HIGH-SPEED FORWARD MODELLING APPLIED IN SEISMIC DATA PROCESSING.

Fact Sheet

Project Information

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Project closed

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Total cost
No data

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No data

Coordinated by
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Objective

TO DEVELOP A VERY FAST "FULL-WAVE FIELD RESPONSE" COMPUTER MODEL FOR FORWARD MODELLING OF SEISMIC WAVE PROPAGATION TAKING INTO ACCOUNT PHENOMENA NOT LOOKED INTO BY PRESENT PROCESSING METHODS.
The research project addressed 3 different forward modelling approaches, the direct global matrix (DGM) method an efficient full wavefield technique for horizontal stratified layers, a Cagniard-de Hoop method which is limited to models with plane

parallel layers, and a spectral method for more general and realistic configurations.

The DGM method was found to be stable for vertical seismic profile (VSP) simulation, seismic shot record simulation, transmission loss simulation in underwater acoustics as well as for simulation of responses from vibrating foundations.

The DGM method was formulated in layer coordinates and based on an assembling of the continuity conditions at each layer interface in a global system of equations. The solution procedure is therefore stable. The method was implemented in a very fast FORTRAN code by reuse of coefficients in assembling the system of equations, an adaptive linear Filon integration procedure, interpretation of the noise introduced by the integration as fictitious sources and by vectorizing the code over frequencies. The method is ensured to produce an accurate result by use of complex frequencies to avoid wrap around, by taking the surface into account exactly when both sources and receivers are placed in a top water layer, by taking dispersion into account and by including the direct response exactly when source and receivers are placed in the same layer.

The DGM method is characterized by very simple input specification and only output of the information that is needed. Specification of complex subsurface models and complex source and receiver configurations only differ by few simple DGM programme input specifications.

A spectral method for forward modelling of seismic waves has also been addressed. For plane layer models the results from the spectral solution method were tested against exact solutions obtained by Cagniard-de Hoop techniques. Such comparisons demonstrate the high accuracy of the spectral method. W ave propagation in 2-dimensional models with realistic dimensions and complicated geometry was shown, combining shapshots of the global wave field and time sections in selected points. The snapshots can ease the interpretation of the time sections.

A generalization of the spectral algorithm to 3 dimensions is straightforward, but the model data size for realistic problems is beyond the memory size of current computers.
THE PRESENT METHODS FOR SEISMIC DATA PROCESSING ELIMINATE PART OF THE INFORMATION THEY ACTUALLY HOLD; AS A CONSEQUENCE, E.G. THE AMPLITUDE OF THE RECORDED AND PROCESSED SIGNALS IS UNRELIABLE FOR QUANTITATIVE ANALYSIS. A NEW COMPREHENSIVE FORWARD MODEL, WHICH WILL BE DEVELOPED WITHIN THE PRESENT PROJECT WOULD AFFORD A VERY USEFUL TERM OF COMPARISON FOR THE DEVELOPMENT OF MORE ACCURATE SEISMIC DATA PROCESSING METHODS.
THE MODEL WILL BE BASED ON A NEW GENERATION OF FAST AND

ACCURATE FULL-WAVE SOLUTIONS BASED ON THE BESSEL TRANSFORM. THE SOLUTION WILL BE FOUND IN THE FREQUENCY DOMAIN AND FOURIER TRANSFORMED. THE SOLUTION IS SEMI THREE DIMENSIONAL. THE PROCEDURE IS A DEVELOPMENT OF A RECENT UNDERWATER ACOUSTICS WAVE METHOD.
IN THE FIRST PHASE OF THE PROJECT THE FIELD GENERATED BY A SINGLE POINT SOURCE OR A VERTICAL ARRAY OF SOURCES ON AN HORIZONTALLY STRATIFIED VISCOELASTIC MEDIA WILL BE CONSIDERED. THE PROCEDURE WILL INCLUDE THE SEPARATION OF SHEAR AND PRESSURE WAVES, THE SUPPRESSION OF SURFACE WAVES AS WELL AS OF MULTIPLES. ONLY CONTRIBUTIONS IN A SPECIFIC PHASE VELOCITY WINDOW WILL BE TAKEN INTO ACCOUNT.
THE PROCEDURE WILL BE APPLICABLE TO BOTH MARINE AND LAND SEISMIC AND WILL SIMULATE SEISMIC SHOT RECORDS AS WELL AS VERTICAL SEISMIC PROFILES. A FORTRAN PROGRAMME WILL RESULT, DESIGNED AND OPTIMIZED FOR SUPER COMPUTERS. IN CO-OPERATION WITH CGG IT WILL BE IMPLEMENTED IN THE CRAY 1 COMPUTER IN PARIS.
IN THE SECOND PHASE THE AFOREMENTIONED PROGRAMME WILL BE USED TO GENERATE SYNTHETIC SEISMIC DATA FOR A NUMBER OF EXPLORATION SCENARIOS, BOTH LAND AND MARINE WITH VARIOUS SOURCE/RECEIVER CONFIGURATIONS. EXTENTION OF THE METHOD TO IMPORTANT NON-HORIZONTAL STRATIFICATIONS BY INTRODUCING E.G. BOUNDARY INTEGRAL EQUATIONS WILL BE MADE IN THE THIRD PHASE. AN ATTEMPT TO INCLUDE DIFFRACTION PHENOMENA AS WELL AS POSSIBLE VARIATIONS OF VELOCITY AND DENSITY IN EACH LAYER WILL ALSO BE MADE.

Fields of science (EuroSciVoc)

natural sciences > physical sciences > **acoustics**

natural sciences > mathematics > pure mathematics > **geometry**

natural sciences > computer and information sciences > data science > **data processing**

Programme(s)

FP1-ENNONUC 3C - Research and development programme (EEC) in the field of Non-Nuclear Energy, 1985-1988

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