Spatial Variability and Robust Interpolation of Seafloor Sediment Properties Using the SEABED Data Bases

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LONG-TERM GOALS

This project is building methods for making the best possible grid maps of seafloor data, even for regions that have weak data coverage. The software and documentation will be made public.

OBJECTIVES

Gridded maps are the most sought-after type of information from seafloor properties databases, but computing them reliably is not straightforward.

The technical goal of the project is a set of gridding methods that are mathematically rigorous and statistically reliable, robust under different qualities of input data, free of geometric artefacts, and acceptable on inspection to experts familiar with the terrain being mapped.

APPROACH

The work is collaborative with John Goff of UTIG (Austin, Texas USA). It proceeds on 4 lines:

(i) investigating how variability of the seabed is distributed and may be dealt with appropriately in mappings;
(ii) writing practical, robust and competent interpolation programs and releasing them publicly; an INSTAAR program is the Competent Seabed Interpolator (CSI).
(iii) to use that development with real datasets, encounter problems with this and other interpolation techniques, and to find and test ideas for solutions and improvements;
(iv) describe the work in publications.

For the first year we adopted a deterministic Inverse Distance Weighted (IDW) method. In the second we (INSTAAR and UTIG) implemented a geostatistical variant and a number of enhancements to increase useability and representativeness.

WORK COMPLETED

The major goals of the project are in place. This year, apart from finalizing those, significant testing and improvement of systems took place.

(i) Testing and deployment during the ONR-sponsored NEST 06 Baltic Sea expedition to test Mine Burial Expert System. The CSI was employed real-time to generate the seabed mappings on which decisions were made, and also to provide inputs to the MBES. The outputs were used by

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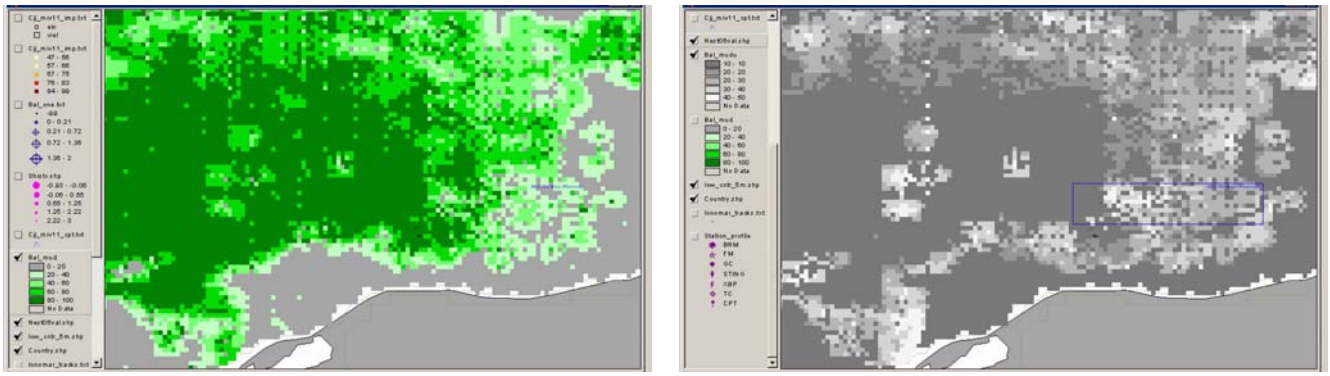
researchers from NURC, FWG, JHU APL, EGUERMIN, DSTO, and others. The Cruise Report is completed (FWG Technical Report) and a section on the at-sea live GIS operations was included in the data DVD (mid 2006 issue).

(ii) Provision of large amounts of data to UTIG for use with the Resampler (now completed, see papers).

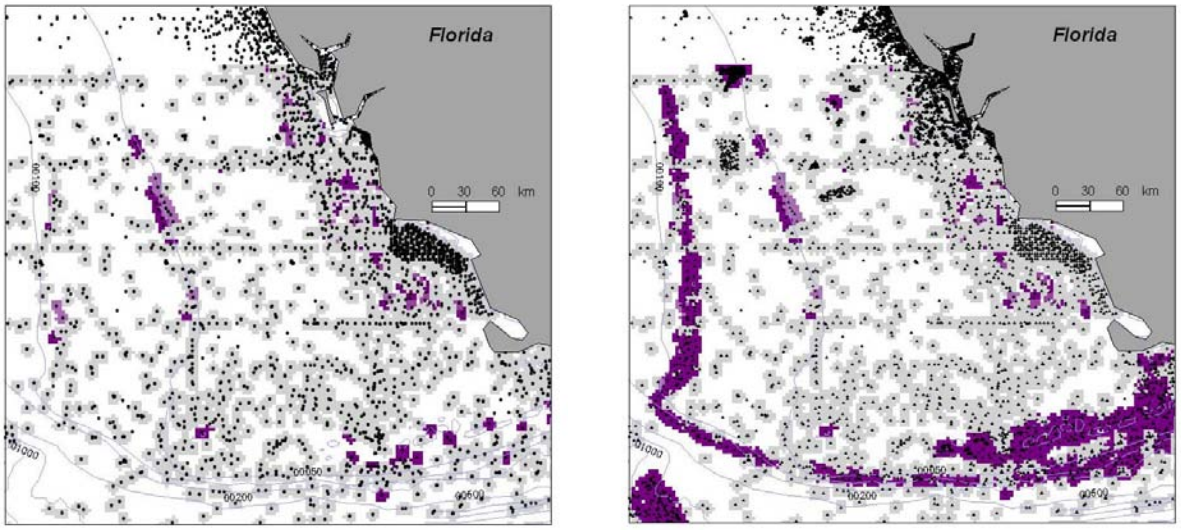
(iii) We focussed on the very important issue of seabed representativeness, especially between sampleable sediment areas, and rock areas which are traditionally mapped geophysically. In ONR terms, we are therefore focussed on problems of Sensor Data Fusion. Software to do the fusion at navigational and attribute levels of data is finalized, with a describing paper. This work was done in concert with a Fisheries hard substrate project, northern Gulf of Mexico.

(iv) Project to merge Mine Burial Experimental Data from FWG (Germany) – probably the largest such set worldwide – with the uncertainty-conveying griddings of the CSI, to produce Mine Impact Burial risk maps. To maximize technical adaptability we are doing this in Geographic Information Systems (GIS). The work is well advanced, one paper published and another prepared.



[The first graphic shows the km-scale patchiness of the seafloor mud contents over an area of 80km. The second shows the standard deviation of the data on mud contents over the same area.

Figure 1. A 500m resolution CSI competent gridding of sediment data, in the NEST06 experiment zones of the SW Baltic Sea: (a) bottom mud %, (b) the grid uncertainties in same units. Here the sand-mud transition coincides with annual maximum wavebase depth (~25m) and the highest seabed sediment uncertainties follow that transition zone.



[The first graphic shows some small scattered patches of hard substrate amongst many sediment sample sites. The second shows those plus the wide hard-ground areas of Pulley Ridge and the submerged Florida Keys.]

Figure 2. The importance of merging sampled sediment data and geophysically mapped rock areas data: (a) seafloor hard substrates mapped using sample, photo, submersible, & diver datasets; (b) mapped with the addition of merged geophysical data. dbSEABED is the best data coverage available, but still must use the geophysical data in oredr to capture major seabed features. The data fusion program was written under this project.

RESULTS

(i) NEST 06 deployment. The system worked as planned, but a public user-friendly release with documentation is required for wider acceptance.

(ii) Software sections completed with paper drafts finalized:

a. "Merging Point-Sample and Polygon-Feature Datasets for Regional Scale Mappings of Seabed Substrates" to merge rock geophysical datsets with the sediment sample information.

b. "CoreNavigator: Visualize, Browse and Serve Marine Sediment Cores in 3D" implementation of core-stratigraphic visualization techniques, taking into account uncertainty issues in typical downcore data.

c. "A Competent Interpolator of Marine Substrates Data" describing the CSI, submitted April 2006, still in review at MarineGeology.

(iii) Outputs of the Competent Interpolator have been used in a variety of projects, namely fisheries habitat and inputs to numerical models. For the latter (and also often, navy) complete seabed coverage is required, and a method of merging CSI and Natural Neighbour grids has been

developed to meet that need. In areas beyond the CSI outputs however, uncertainties are marked 'complete'.

IMPACT/APPLICATIONS

There is a high level of demand for gridded maps from seabed databases like dbSEABED. This project is having a significant impact on the reliability of inputs to coastal and sediment transport models, global change models, habitat mapping and analysis, and acoustic propagation studies. That is in evidence in projects the CSI is already applied to. The impact is enhanced by the quantity of data in the accompanying dbSEABED group, including the now public, large, and national-scale usSEABED datasets from USGS.

TRANSITIONS

Throughout the work we have had close cooperation with the US Geologcal Survey (USGS; Coastal Marine Geology Group Woods Hole, St Petersburg and Santa Cruz), Forschungsanstalt der Bundeswehr fuer Wasserschall und Geophysik (FWG; Kiel, Germany), and various users of the grids as mentioned above. The interpolator will be standard within dbSEABED group, but a version will be released open source by INSTAAR for others to consider using on other datasets, using a web public facility. A design of delivery web page and of the program uptake of customer input data tables has been devised.

RELATED PROJECTS

UTIG (Austin, TX USA) collaborator, is investigating geostatistical noise-suppression and interpolation using the data and ideas of this program. CSIRO (WA AUSTRALIA) is applying gridded results to forward modeling of the seabed under Global Change with consequences for the insurance industry and maintenance of subsea pipelines, etc. The German Navy (GERMANY) is assessing methods of bringing the grids into Electronic Charting Display and Information Systems (ECDIS). USGS (MA USA), Univ New Orleans (LA USA), Florida Fisheries Wildlife Commission (FL USA), and the 5-states' Gulf States Marine Fisheries Commission (GSMFC, MS USA) have been Beta and end-users, employing the dbSEABED routines to produce gridded maps of various US EEZ regions.

PUBLICATIONS (All published)

Papers

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