Appendix B Neighbourhood Algorithm

B.1 Introduction to the Neighbourhood Algorithm

The Neighbourhood Algorithm (NA) was used to solve nonlinear inverse problems as they were encountered at various stages in this project. The Neighbourhood Algorithm is a direct search (derivative-free) method in the same class of inversion techniques such as Simulated Annealing and Genetic Algorithms. These methods are similar in that they use randomized decisions in exploring the parameter space and require primarily the cost function and a forward model to be specified. They are in general very flexible because the complexity of the cost or objective function is the limiting factor, since its derivatives are not required to guide the search (Sambridge, 1999a). The advantages of the Neighborhood Algorithm are 1) the simplicity of its two-parameter tuning scheme (in contrast to the more complicated tuning mechanisms of other methods, such as the cooling schedule required by Simulated Annealing) and 2) that the rank of models (how the misfit of a given model compares to the misfit of other models), rather than the value of the misfit itself, drives the search process (Sambridge, 1999a).

The Neighbourhood Algorithm (NA) is a two-stage inversion approach. In the search stage (referred to by Sambridge as *NA-Sampler*), it uses nearest-neighbour regions called Voronoi cells to partition and search the parameter space. It is assumed that the misfit or objective function is constant within each Voronoi cell. With each iteration, sampling is concentrated on the cells with relatively lower misfit relative to the rest of the cells. Two tuning parameters control the number of cells to resample and how many new samples to generate in each resampled cell. These parameters control whether the algorithm performs as an optimizer (characterized by concentrated sampling in a region of low misfit, at the cost of possibly being trapped in local minima) or as a sampler (sampling a wider region of parameter space with relatively good

misfit, at the cost of taking much longer to find the global minimum).

The appraisal stage of the Neighbourhood Algorithm (referred to by Sambridge as *NA-Bayes*) facilitates error analysis of the ensemble of models generated in the search stage. Rather than being forced to make inferences about the system being studied from the single, lowest-misfit model, it provides the option of using the suite of all generated models in making inferences regarding the system (Sambridge, 1999b). The idea is that even poor-fitting models contain information about the system.

B.2 Applications in this thesis

The Neighbourhood Algorithm to solve the following inverse problems:

- Finding "best" 11 envelope parameters for each envelope history in the database (Chapter 2)
- Finding magnitude and distance dependence coefficients for ground motion amplitude attenuation relationships (Chapter 2)
- Recommended for finding magnitude and location estimates given available data in real-time (Chapter 10)

B.3 Availability

The Neighbourhood Algorithm (both NA-Sampler and NA-Bayes) can be obtained by contacting Malcolm Sambridge. Instructions on obtaining the latest version are available at *http://rses.anu.edu.au/ malcolm/na/na.html*. The NA-Sampler package (source code) is also included in the subfolder for Chapter 85.15 in the CD attached to Volume B of the International Handbook of Earthquake and Engineering Seismology.