Geophysical Research Abstracts
Vol. 15, EGU2013-5752, 2013
EGU General Assembly 2013

Effect of environmental uncertainty on low frequency sonar propagation in a shallow sea

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Underwater acoustics is widely used in navigational, scientific and military areas. The technique of coupled ocean-acoustic modelling has been of interest for many years. The predictive capability of acoustic propagation modelling is highly dependent on the marine environment and seabed properties. The direction and intensity of sound propagation is determined by the sound speed gradients in the water column, which in turn are dependent upon variations in temperature and salinity. These variations occur on a range of scales – from climatic (tens of years) to the mesoscale (days and weeks) in time and from hundreds of meters to tens of kilometres in space, especially on the continental shelf. In shallow water, extremely dynamic features such as strong density fronts, intense stratifications, eddies, filaments and other mesoscale features exist persistently. These features described above have significant impacts on underwater sound propagation and therefore must be investigated in order to improve the predictive accuracy of acoustic modelling.

Uncertainties in the ocean model simulations are transferred to the acoustic field due to the usage of coupled ocean-acoustic system. The area selected for this study is the Celtic Sea, which is typical European continental shelf shallow water. It is filled with mesoscale eddies which contribute to the formation of the residual (tidally averaged) circulation pattern. The sea is strongly stratified from April to November along with bottom fronts, which adds to the formation of density driven currents. In this paper we employ the ocean model POLCOMS which has been validated for different regions of the world ocean and also been used operationally by the UK Met Office for the European Shelf seas to construct the environmental condition for the acoustic model and the sonar performance model HARCAM, which has been validated formally by the U.K. Ministry of Defence over a variety of frequencies, to generate acoustic propagation data.

The effect on acoustic propagation using predicted and observed environmental data respectively are evaluated in the presence of dynamical features (e.g. fronts and stratifications). The study compares the sensitivity of the propagation loss to variations between the observed and simulated temperature and salinity fields. This study also analyses the effects of various seabed characteristics on the acoustic propagation loss in the Celtic Sea. A comprehensive statistical and probabilistic analysis based on Taylor diagrams is presented. The main conclusion is that the ability of the ocean model to resolve the temperature and salinity fronts is crucial to the accuracy of acoustic simulation.