MT Inversion with Dplus

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Introduction

The program *dplus* is an implementation of the theory for inverting 1-dimensional magnetotelluric problems as given by Parker (JGR, 85, 4421-8, 1980, *Geophysical Inverse Theory,* 1994, Parker and Whaler, JGR, 86, 9574-84, 1981). Its purpose is to find the best-fitting 1-dimensional conductivity profile consistent with a given finite number of magnetotelluric responses. The measure of fit is chi squared, the weighted sum of squared residuals. The program operates like *plotxy* by reading simple instructions from the command line until a task has been specified, and then executing the instruction set. The syntax of an instruction is:

command *parameters*

where the command starts in the first position and comprises a word of four or more letters (which can always be abbreviated to just four), and the parameters may be numerical values or words depending on the context. Some commands are not followed by any parameters, for example, **execute** tells the program to begin its calculations based on the instructions entered up to that point. After this execution, further instructions can be entered, and all the previous parameters remain in force unless altered before the next **execute**. Here is a simple sample program

```
file olden.dat
options freq admit
scale 1  1e3  1e3  1e3   1e3
plot
execute
quit
```

Here a data file contains frequencies and admittances, that is, Schmucker/Weidelt complex c values. The admittances are given in kilometers, which are scaled by one thousand to get them into meters as *dplus* requires. A plotfile is prepared with graphs of the data and the optimal solution. A complete explanation of the commands is given next.

COMMAND CATALOG

Any command can be reduced to its first four letters.

file *filename*
file *

In the first form, provide *dplus* with a data file from which to construct the best-fitting one-dimensional electrical conductivity. The disk file must be in ASCII and each line refers to a single frequency or period. The

contents of the file is described in the **option** command. The file is always read to the end-of-file.

If an asterisk (*) is used in place of a filename, data are read from the terminal, or if *dplus* is running from a script, that file. The read operation begins immediately after the **execute** command. The end of terminal input is signaled with a negative frequency (or period), or a contrl-D. The teminating line must contain dummy entries in the remaining columns, even though these are not used in the inversion.

option [*freq*/*omega*/*period*] [*admit*/*rho*]
The words in brackets are the possible legal choices, which signify the various types of data to be read, as follows. If *freq* is entered, column one of the data file contains the frequency in hertz; with *omega*, the frequency is the circular frequency in radians per second; *period* means column 1 contains the period in seconds. If none of these options is stated, frequency in hertz will be assumed by default. If the observations are not in these required units, they can be mapped in the correct ones using the **scale** command.

The second group of parameters specifies the kind of response. For admittance data enter *admit*. Then the data file must contain the real part of *c* in column 2 and the imaginary part in column 3, with the standard error of the real part in column 4, and the imaginary part in column 5. If there are only 4 numbers in a row, *dplus* assumes that the real and imaginary parts have the same uncertainty. The units of *c* must be meters. If your data are in other units, use **scale**.

If *rho* is entered, the observations are taken to be apparent resistivity and phase, arranged as 5 numbers per line in this order: frequency (or period), rho-apparent (siemens per meter), its uncertainty, then phase (degrees) and its uncertainty. These values are converted into admittances internally. The mapping is only approximate in the uncertainties; for an exact theory see Parker, R. L., and Booker, J. R., Optimal one-dimensional inversion and bounding of magnetotelluric apparent resistivity and phase measurements, *Phys. Earth & Planet. Int.*, 98, 269-82, 1996.

scale *s1 s2 s3 s4 s5*
Multiply the numbers in each row of the data files by the values specified by *s1*, *s2*, etc, where *s1* is applied to the number in column 1, and so on. This allows the user to convert the units in the data file to those needed by *dplus*. When fewer than five values are supplied, the remainder are taken to be unity.

uncertainty *factor*
When admittances are read the user can assign uniform uncertainties with this command, eliminating the need to provide values at each frequency. The standard deviation assigned is *factor* times the absolute value of the admittance; thus for 10% errors use *factor*=0.1.

base *h1 h2 ...*
In normal operation *dplus* terminates the conductivity with a perfect

conductor or an insulator as needed. With this command the program solves a series of inverse problems by fitting the measurements with the additional constraint of a perfect conductor at each of the given depths (in meters). The corresponding misfits can be used in a penetration analysis: see Parker, *Geophys. J. Roy astr. Soc.,* 68, 165-70. 1982.

mu_0 *muo*
Another way to scale the data is to provide a nonstandard value for the permeability of free space, replacing the SI value of $4\pi \times 10^{-7}$ with something else.

intervene
Various internal default parameters may be set immediately after entering this command. To be used interactively by one who knows the intimate details of the program.

print *n*
Controls the amount of printing with the integer n. A parameter value of zero yields the least amount of material: a listing of the data (in the units used internally), a summary of the progress of the iterations that reduce the model chi-squared, and a listing of the final model profile. With n=1, the model's responses is added; n=2 includes the spectral functions; with 3 internal arrays are listed. The default level of printing is n=1, which is usually satisfactory.

plot
Prepare a *plotxy* plotfile in fort.19. The plot comprises a graph of the data and the model response as admittance versus frequency, and two plots of the delta-function conductivity profile, one on linear axes, the other on a log-log scale. If several solutions are obtained in a single run, the plotfiles are written in order on fort.19 and must be split up to be displayed.

clear *command*
Upon reaching an **execute** instruction *dplus* runs using the instructions currently in the command stack. If there is more than one entry of a particular command (say **file**) *dplus* uses the most recent one. To remove a command from the stack (such as **plot**) use the **clear** command, which deletes all entries of the named command. The command **clear** does not itself go onto the command stack; it is executed immediately.

review
List the current command stack at the terminal; see **clear**. This command does not go onto the command stack but is executed at once

execute
Run the program *dplus* using the instructions in the current command stack. If there is more than one entry of a particular command *dplus* uses the most recent one. After execution *dplus* is ready to read further instructions, which it will accumulate until the next **execute** command

quit
End the session.