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Short Note

The ingredients for a simple auto-statics program

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INTRODUCTION

Seismic processing schemes often seem to work best and have the widest field of application when they are simple to the point of being simplistic. The classic example is the NMO removal algorithm, which depends for its accurate results on precisely the structure we do not want to find, a flat one. Nevertheless, it is probably true that all, or almost all, datasets recorded in modern times have been subjected to NMO removal as a matter of course. I believe there are three basic reasons why these simple schemes may often work well:

- They are sufficiently loosely related to a specific model that they are able to handle the extraordinary variability of seismic data.
- The code is more likely to be relatively bug-free if it is brief and not complex.
- The list of parameters may be short enough that their proper choice may be understood by persons who are not necessarily expert geophysicists.

The statics algorithm presented in this paper seeks to emulate this desirable simplicity.

DEVELOPMENT

Elements

As I understand them, conventional auto-statics programs embody several features:

- Two types of essential variables, source and receiver.
- Two types of auxiliary variables, move-out and structure.
- Pilot traces.

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- Correlations to this pilot trace in several directions.

In addition, these statics programs are applied after NMO removal because they involve correlating traces with different source-receiver offsets. Under the scheme proposed in this note there are the following simplifications.

- One type of cross-correlation, between adjacent constant-offset traces.
- One essential variable, a differential weathering term.
- At most one auxiliary variable, a differential structure term.

An immediate consequence of the cross-correlation restriction is that the auto-statics program can—and probably should—precede velocity estimation and NMO removal.

Essential variables

Any auto-statics program is primarily aimed at removing variable weathering effects, and it seems, on the face of it, improper to assign independent variables to the weathering under the sources and receivers. If there is good reason to believe that the sources may have timing errors, then this might be handled with a separate variable, but these errors would likely have quite different statistics to the weathering sequence and should be handled independently.

Auxiliary variables

Conventional statics programs often carry two auxiliary variables: a structure term and a moveout term. This latter is not necessary in the subject scheme since there are no correlations with an offset component. The structure variable is more problematical. Additional parameters will always appear to improve solutions, but a structure-free algorithm that iterates enough (2 or 3 times?) to spread out structural effects and a low-cut filter that follows the final integration may perform better than extrinsic recognition of a structural problem.

A goodness measure

In addition to providing estimates of time corrections, iterative algorithms must also incorporate some measure of goodness which will both control the end of the iteration process and provide a tool for diagnosing some data problems. Since we are looking at a purely kinematic effect, a time shift, it seems reasonable to exclude amplitude from the problem and look to phase coherence as a function of time-shift as our principal measure of goodness. A simple way to do this is to cross-correlate instantaneous-phase representations of the traces rather than the traces themselves, and then use envelopes of these correlations to define phase coherence as a function of time-shift. A side benefit of this measure is that it immunizes the algorithm against dead traces and/or excessive noise.

Algorithm

The following scheme for an algorithm includes some features designed to contribute to its robustness against some of the horrors of data recorded in a real world.

1. Normalize and AGC the selected data segments using a short or zero time constant.
2. Cross-correlate all adjacent constant-offset data segments.
3. Form the envelopes of the cross-correlations.
4. Begin iteration loop
   (a) Average the envelopes over subject source and receiver locations to provide estimates of differential weathering corrections and their quality.
   (b) Average the envelopes over common depth-points to provide estimates of the differential structure corrections and their quality.
   (c) Correct the individual envelopes for these weathering and structure times.
   (d) Test to see if stop criterion is met. If true then go to END else if false go back to BEGIN.
5. End iteration loop
6. Integrate the sum corrections over the length of the section.
7. Low-cut filter the corrections to remove wavelengths longer than the cable.
8. Apply the result to the original data.

DISCUSSION

The suggested AGC emphasizes phase correlation and also normalizes the correlations so that poorly correlated traces will have a low amplitude envelope which will, in turn, make less of a contribution to the sum. Using envelopes rather than the cross-correlations themselves is designed to mitigate the leg-jump problem and I do not believe there is any evidence that envelopes are less sensitive to phase shift than the correlations. The scheme may be somewhat under-damped if both full weathering and structure corrections are made, and it may be advantageous to damp down the corrections by, say, 50%. In any case, under-damping could be quite simply monitored internally. The most serious missing element is any discussion of the use of data and correction statistics to improve the solutions. One of the features of the scheme is that it is not necessarily a least-squares scheme depending for success on a Gaussian model, but may take advantage of measured (spatial) non-Gaussianity in the data. The envelope averages are not necessarily means, they might be medians.

ACKNOWLEDGMENTS

Ray Abma and I have had some interesting discussions on auto-statics, but in the end his work (Abma, 1994), which is backed by some modeling studies, took a different track.

REFERENCES

Abma, R., 1994, Statics prediction from cross-correlations in orthogonal directions: SEP–**80**, **??–??**.