Integrating Marine Modeling Data into a Spatial Data Infrastructure

Christoph WOSNIOK[a], Michael BAUER[a] and Rainer LEHFELDT[b]
[a] *Research Assistants, Federal Waterways Engineering and Research Institute, Hamburg,Germany {christoph.wosniok|michael.bauer}@baw.de*
[b] *Senior Scientist, Federal Waterways Engineering and Research Institute, Hamburg, Germany rainer.lehfeldt@baw.de*

Abstract. Spatial Data Infrastructures (SDIs) have become widespread within the last few years, in Europe largely evoked by the implementation of the INSPIRE directive of the European Union. Search processes for metadata within spatial portals usually result in single data sets spread across several topics without the possibility to get an encompassing overview over a geographic complex. The German Marine Data Infrastructure (MDI-DE) addresses this issue and aims at providing an integrated view on semantically close topics. The Elbe estuary serves as a prototypical example, which is described in detail on several levels. Along with the usual data such as maps, aerial pictures, or gauges, a section of the MDI-DE under the label Elbe will collect results from numerical models of the estuary. This raises additional questions on the technical level, i.e. how to integrate the diverse numerical data into a classic SDI and how to visualize aggregated data. In the following a concept and first prototypical implementation of ways to integrate modeling data into SDIs will be shown.

Keywords. Spatial Data Infrastructures, Marine Data, Model Data, Information Infrastructures, INSPIRE, MSFD

1. Motivation

The European directive "Infrastructure for Spatial Information in the European Community" (INSPIRE)[1] requires the member states to provide an overview on the present metadata within the countries in a standardized manner. To ensure compatibility on national and international level, implementing rules for metadata, data specifications, network services and others have to be adopted by data providers. The Marine Strategy Framework Directive[2] (MSFD), which should ensure protection, conservation and, if possible, restoration of European sea habitats, demands provision of data from the maritime domain by 2012. Other directives like Habitats Directive already require status reports and data.

In Germany with more than 2000km of coastline including the world natural heritage Wadden Sea and several other nature reserves on different legal levels, the production and maintenance of spatial data for the coastal zone is distributed between differ-

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF
[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

ent federal state authorities. Additionally, national park administrations conduct monitoring and collect data. Consequently, there are several marine data collectors, providers, and archives, distributed spatially and affiliated with diverse agencies in northern Germany. With the implementation of INSPIRE and the MSFD, data collecting agencies are ultimately required to publish their data according to the directives. Mandatory data encompass, e.g. water networks, protected areas, digital terrain models, and oceanographic parameters.

Numerical modeling is another area handling big amounts of marine data concerning the North Sea. Agencies and companies run models to analyze the impact of dredging in the German estuaries Elbe, Weser, Jade, and Ems. An example, which regularly attracts public interest, is the Elbe deepening [1][2]. As deeper rivers commonly have higher currents, which increase sediment transports and may lead to further bathymetric changes, dredging is pre-assessed in numerical models with regard to risks for the environment and dykes. Federal agencies like the Federal Waterways Engineering and Research Institute[3] (BAW) or the Federal Institute of Hydrology[4] (BfG) regularly develop status reports of the estuaries to back up political decisions.

A central platform for the publication of such reports or related data is currently not available. In the following, we propose a concept for the integration of such data into a SDI. This concept will be implemented in the course of the MDI-DE [3] project.

2. Use Case Scenario

For our scenario, an engineer from a coastal authority wants to check the state of the coastal and riverbank protection in the Elbe estuary and to identify potential needs for additional groins after a deepening of the river. Currents are strong in the lower reaches of the Elbe, so groins were built to prevent erosion processes and possible danger for inhabitants during storm surges. Changes to the riverbed can have significant effects on the characteristics of the current, erosion and sedimentation, local water levels and many other parameters of the estuarine system. To get an overview, the engineer chooses to consult a SDI, having in mind specific questions such as “Which parts of the banks along the Elbe could be affected by the deepening of the riverbed?”.

Such a query could bring up data sets with groins along the Elbe River. However, a condition of the bank structure can only be approximated within the spatial metadata sets. Without engaging into deeper research of his own, our engineer could with a little luck also find a ready made solution. The Elbe River as one of Germany’s largest water ways is an economic factor [4] for the region and is regularly subject of research projects[5] and status reports. Results from these studies provide information based on geographic and model data, and can help users in decision making.

3. Aggregating Marine Model Data

A common thematic map consists of topography and thematic data one wants to show, along with properties for a common reference system and a defined legend [5]. So far,

[3] http://www.baw.de
[4] http://www.bafg.de
[5] http//www.kfki.de

in SDIs one can usually find topographic and thematic data, which enable the user to combine both into one single map. Products in the marine domain are often more complex. For instance, the bathymetry of the Elbe estuary needs regular updates, as conditions are changing continuously. Other than land based topography, the wet zone is under the constant impact of tides and currents. Especially shipping channels, with high freighter traffic volume underlie constant changes and are of both economic and environmental interest. As a daily surveying of an entire estuary is not feasible, numerical models are applied to estimate the bathymetric changes. Consequently, there is not one single bathymetric map, but several, which reflect the different assumptions made in the numerical modeling scenarios.

Model data have the advantage of giving multidimensional overviews in different scales on an area of interest, in our scenario the Elbe River. Several parameters can be calculated within models: currents, sediment transport, and/or changes of bathymetry. Results from numerical models could show the effectiveness of bank fortifications, i.e. does a groin help to stabilize a dike by reducing stress from high tides, are structures redundant or are there places where new obstacles could direct the currents better than in the present state. Additionally, models are not only constructed to show the present state but to forecast the behavior of a system, in this case the Elbe, which can support our engineer with her decisions on possible further constructions. Consequently, model data can provide more information than simple spatial data sets, but connections between geographic data and models must not be underestimated: the more accurate the underlying geographic data is, the more exact are the models.

The Marine Data Infrastructure Germany (MDI-DE) is an attempt to aggregate relevant data for marine data products on all levels [5]. The collaborative research is carried out with joint project management of the Federal Waterways Engineering and Research Institute and the Federal Maritime and Hydrographic Agency[6] (BSH) of Germany. It is based on the previously conducted NOKIS Project[7] [6] and on the GeoSeaPortal [7] of BSH. NOKIS aimed at establishing a metadata information system for marine data, with a metadata editor as the core element. Several data collecting organizations participated in this research and development project and added several thousand geographical metadata sets, which led for a first time to a publicly available overview over marine data in Germany. Driven by INSPIRE and MSFD to publish spatial data within a tight schedule, public data collectors and providers along the German North Sea and Baltic Sea coast have gathered to fulfill the technical and political conditions to provide not only the metadata but also services to access the data properly. The aim is to set up a portal where available marine data is aggregated, searchable and, unless there are legal restrictions, downloadable.

The original NOKIS project pinpointed on establishing an initial basic infrastructure for coastal data [8]. MDI-DE will use this basic metadata catalogue and extend the functionality to that of a complete SDI. NOKIS focused on metadata sets from coastal geographic data, so called geo–metadata sets, which are created with the NOKIS metadata editor, or directly imported using a NOKIS XML profile. This NOKIS coastal metadata profile is a profile derived from ISO19115 [9], and is compatible with INSPIRE. Additional metadata profiles regarding research projects and literature have been derived as well and are being used in the Web sites of KFKI[8] and NOKIS. As the

---

[6] http://www.bsh.de

[7] http://www.nokis.org

[8] http://www.kfki.de/

ISO standard for spatial data is formulated in an abstract way, it is also possible to describe results from numerical models by specifying an appropriate profile. The editor is being adjusted to represent these model specific metadata elements. The integrated metadata catalogue constitutes therefore a universal platform for different types of data and within the framework of MDI-DE we aim at ensuring interoperability between the existing data types.

4. Workflow

The MDI-DE is a distributed system (figure 1). Several NOKIS Editor instances (so called nodes) are connected via a CS-W Interface to a NOKIS core instance, where the combined metadata is stored. External portals like the German Spatial Data Infrastructure GDI-DE and the German environmental portal PortalU[9], access this core instance via CS-W requests. A new portal "Meer und Küste / Ocean and Coast" will be established to serve as main access point for users searching for marine data. It makes use of the metadata concerning data from numerical modeling, describing projects and referencing literature, which are merged for an integrated information search by NOKIS[10]. The new MDI-DE portal will enhance the existing metadata search by visualization and download methods. In case of model data additional methods will be developed in order to cope with three dimensional and time dependent data sets.

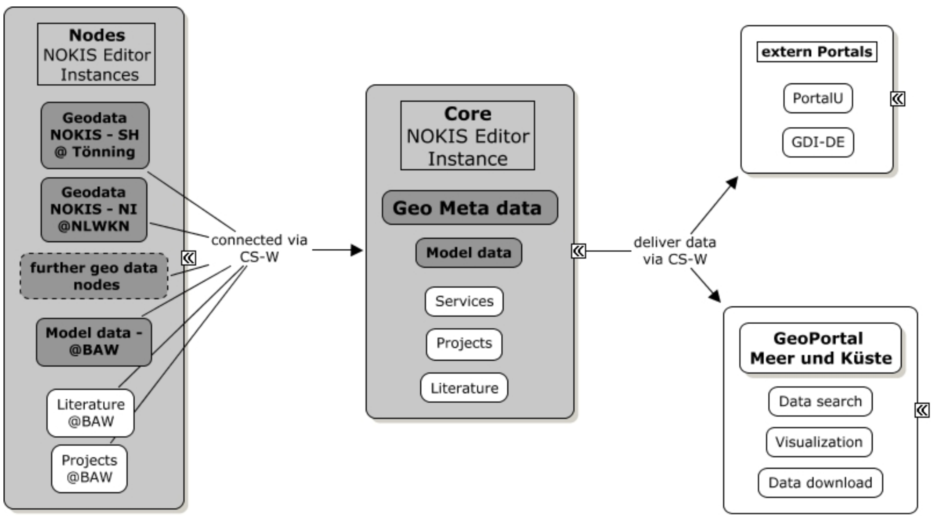

Figure 1. The general structure of MDI-DE. Relevant elements are marked in dark grey.

In order to make model data available through a SDI, the data first has to find its way into an appropriate service. In a first prototype, this is accomplished by converting the binary export file format of the modeling software into an exchange format, where we chose ESRI shape files, as it is a de facto standard and there are several tools for

---

[9] http://www.portalu.de
[10] http://www.kfki.de/nokis/de

data transformation and handling available. The shape files are transferred into a database, which can be accessed from different OGC web service implementations [10] to generate diverse services. These steps are wrapped in a shell script for easy processing of large model data sets. To guarantee a consistent visualization across platforms according to the conventions of the marine engineering community, the data is classified and visualized via the Styled Layer Descriptor (SLD) technology [11].

5. Future Work

The first proof of concept simply displayed 2d maps consisting of model data aggregated into polygons. A wide range of services can be provided using model data and the variety of OGC Web Service specifications. An obvious choice would be the provision of a Web Feature Service (WFS) [12], but also more elaborate services could be implemented.

Simulations of currents, tides and other marine parameters are usually conducted in three dimensions, thus three dimensional data is produced. To display such data as two dimensional maps means losing a lot of information inherent in the original model data. In order to provide the best information to the user through the SDI, 3d services could be set up, using one of the upcoming OGC services for displaying 3d data like the Web 3D Service [13] or the Web Perspective View Service [14]. These would allow the visualization of 3d structures, objects or point clouds to present depictions closer to the original data than plain maps. The above mentioned SLD technology can be applied to these, too [15].

Using the WFS for data provision is an established and sound method, but it is also be conceivable to utilize a Sensor Observation Service to get the data from the data storage – even though it’s not sensor data in the narrow sense [16]. Having set up such a service, live sensor data could also be added to the SDI and in turn used for the simulations to create faster updating model data. On this level, cooperation with the COSYNA project is planed. COSYNA [17] aims at constructing a long-term observatory for the North Sea including the presentation of near-real-time data on its portal. Metadata is already stored in a NOKIS instance and a connection with proper integration into MDI-DE is being established.

A consequent although difficult step for the future would be to migrate the simulation process itself into the SDI using Web Processing Services (WPS) [18], once the specification process is completed.

Using the netCDF format as a model output format would be a new component in the workflow. NetCDF [19] as a binary format is self-describing and has been established for the exchange of scientific data mainly in meteorology. It would replace the currently used shape files as the exchange format.

6. Conclusions

The recently started project German Marine Data Infrastructure aims at pulling all the aforementioned data strings together and to establish an integrated view on complex questions within the coastal community. While spatial data in SDIs only show a small part of the production chain of geographic products, MDI-DE provides a framework for different types of spatial data. Integrating modeling data enhances the capabilities of an

SDI, as the results from numerical models enable the user to browse through a complex product based on spatial reference data.

7. Acknowledgements

The work presented here is funded by the Federal Ministry for Education and Research (BMBF) through Project Management Jülich (PtJ) under grant number 03KIS089 (Coastal Engineering). The authors gratefully acknowledge this support as well as the contributions from co-workers and other partners to this research project.

List of literature

[1] Projektbüro Fahrrinnenanpassung (beim Wasser- und Schifffahrtsamt Hamburg), *Fahrrinnenanpassung Unter- und Außenelbe. Das Projekt im Überblick.*, Fraujansen Kommunikation, Hamburg 2007.

[2] Bundesanstalt für Gewässerkunde, *Umweltrisikoeinschätzung und FFH-Verträglichkeitseinschätzung für Projekte an Bundeswasserstraßen, Weitere Fahrrinnenanpassung von Unter- und Außenelbe an die Containerschifffahrt mit einem Salzwassertiefgang von rd. 14,50 m*, BfG – 1380, Koblenz, 2004.

[3] Lehfeldt, R., Melles, J., Marine Dateninfrastruktur Deutschland – MDI-DE. In Traub, K-P, Kohlus, J., Lüllwitz, T. (Eds.) *Geoinformationen für die Küstenzone. Beiträge des 3. Hamburger Symposiums zur Küstenzone*. Wichmann Verlag (2011, in print).

[4] Klimke, Jürgen, Elbvertiefung bringt klare Wettbewerbsvorteile für Hamburg. *Kommunalpolitische Blätter* **58** (2006), 3, 41–42.

[5] Kraak, M.-J., Ormeling F., *Cartography - Visualization of Geospatial Data*. 2nd ed. Prentice Hall. 2003.

[6] Lehfeldt, R., Reimers, H-C., Kohlus, J., Sellerhoff, F., A Network of Metadata and Web Services for Integrated Coastal Zone Management, *COPEDEC VII, Dubai, Cyber-proceedings*, (2008) paper 207.

[7] Soetje, Kai C., To be on the right path from BOOS to an integrated pan-European marine data management system, *US/EU-Baltic International Symposium, 2008 IEEE/OES*, Tallin, 2008.

[8] Lehfeldt, R., Heidmann, C., Piasecki, M., Metadata in Coastal Information Systems. In Holz, K.P., Kawahara, M., Wang, S.Y. (Eds.) *Advances in Hydro-Science and –Engineering, Vol. 5. Cyber-proceedings, 5 Intl. Conf. Hydro-Science & -Engineering*, Warsaw (2002).

[9] ISO/ TC211: ISO19115:2003 Geographic Information – Metadata.

[10] OGC Web Service Common Implementation Specification: http://www.opengeospatial.org/standards/common.

[11] OpenGIS Styled Layer Descriptor Profile of the Web Map Service Implementation Specification - http://www.opengeospatial.org/standards/sld.

[12] OpenGIS Web Feature Service - http://www.opengeospatial.org/standards/wfs.

[13] Zipf, A., J. Basanow, P. Neis, S. Neubauer, A. Schilling, Towards 3D Spatial Data Infrastructures (3D-SDI) based on Open Standards - experiences, results and future issues. In: *3D GeoInfo07. ISPRS WG IV/8 International Workshop on 3D Geo-Information: Requirements, Acquisition, Modelling, Analysis, Visualisation.* Delft, NETHERLANDS (2007).

[14] Hagedorn, B., Hildebrandt, D., Döllner, J., Towards Advanced and Interactive Web Perspective View Services, *Developments in 3D Geo-Information Sciences, Lecture Notes in Geoinformation and Cartography*, Springer, 2009.

[15] Neubauer, S., Zipf, A., Suggestions for Extending the OGC "Styled Layer Descriptor (SLD) Specification into 3D". Towards Visualization Rules for 3D City Models. In: *Urban Data Management Symposium* (2007). Stuttgart, Germany.

[16] OpenGIS Sensor Observation Service - http://www.opengeospatial.org/standards/sos

[17] Doerffer, R., Colijn, F., van Beusekom.J. (Eds.), *Observing the Coastal Sea - an Atlas of Advanced Monitoring Techniques. LOICZ Reports & Studies No. 33*. Geesthacht, Germany: GKSS Research Centre, 2008.

[18] Web Processing Service - http://www.opengeospatial.org/standards/wps.

[19] Rew, R. K., G. P. Davis, The Unidata netCDF: Software for Scientific Data Access, *Sixth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Anaheim, California, American Meteorology Society*, 1990, 33-40.