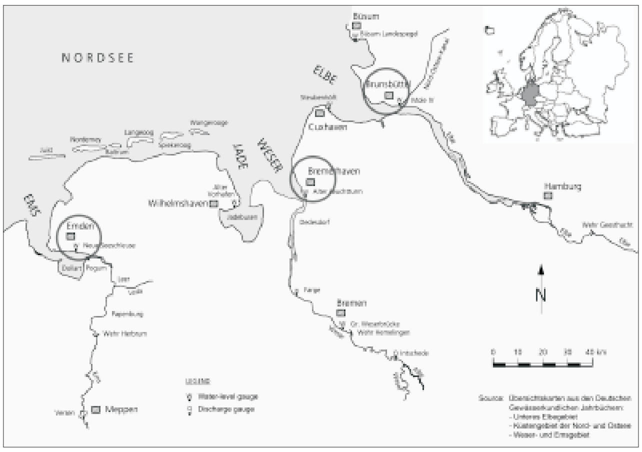

Figure 1:
Map of the German North-Sea Coast

The paper presents results of in-situ measurements as well as methods for the prevention of sedimentation in such harbours. The behaviour of the cohesive sediments is determined not only by physical but also by chemical and micro-biological processes. With changing rheological properties (viscosity and shear strength) fluid mud increasingly adopts characteristics of plasticity inside a transition zone. The research studies have shown that in general the water - fluid mud interface is to be found at the high frequency echo. Below that is the transient zone to navigable mud with Newtonian behaviour. In the vicinity of the 15 kHz horizon non-navigable material was detected with densities of $\rho > 1.2 t/m^3$ and viscosities $\mu >> 100$ Pas (Fig. 2).

Based on data of current and morphological conditions, innovative strategies using water injection or remedial dredging were developed to Keep the Sediment In the System (KSIS). Handling and controlling fluid mud is possible either by Keep the Sediment Navigable (KSN) or Keep the Sediment Moving (KSM).

The KSN strategy takes advantage of the ability of ships to sail through fluid mud by maintaining the aerobic conditions in the fluid mud layer with the supply of oxygen. The KSM method is based the bottom sloped from the sea-lock towards the harbour entrance.

With these measures conventional dredging in the outer harbours has been reduced to zero saving costly deposition or dumping of dredged material.

In the full paper the hydraulic boundary conditions, the fluid mud pattern and the variation of fluid mud properties between the "lutocline" layer and the 15 kHz-horizon (variation in ignition losses, solid matter, density and viscosity) are discussed.

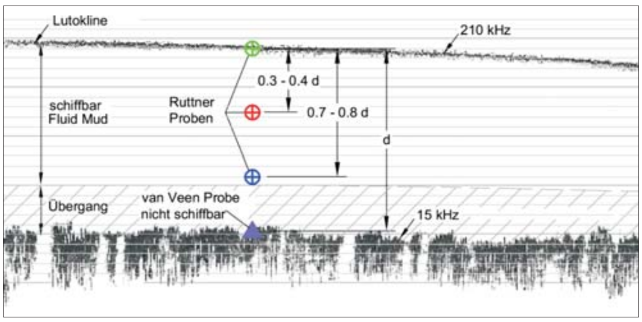

Figure 2:
Depths of the Ruttner- and van Veen-Samples

kfkiGIS – Information and Design Tools in NOKIS (03KIS073)

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German Coastal Engineering and Research Council (KFKI)
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smile consult GmbH

Introduction

kfkiGIS can be considered the prototype of a web-based geographic information system which has been developed by the GCERC (KFKI) office. This system will provide distinctly improved information about coastal engineering data. Fundamentals of the system will be the standardized methods and Internet-based services of NOKIS. kfkiGIS is a Java web-start application which is available from NOKIS ***www.nokis.org*** and GCERC ***kfki.baw.de.*** It has been well documented with attached examples for its utilization.

kfkiGIS Technology

First of all, a structured documentation of the data inventory is done using the NOKIS metadata profile of the coastal zone. Thus, coastal data can also be found and accessed via existing information and search systems such as GDI-DE and Portal U.
In addition to the bounding box, metadata generated with the NOKIS information infrastructure commonly include complex polygons for the description of the actual location and extension of data. For a map-based search, these polygons are analysed and evaluated within the visualisation modules of the NOKIS servers. By using industry standards for Internet-based services of the Open GIS Consortium OGC the access to available coastal data is made possible. These are catalogue services (CS-W) for the communication between metadata servers, map visualization (WMS) and data allocation services. For those data which have been processed using adequate techniques these three core technologies support the inter-sectoral information exchange between all Federal and State coastal agencies cooperating in GCERC.
Generally, metadata of visualized data can be accessed by mouse click in all maps offered in kfkiGIS. Previous WMS applications mainly access GIS data sets which describe topical maps. Within geo-processing they avail themselves of the interoperability of data from various sources.
So far, no standardized web-services have been available for data such as time series of scalars and vectors as well as their statistical analysis. Particularly hydrological measurements result in this type of data, thereby creating a deficit in the web-based management which is made up for by methods embedded in kfkiGIS, now.
A service desktop provides the connection between metadata and services for predefined data types. A visualization of data can directly be initiated from the hit list resulting from a data search.

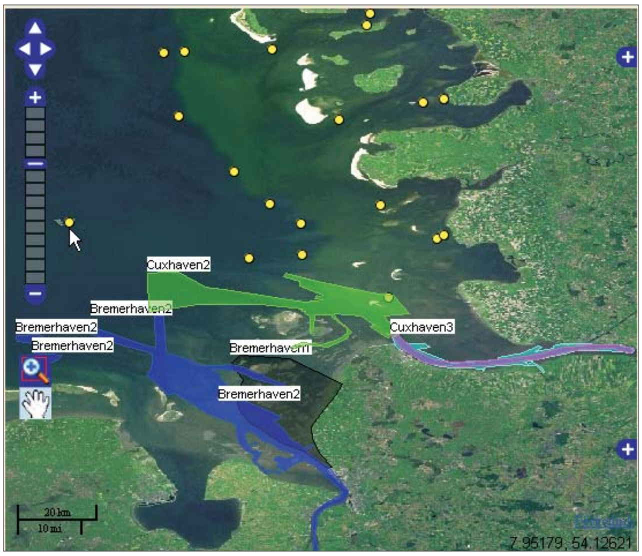

Figure 1:
Maps generated by NOKIS-map - servers of the BLMP – measuring programme and the GCERC synopsis in kfkiGIS

kfkiGIS examples

At present, 10 map servers for coast-relevant information with altogether 150 thematic layers are integrated in the kfkiGIS prototype application. These also include NOKIS WMS which shows the active measurement installations of the joint Federal State Measurement Programme BLMP (Bund-Länder-Messprogramm) as well as the scheduled campaigns of the GCERC working group on 'synoptic bathymetric survey'. The example of an ADCP measuring campaign in the Elbe estuary demonstrates that geo-referenced GIS–atypical coastal engineering data can be processed and published based on the given standards. More data inventories stemming from GCERC projects will be processed accordingly using WMS and WFS. The concepts and techniques for the interfacing of metadata and web-services in kfkiGIS will be further developed in the future.

Identification of Morphological Trends and Velocities in the Near-shore Zone (03KIS059)

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Introduction

Bathymetric surveys carried out regularly by various institutions and with different methods and objectives are the basis for the evaluation of long-term morphological changes and the responsible physical processes at the German North Sea and Baltic Sea coasts. Even though measurement methods and techniques are being continuously improved a synoptic inventory of the sea bottom (bathymetry) of vast areas will not be possible in the near future. The concept of a digital terrain model in space and time is used for the assessment of spatial and temporal changes. Consequently, this implies a multitude of basic data sets with their interpretation codes attached.

Methodology

Bathymetric data sets supplied by project partners such as NLWKN, LKN-SH, StAUN-Rostock and BAW Hamburg were structured in a day-sequential order and considered to be the basis data sets. After suitable spatial interpolation and attaching metadata, they were stored and archived in an object-oriented databank ***www.db4o.com.*** This procedural method permits the application of dedicated approximation and interpolation methods tuned to the type of survey data (line or fan-type echo-sounding, laser-scanning etc.) Moreover, their validity domain was established. For the determination of quasi-synoptic bathymetric models at random points in time interpolation and approximation methods have to be additionally applied together with the determination of temporal validity domains. Then, a quasi-synoptic digital bathymetry at a certain time step can be interpreted as a horizontal intersection in a spatial and temporal validity domain.

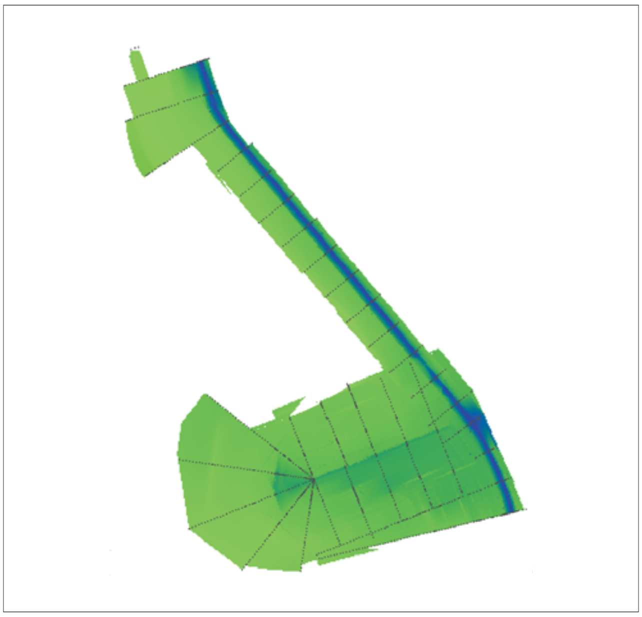

Figure 1:
Profile interpolation within the non-convex validity domain of a data set

Such a quasi-continuous bathymetric model is variable in space and time and based on a data bank. On this assumption multifarious non-classical analyses such as the computation of derivations and iso-planes as well as their derivatives are possible.

Preliminary results

For data processing and the assessment of methods for interpolation and analysis a graphics user interface with various views on data and engineering-compatible visualization was implemented. This included a differentiation between assessing original data with the attached metadata, the quasi-synoptic bathymetric models with their interpolated depth values and the derived analysis methods.

Generally, the identification of morphological changes is achieved by comparing and balancing the bathymetry obtained for different years. The spatial and temporal examination of a digital bathymetry leads to further geometrical analyses, e.g. to the continual identification of contour lines and ridges. Moreover, abstract mathematical methods such as the theorem for implicit functions can be applied to derive morphological process velocities. A "morphological process velocity" is considered to be the speed of the movement of contour lines and can be used to identify, e.g.,

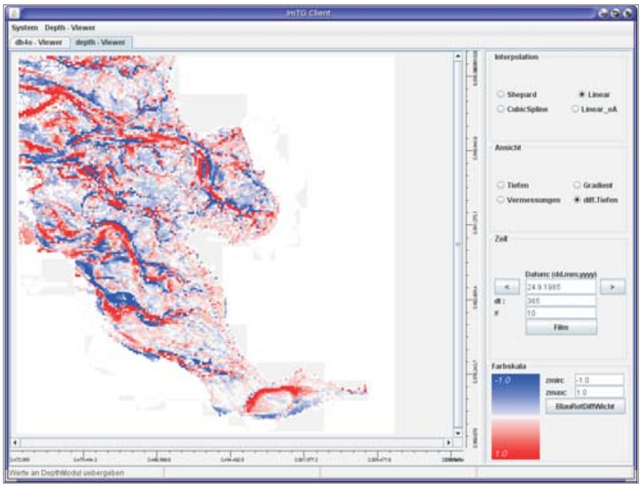

Figure 2:
Areas of deposition and erosion in the region Dithmarscher Bucht derived from the depth differences between the years 1985 and 1984.

coastal recession or shifting of mega ripples and other transport bodies.

Future prospects

Further information can be called upon to continuously improve the coupled spatial and temporal interpolation and approximation methods. This includes the consideration of spatial and temporal glitches and discontinuities, caused by man-made interferences, or of derived morphological velocities. The assessment of resulting sediment transport rates which have caused the observed bathymetry changes can be carried out by applying an inverse finite volume method. Resulting sediment transport rates, however, are only unequivocal for closed systems. For areas with open boundaries, a link with process-based morphodynamic simulation models is necessary. Further optimization of the object-oriented data and method administration within the bathymetric data bank as well as its integration into engineering applications are yet another challenge within the project.

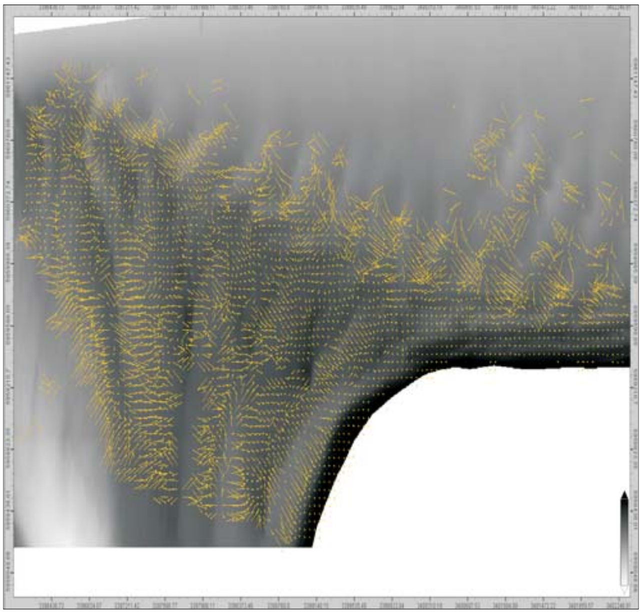

figure 3:
Derived morphological process velocities off Langeoog (> 1,300m/a); depth distribution of 2002

Integrated Height Monitoring System in Coastal Regions - IKÜS (03KIS056)

IKÜS-B: Water Gauges

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The cooperative project IKÜS was carried out in order to combine measurement methods (levelling, Global Navigation Satellite System GNSS, gravity and gauge measurements) in a consistent, homogeneous and kinematic model for the survey of recent movements of the earth's crust in the area of the German Bight. As part of IKÜS, BfG carried out the tasks of analysing data from levelling campaigns along the Federal waterways (BfG / WSV) and processing and analysing geodetic gauge information and water level data. In a technical sense, these levelling ventures cannot be differentiated from those carried out by the State survey authorities and were connected with the official height network. Consequently, all available levelling data of BfG/WSV concerning the coastal area were processed and implemented into the IKÜS databank. In order to minimize possible errors during digitizing within the IKÜS scheme, it was decided to use the original field log denotations. Depending on the field campaign, the time and the executing authority, measurement points and, consequently, benchmark points (PFP = Pegel-festpunkt) and reference data (PNP = Pegelnullpunkt) have different denotations. For this reason, it was necessary to identify single points or rather store the various denotations of identical points in the databank. In addition to the processed levelling results of the State survey authorities, those produced by BfG/WSV together with the identification table for points constituted the basis for the kinematical model of the project partner TU Braunschweig.

Processing of the gauge data primarily included the processing and implementation of the geodetic gauge information. The gauge directive (Pegelvorschrift PV) defines a "gauge" as being an installation to measure water levels. Accordingly, its decisive components are a staff gauge and at least three dedicated benchmark points. The point of origin of a staff gauge is called the reference datum (PNP). The benchmark points are to register vertical movements of the surroundings and, consequently, of the gauge itself. Thus, the internal geometry of the gauge system must always remain constant.

In practice, this means that the height set-point differences dh_{soll}, which are defined to be the height differences between PFP and PNP at the time of the installation of the gauge, have to be kept constant during the entire service time of the gauge.

Because of the PFP being subjected to different vertical movements in due time, at least one PFP has to be declared representative based on local conditions and experience. Through a connection to an official height reference system a PNP is geo-referenced or its level is defined in relation to a higher-ranking height reference system. Only this regulation permits a comparison between water level registrations of various gauges. The analysis of long-term water level variations (e.g. as an indicator for climatic changes) implies that the absolute level of gauges and their PNP are constant or known during the entire observation period. The gauge directive prescribes that - for an initial measurement - the PNP in the coastal region is to be set at NN – 5.00 m. Tectonic and man-made influences (e.g. extraction of natural gas) can cause a vertical movement of the earth's crust (recent crust movements) with the installed gauges following these movements. Frequently, real water level modifications are super-imposed by recent crust movements which can attain some mm/a along parts of the North Sea coast. Consequently, these hidden vertical movements of gauges can result in spurious water level changes while hydrological causes or climatic changes of the water level cannot be identified or proven. This problem is met by the gauge directive (PV) requiring regular levelling of the gauges and connection with the higher-ranking height network of the State authorities.

Historically developed, various realizations of suitable official height reference systems exist, which differ by the order of several centimetres and cannot be directly combined.

Due to their connection with the respectively valid height reference system, level information of gauges are available in various realizations. As an example, the effects of the system change of the gauge "Helgo-land"' from the reference datum HN (Helgoländer Null) to NN are shown in Fig. 1. Contrary to this step occurring in the water level time series of 2002, as illustrated in Fig. 1, the effects of other system changes are frequently big enough to falsify long-term trends but too small to show in the time series of water levels.

Due to misinterpretation of the gauge directive, the reference data (PNP) of gauges were kept at NN -5.00 m by shifting the staff gauge in spite of level changes of the benchmark points (PFP). Consequently, the height set-point differences dh_{soll} and the internal geometry were changed. Moreover, the PNP was set back to NN – 5.0 m after a gauge had been relocated or rebuilt. This entails, that possible vertical crust movements were mechanically compensated by shifting the staff gauge.

Postulations for a constant internal relation between PFP and PNP and for a PNP at NN – 5.00 m exclude one another because level changes of the PNP inevitably lead to a contradiction followed by different interpre-tations of the gauge directive concerning the main-tenance of the PNP level and consideration of different height reference systems. So far, the approach towards dealing with confirmed level changes on the

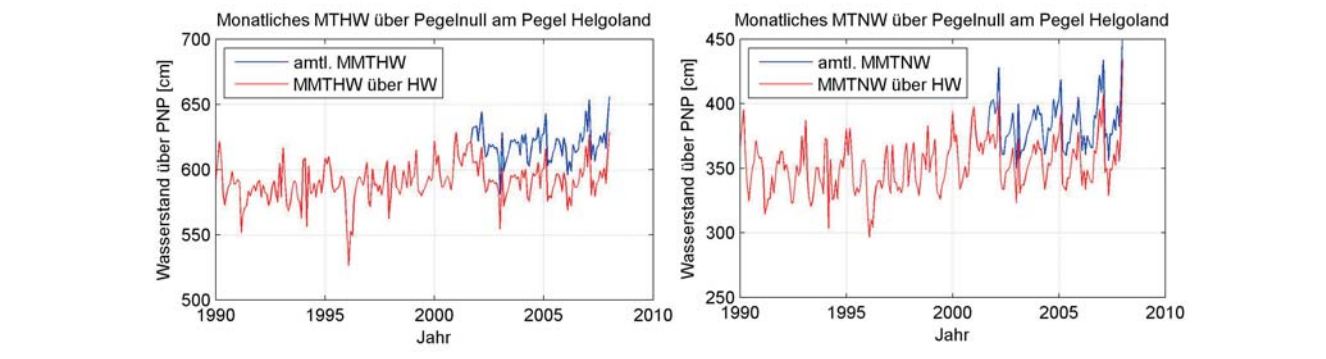

Figure 1:
Effects of the system change from Heligoland reference datum H.N. to N.N on the registered water level

one hand consists of a mechanical shift of the staff gauge with consideration of the resulting height set-point differences dh_{soll}; on the other hand the dh_{soll} is kept constant and the level information of the PNP is changed. In the past, both methods have been applied to one and the same gauge with the result of heterogeneous data sets which - from the viewpoint of geodesy and for the verification of secular water level changes - are inadequate.

Within the framework of IKÜS the geodetic gauge information has been processed such that the request for a constant geometric relation between representative PNPs and PFPs (constant height set-point differences dh_{soll}) has been met and, at the same time, the true levels of the PNPs are displayed. This practically means a reversal of the shift of the staff gauge by an application of offsets on the water level data. Should staff gauge shifts have taken place at a gauge it is important to know which PFP was considered representative for the vertical movements of the immediate surroundings. These circumstances are of special interest in connection with coastal structures since the water level changes relative to the immediate surroundings are important.Through a combination of processed gauge information, the connecting levelling and the results contributed by the TU Braunschweig, PNPs and PFPs can be integrated into the kinematic IKÜS-model.

Based on the water level data above PNP conclusions towards secular water level trends with the consideration of vertical crust movements can be drawn. The associated water level data was analyzed within IKÜS and was implemented in the IKÜS-databank with metadata attached. A concept for future gauge monitoring was developed and realized in its beginnings. The core of this concept is constituted by permanent GNSS gauge stations. The data collected will be analyzed in a homogeneous, globally compatible reference system meeting official as well as scientific requirements.

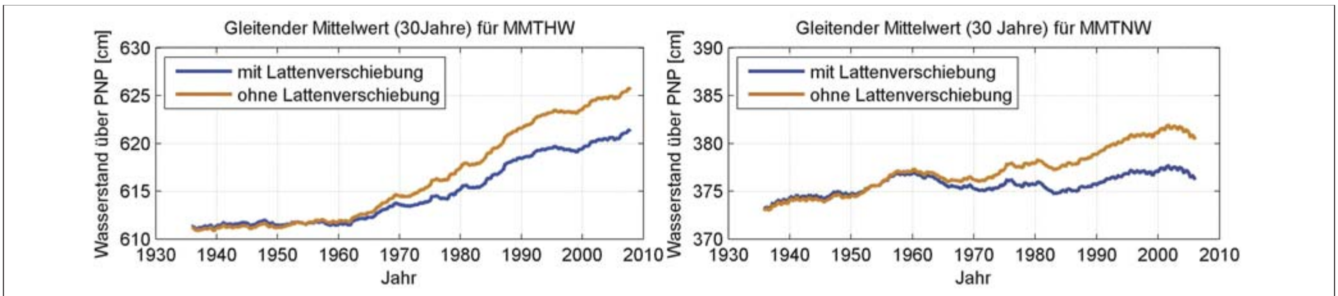

Figure 2:
Official water levels and those corrected by staff gauge shift for the tidal gauge Norderney

IKÜS – Integrated Height Monitoring System in Coastal Regions (03KIS057)

IKÜS – C : Composite Information Derived From Height Measurements

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Project definition

The original objective of the project IKÜS is the verification of current height changes in the North Sea region. This is done by in-depth processing and analysis of the available primarily geodetic measurement information and a subsequent algorithmic-numerical combination. Within this work, one aspiration was the stringent combination of physically different sensors in order to detect and eliminate any remnant systematics by using redundancies. Of overriding importance was the determination of firm conclusions concerning the well-known or expected height changes of the earth's crust which have to be considered in the present discussion about the anticipated mean sea level rise for the design of special coastal structures, in particular dikes. Processed measurement data and its attached meta-information are stored in a special databank which will be made available to the GCERC (KFKI) community after completion of the project.

Database

Processed levelling data of the last 100 years and recordings of continuously operating GPS stations (mostly SAPOS stations) of periods of up to 10 years were used as a data basis. The project area of IKÜS is generally the German North Sea coast. However, since data from GPS time series in Schleswig-Holstein were available to us for only a maximum of 2 years, this area was not included in the combined analysis. Gauge records themselves have not been included in the analysis model; processing and analysis carried out by BfG, however, stringently allow for IKÜS-determined height changes in the time series of water levels.

Mathematical model for the combination

a) Direct determination of height changes

The innovative approach of the IKÜS-project focuses on the derivation of height changes as discrete information. So far, elevations had been directly determined from a levelling campaign. Height changes were then determined from comparison. Problems with this classical approach arise from changes in the reference point system and/or different benchmark points used for these measurement campaigns which often lasted for several years. A priori, the motion behaviour of these benchmarks is not known.

To avoid these problems with reference data in IKÜS so-called double-differences were derived from the levelling data. In essence, the repeated generation of height differences between two neighbouring points with a sufficient time interval between repetitive measurements results in a "datum-free" information.

In GPS time series temporal changes are available directly and with a high accuracy, even though the absolute position of the station may not be known exactly. However, for GPS data a necessary change of antennae requires offsets in the motion model quite often.

b) Linear planar motion model

A linear motion model has been set up for the expected movement of measured points. This approach considering only linear changes is surely justified for the relatively short period of approx. 100 years within a geological time scale. In addition, it has been proven to be meaningful to include seasonal movements in the evaluation model. So far, however, anthropogenic influences such as mining activities e.g. in the gas field "Groningen", other active oil and gas extractions or major dredging works have not been taken into account. A special feature in the evaluation approach is the claim to derive information about movements of areas and, thus, obtain complete motion pattern for the entire investigation area. Since continuous GPS data are only available on points and levelling data follows lines a mathematical "ansatz" had to be found to include both, the spatial and temporal interpolation. A suitable approach was the utilization of "radial basis functions (RBF)" which were applied as "normal probability curves" in this project. The height of a normal probability curve (bell-shaped curve) is in accordance with velocities and was determined by approximation; the effective or interpolation width was prescribed.

Results

Final objective of the project IKÜS-C was a stringent combination of processed data sets obtained from GPS and levelling based on the stated principles for the model generation. Due to a lack of GPS data, the North Sea coast of Schleswig-Holstein had to be omitted, however. Compiled results are illustrated in the attached figure. Using the RBF, height changes in the order of mm/a have been interpolated for areas. GPS stations in Southern Lower Saxony classified as stable were chosen as reference points. It has to be noted, that much less levelling information and hardly

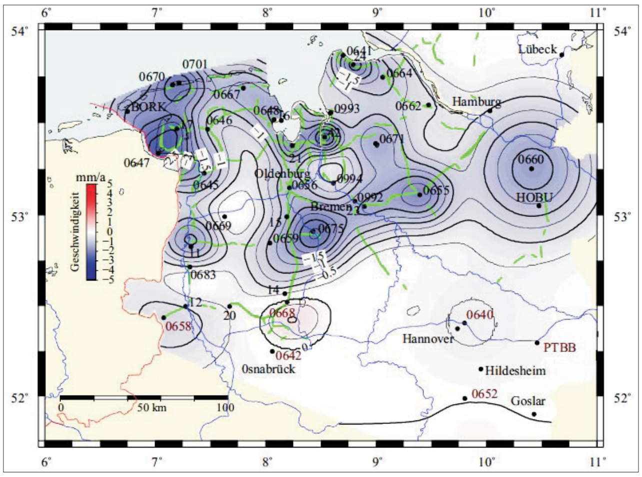

Figure 1: IKÜS-result: height changes derived from a stringent combination of GPS time series and levelling data

any GPS data were available for the islands off the coast; thus, part of the results here should be rather considered an extrapolation.

NOKIS++ - Information Infrastructure for an Integrated Protection of Coastal Waters (03F0412B)

Monitoring of the Marine Environment - Example: Operational Monitoring of Sediment and Habitat

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Ministry of agriculture, environment and rural areas the State of Schleswig-Holstein

The research project NOKIS++ (Information Infrastructures for the North Sea and Baltic Sea) was launched in 2004. It is supported and funded for four years by GCERC (German Coastal Engineering Research Council - KFK) and FMER (Federal Ministry of Education and Research - BMBF). In addition to 14 partners from State and Federal agencies working in Germany's coastal regions, IT developing firms and research institutions took a decisive part in the realization of the project.

Based on the North Sea and Baltic Sea Coastal Information System NOKIS, the objective of the two-phase project was to develop an information infrastructure for an integrated coastal hydrography and for an integrated protection scheme for coastal waters. These structures are generally based on standardized metadata (ISO19115), web services (ISO, OGC) and the linking-up of information (networking). The technical aspects of this development have already been described in a previous edition of KFKI-aktuell (6 (2) 2006, 7 (1) 2007). To understand the motives for launching the sub-project "information infrastructures for an integrated protection of coastal waters" one has to take a look into the development of marine monitoring. Issued already in 1976, the "recommendations for a monitoring network for water quality in the coastal waters of the Federal Republic of Germany" were the beginning of a coordinated monitoring in Germany. Since then, the

Federation and the States have been involved in monitoring programmes such as OSPAR, HELCOM, TMAP and the "Federal-State Monitoring" (Bund-Länder-Messprogramm). These programmes focus on hydrographic measurements, monitoring of the nutrient budget, the chemical load and their effect on the marine environment and its aquatic communities.

The Flora-Fauna-Habitat Directive (FFH), the EG-Water Framework Directive (WRRL) and the Marine Strategy Framework Directive (MSRL) have added further fields of responsibility to monitoring and evaluation of the marine environment. Not only biological and physical-chemical quality components (indicators) have to be investigated in the future. In addition to the measurements of currents, waves and bathymetric parameters, particularly the gathering of data about the properties and distribution of marine sediments and substrates will be the focus of the so-called hydro-morphological and habitat monitoring. So far, in contrast to hydrology and morphology, sediments and substrates have been looked at only in the course of research projects and environmental impact assessment studies and not in an operative application. Furthermore, this had only been done for sub-domains and not with blanket coverage as required by the above-mentioned European directives.

Starting only recently, we have - in addition to the traditional methods of extracting samples and mapping – techniques at our disposal to handle these tasks. They help to combine local investigations into an overall picture of the bathymetry and the marine environment. This especially includes sonar and echo-sounding techniques, satellite and aircraft based remote sensing as well as the utilization of numerical models.

The sea bottom when fallen dry is captured on up to 160 spectral channels when using multi- and hyper-spectral remote sensing methods. Special computer software permits to segregate these spectral components and relate them to specific sediment and colonization categories. Similarly, but for the acoustic field, this can be done with echo-sounding and side-scan sonar methods. These can be used not only for determining the exact water depth but – on the basis of intricate hydro-acoustic and statistical operations – also discerning the properties of sediments and the nature of their colonization.

The example of the "sea bottom classification system Echoplus", which has been operating on-board the research vessel "MS Haithabu" for several years, has shown that the actual measurement can be carried out in relatively automatic mode and to a large extent independent from other measurement jobs. Therefore, this method is superbly suited for an operational routine monitoring.

In the post-processing routines of the "Java sediment classification tool Jedi" spatial, temporal and quality information about the results are determined automatically and in the same process described instantaneously by ISO – compliant metadata according to the NOKIS profile for coastal zone monitoring (cf. KFKI-aktuell 6 (1) 2006). Consequently, these are stored on a central server ***www.nokis.org*** . Starting in early 2009, they will be available there in a closed workflow for enquiries, enabling the access to data as well as for the planning of further monitoring or other measures (Fig. 1).

Under the impression of national and international directives for the protection of the marine environment, the project NOKIS++ has provided a valuable contribution to the optimization of operational marine monitoring.

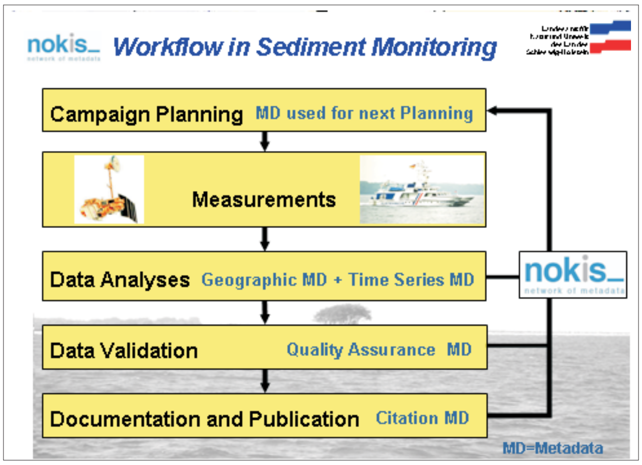

Figure 1:
The different components of the marine monitoring are not only supported and complemented by NOKIS++ developments. They are also merged to form an operational workflow scheme supported by metadata.

MUSTOK - Model – Based Investigations of Extreme Storm Surge Events at the German Baltic Sea Coast (03KIS052-54)

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The assessment of possible extreme loads exerted by water levels and wave forces is an essential basis for the design of coastal structures. While, generally, not the highest possible load can be used as a design parameter it contributes - together with other observed data - to find a technically and economically meaningful solution. Since mainly water levels and waves put a load on a dike combinations of these parameters need to be investigated.

Possible extreme water levels and - at the same time - combinations of water levels and waves were needed to arrive at decisive design parameters. Therefore, in 2005 the GCERC joint project "Model – Based Investigations of Extreme Storm Surge Events at the German Baltic Sea Coast (MUSTOK)" was launched and funded by the "Federal Ministry for Education and Research – BMBF" for a period of 3.5 years. The project is divided into three sub-projects:

- MUSE Ostsee (Baltic Sea) (objective: assessment of possible extreme water levels and determination of their likelihood of occurrence)
- SEBOK A (objective: definition of decisive design parameters for coastal protection structures at the coast of Schleswig-Holstein)
- SEBOK B (objective: definition of decisive design parameters for coastal protection structures at the coast of Mecklenburg - West Pommerania)

MUSE Ostsee

In the sub project MUSE Ostsee physically feasible extreme water levels have been derived using a schematic suite of numerical models (DWD – GKSS – BSH) for the entire German Baltic coast. Thus, for the first time and with present-day simulation models, it has been possible to hindcast the catastrophic storm surge event of November 12/13 1872 with a good match of the observed extreme water levels. This may help to further improve storm surge forecasts.

It is obvious that extreme water levels clearly exceeding those of the event of November 12/13, 1872, are not likely to occur at the present time. Results, however, indicate regional differences. By including simulated extreme values, historical events and regularly recorded storm surge levels the extreme value statistics can be improved (Fig. 1). Consequently, the likelihood of occurrence can be stated more reliably. The likelihood of the recurrence of the extreme event of 1872 at the gauge "Travemünde" can be explicitly stated to be between T = 3,400 and 7,000 years.

SEBOK A

In the sub-project SEBOK A a method for the design of future and the safety check of existing coastal protection installations has been developed. This approach is based on the estimate of extreme loads on the coast. Altogether 60 of the storm events with a high storm surge potential, which have been generated in the sub-project MUSE, together with the meteorological reconstruction of the historical storm surge of 1872, were input into a suite of models. In a stepwise approximation, water levels as well as wave heights were initially determined supra-regionally and finally - with a very high local resolution - for the entire German Baltic coast.

The applied models are based on the model suite of the "Danish Hydraulic Institute". They were calibrated and verified with measured data and show a good match with prototype data. On a supra-regional level, i.e. for the entire Baltic Coast, a three-dimensional current model was coupled with a depth-averaged spectral wave model. On a local level, high-resolution profile models were applied to calculate the effect of various scenarios on the morphology as well as the spatial development of waves and mean water level up to the beach. Time series of water levels and waves obtained from the supra-regional models drive these models for coastal waters at their open boundaries.

Depending on the decisive design load, the time series of energy input or wave run-up of various scenarios and the reconstructed reference event of 1872 can be compared. Thus, the highest load locally possible can be determined in each case. Following this, an iterative design as well as an assessment of the safety level of existing structures designed on the basis of the event of 1872 can be carried out.

SEBOK B

The objective of the investigations of the sub-project SEBOK B is the application of a methodology for the determination of decisive hydrodynamic input data for the planning and design of coastal and flood protection structures at the German Baltic coast. These input data were based on time series of hydrodynamic parameters which were as comprehensive as possible. The time series of wind and water levels were generated from prototype measurements, those for waves by means of wind-wave correlation calculations and long-term (< 55 years) wave simulations.

Design parameters such as water levels, duration of a storm surge and wave height, period and propagation direction were extracted from the time series and were analyzed with methods from extreme value statistics. For combinations of design parameters, a combined likelihood of occurrence was calculated which constitutes a possible basis for the design of coastal structures and the assessment of dike safety. Additionally, a comparison of the numerical models utilized in MUSTOK is carried out in the course of the project. Moreover, various methodological approaches for the definition of decisive design parameters are eminently discussed in a case study.

Workshop

On March 4 and 5, 2008, a workshop on the project MUSTOK titled "Storm Surge Hazards at the Baltic Coast" was held at the University of Rostock. More than 100 experts from science and practice as well as decision makers from politics and administration participated. Objective of the event was the discussion of results within a broad professional public with a focus of practical applicability.

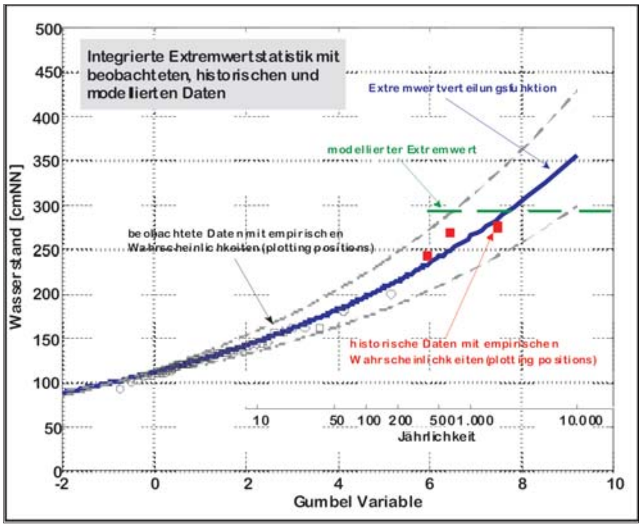

Figure1:
Schematic graph of the integrated extreme value statistics

MudSim - Numerical Simulation of Fluid Mud (03KIS066-67)

Rheological Investigations and Parameterizations

- Development of an Iso-pyknic Model -

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Introduction

The development in deepening and improving navigation channels in many coastal areas has led to increased siltation problems in harbours, harbour access channels and parts of the fairways themselves. Removal of silty depositions and the re-establishment of a sufficiently navigable depth is quite cost-intensive. Therefore, the objective of this project is to develop a numerical method for the simulation of fluid mud dynamics (genesis, deposition, transport, fluidization, re-suspension, consolidation). The developed tool is supposed to predict the behaviour of fluid mud and help to optimize maintenance measures in harbours and estuaries.

Methods

A basis for the development of new methods for the numerical simulation of fluid mud are the investigation of the rheological properties of that material and the determination of characteristic parameters for its description. One of the most important characteristic parameters for the behaviour of fluid mud is the concentration of solids or the proportionally attached density. In the numerical modelling process, this parameter is needed for the differentiation of rheological behaviour. For that purpose and under the assumption of a stable stratification, the water body containing fluid mud is sub-divided into layers of equal density (Fig. 1). In the following, these are called "iso-pyknes"(layers of equal density). In addition to the iso-pyknic/density oriented vertical

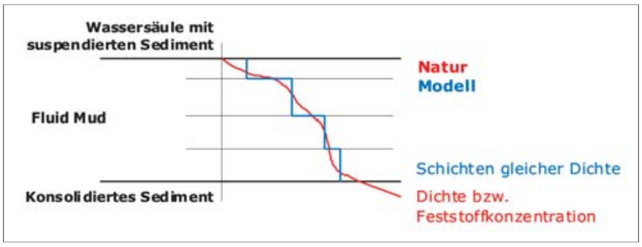

Figure 1:
Schematic graph of the density approximation.

resolution the numerical model MudSim will be furnished with a three-dimensional discretization based on static z-layers. Thus, for each density layer a three-dimensional velocity field can be determined. Each of these density layers is also assigned a certain rheological behaviour (Newton or non-Newton fluid) (Fig. 2).

The development of the model MudSim is based on a hydrodynamic iso-pyknic model which has been made available by Prof. Casulli (Department of Civil and Environmental Engineering, University of Trento). Essential steps for the extension of the model to simulate fluid mud are:

- the integration of the non-Newton stress tenso - approximation for the rheological behaviour of fluid mud,
- the integration of the transport of solids and
- an exchange of matter between layers of equal density.

Perspective

In addition to the already mentioned development of the numerical model, the investigation of the influence of turbulence on the rheological behaviour of fluid mud and the configuration of a schematic physical harbour model at a feasible laboratory scale will be the focus of further research and investigation.

Ph.D. training

Within the framework of the MudSim project, seminars at the University of the Armed Forces, Munich,

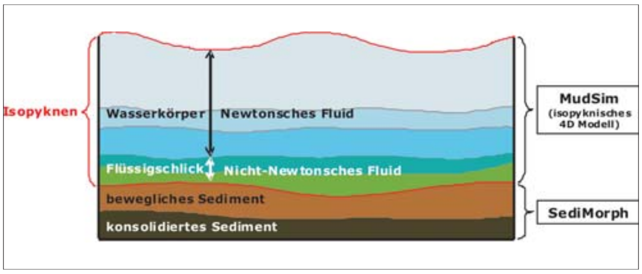

Figure 2:
Schematic illustration of the iso-pyknic model MudSim and the sediment transport model SediMorph.

and at the Federal Waterways and Engineering Research Institute (BAW), Hamburg Office, will be held to further education and training of Ph.D. students and young academics. The following seminars have been held or are planned for the months to come:

- The Cauchy equations as a basis for rheological modelling (Feb. 20 – 22, 2008)
- Modular programming (Nov. 26 – 28, 2008): Knowledge transfer from practice – modular scientific programming in FORTRAN90
- Rheology of granular suspensions (Feb. 2009)

The NLWKN Storm Surge Warning Service for the Coast of Lower Saxony

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Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency

Introduction

In the past, hazardous situations due to storm surges could not be detected in time or with little advance warning. As of 1998, the German Meteorological Service (DWD), using its global weather forecast model GME, has been able to supply spatial coverage weather data (DWD, 2007).

With the access to wind field data, which the DWD is making available via a server in Offenbach, the Lower Saxony Water Management, Ecology and Coastal Protection Administration NLWKN (1998, formerly NLWK) was for the first time able to providently evaluate (forecast) wind development across the entire North Sea at a lead time of 5 days and, thus, issue precautionary warnings of imminent storm surges.

The protection of coastal islands, which the federal state administrates in its function as the responsible agency for dike maintenance, requires reliable forecasts regarding weather and tidal water level elevations for its resource planning – especially on weekends. This applies equally to the cultivation of dike foreshores and construction and maintenance measures within the tidal zone. The operation of flood barrages is also dependent on information about the development of water levels. The operating plan for the Ems Flood Barrier, for instance, requires that weather conditions which may result in storm surge water levels exceeding 1.5m over the mean high water mark (MThw) need to be tracked at an early stage.

Other closures of the barrages, e.g. for raising the water level of the Ems estuary for the safe transfer of large vessels, also require long-term preparations and forecasts of several days’ duration of the tidal water levels and expected precipitation. Counties and their emergency task forces are asking that storm surge warnings be issued with at least one day's advance notice, so that personnel-in-readiness may be mobilized in due time. During the summer months, the island communities and tourist facilities along the coast are dependent on timely warnings when there is danger of beaches and dike foreshores being flooded.

Procedural sequence of the Storm Surge Warning Service

The sequence of actions of the storm surge forecast of NLWKN results from multi - level observations and evaluations of the development of wind and wind set-up. The wind field data is extracted online from the DWD-server with the help of the KÜSTE (”COAST”)-software of the DWD and copied into a corresponding software application. This application contains wind direction-dependent empirical valuations for the determination of wind set-up. As a result, time series of wind set-up are issued for the area of the East Frisian Islands (Norderney) and coastline (Emden), as well as for the Elbe estuary (Cuxhaven). These, superimposed on the mean tidal curves, determine the storm surge water levels.

During light storm surges, astronomical deviations are also taken into account. However, the astronomical influences decline with the increasing severity of a storm surge (DICK, 2000) to become entirely negligible during very heavy surges (NIEMEYER, 2001).

The wind set-up values allow for various effects with changing wind velocities: If a decrease of the wind field is to be expected before mean high water (MHW), the wind set-up will decrease correspondingly without delay. With growing wind a certain trailing effect of the increase in set-up is taken into consideration.

The advantage of this method lies in the long-term large-area monitoring of the development increasing the accuracy as the lead time decreases. Trends and changes in up to 16 wind forecasts are identified and included in the prediction of the wind set-up. In addition, predictions of set-up issued by other institutions such as the Federal Maritime and Hydrographic Office (BSH) and Rijkswaterstaat of the Netherlands are taken into account, when available. These, however, must be particularly weighed in case of diverging results.

The results of the analysis are summarized in a notification issued by the Storm Surge Warning Service. This note includes the deviations from MHW of the expected crest levels at the controlling tide gauges at Norderney, Emden and Cuxhaven.

Depending on the severity of the situation, these reports will be forwarded to the NLWKN operations offices concerned. The staff of the Ems Barrier receives these reports routinely, too.

The lead time (of up to 5 days) permits an initial evaluation of potential threats and planning of personnel-in-readiness, if necessary. Should the prognosis of wind and set-up development be confirmed on the basis of more reliable data, the States, dike associations and island communities will be informed about the threat level.

Furthermore, the interested public may obtain information regarding the development of a storm surge from the NLWKN homepage ***(http://www.nlwkn.de)*** menu items "Aktuelles" ("current"), "Warndienste" ("warning services") and "Sturmflutwarndienst im NLWKN" ("storm surge warning service").

During the final phase of a storm surge, the wind-based forecasts will be adjusted by means of extrapolation calculations of the set-up via forward tide gauges, constant monitoring of individual gauges and determination of the deviation of tidal water levels from the mean and astronomical tide curves, respectively.

Forward tide gauges are located on the West Frisian island of Terschelling, at Wierumergronden and Huibertgat. Data from these stations are retrieved by way of the MFPS-system of Rijkswaterstaat and then analyzed. Roughly 5 hours before high water at Norderney, for example, the set-up of the first flood phase in the Netherlands can be extrapolated for the East Frisian Islands. To achieve this, the forecasted set-up levels will be adjusted to locally measured water levels. This local checkup of the water levels is very important, as their continuing development contains the sum of all local influence factors and can be tracked with higher accuracy. Thus, as an example, regional services supply additional active support for the barrages along the Weser estuary.

Due to occasional malfunctions of the existing gauge transmitters, various means of data transmission are being utilized. Moreover, data from eight Lower Saxony coastal gauge stations are being made available on the NLWKN homepage

(http://www.nlwkn.de, under "Aktuelles" ("current") and "Aktuelle Messungen" ("current measurements")). Here, the precautionary set-up forecasts are being illustrated by means of examples.

Quality control

The forecasts and actual water levels are compiled and stored in a databank within the framework of quality control. In addition, in case of storm surge events all relevant information, warnings and telephone calls are being recorded in a log book. This quality control serves to objectively evaluate the precision of the forecast in relation to the lead time to the predicted crest water level. Those forecasts based on meteorological prognoses depend on the quality of the wind field forecasts, whose accuracy generally increases the more up-to-date the dataflow is.

Classification of storm surges

The classification of storm surges is governed by DIN 4049, part 1, Nr. 3.3.50 to 3.3.53. Accordingly, high tide water levels with a mean annual frequency of occurrence of 10 or less are classified as storm surges. The range of storm surges is defined.

Outlook

The empirical forecasting method of the NLWKN is to be further developed including hindcast wind fields of previous storm surges and tide gauge data. The gauges at Borkum, Norderney, Emden, Bensersiel, Alte Weser, Wilhelmshaven, Bremerhaven and Cuxhaven are to be included in the future. With these data, an attempt is to be made to establish a neural network with which the major components of water levels and wind fields can be analyzed. Prerequisite for this is the availability of suitable wind field data. Prognosis calculations using the DWD-models have already been carried out as part of the KFKI-project MOSES. Those models are based on re-analyzed data (ERA-40) of the European Center for Mid-Range

Weather Forecasts (EZMW) (FRANK et al, 2006). For this, further research is planned.

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NLWKN: URL: ***http://www.nlwkn.de/***, "Aktuelles", "Warndienste" und "Sturmflutwarndienst im NLWKN"

Events

March 12-13, 2009	**3. Symposium Sicherung von Dämmen, Deichen und Stauanlagen**, University of Siegen info: http://www.uni-siegen.de/fb10/subdomains/geo/veranst/veranst/flyer_daemme_2009_1.pdf
March 12-13, 2009	**Dresdner Wasserbaukolloquium "Wasserkraftknutzung im Zeichen des Klimawandels"**, Technical University of Dresden, Germany info: http://www.iwd.tu-dresden.de/Resources/Colloquium2009/Call_for_Papers_E_Wasserbaukolloquium_2009.pdf
March 30 to April 2, 2009	**2. Internationales Symposium zur Wasserwirtschaft**, Messe Berlin info: http://www1.messe-berlin.de/vip8_1/website/Internet/Internet/www.wasser-berlin/deutsch/index.html
April 28, 2009	**Neubau der Kaiserschleuse in Bremerhaven - Baustellentag**, Conference Center SAIL CITY, Bremerhaven, Germany info: http://www.htg-online.de/ ->Veranstaltungen
May 25, 2009	**Climate Change in the southern Baltic region**, Szczecin, Polen info: http://www.baltex-research.eu/SZC2009/

Imprint

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