12. Secondary Parameters

12.1 General

Secondary parameters can appear in a PEST control file that is read by any member of the HP suite of programs, including PEST_HP. The use of secondary parameters removes the need to employ PAR2PAR in a batch or script file that is run as "the model".

Secondary parameters are not optimised. Their values are simply calculated from primary (i.e. normal) parameters using equations supplied in the PEST control file. These equations can feature the primary parameters that are cited in a PEST control file (including fixed and tied parameters) and other secondary parameters whose values were previously calculated. They can also feature so-called "file parameters". See the "HP Suite" companion to this manual for a description of these parameter types. PEST_HP does not support the use of file parameters; however CMAES_HP, a member of the HP suite, does support their use.

12.2 Defining Secondary Parameters

A secondary parameter can be defined in a PEST control file anywhere within the "parameter data" section of this file. Figure 12.1 shows an example of the "parameter data" section of a PEST control file in which secondary parameters are defined.

```
* parameter data
ro1  log factor 1.000000 0.1 100 ro 1 0 1
ro2  log factor 1.000000 0.1 100 ro 1 0 1
ro3  log factor 1.000000 0.1 100 ro 1 0 1
ro4  log factor 1.000000 0.1 100 ro 1 0 1
ro5  log factor 1.000000 0.1 100 ro 1 0 1
ro6  log factor 1.000000 0.1 100 ro 1 0 1
ro7  log factor 1.000000 0.1 100 ro 1 0 1
ro8  log factor 1.000000 0.1 100 ro 1 0 1
ro9  log factor 1.000000 0.1 100 ro 1 0 1
ro10 log factor 1.000000 0.1 100 ro 1 0 1
h1   log factor  0.25  0.05 100 hhh 1 0 1
h2   tied factor  0.50 0.05 100 hhh 1 0 1
h3   tied factor  1.00 0.05 100 hhh 1 0 1
h4   tied factor  2.00 0.05 100 hhh 1 0 1
h5   tied factor  4.00 0.05 100 hhh 1 0 1
h6   tied factor  8.00 0.05 100 hhh 1 0 1
ep1 = ro1+ro2
ep2 = ep1+ep1
h7   tied factor  16.0 0.05 100 hhh 1 0 1
h8   tied factor  32.0 0.05 100 hhh 1 0 1
h9   tied factor  64.0 0.05 100 hhh 1 0 1
h2 h1
h3 h1
ep2 = 2*ep2
h4 h1
h5 h1
h6 h1
h7 h1
h8 h1
h9 h1
```

Figure 12.1 The "parameter data" section of a PEST control file wherein secondary parameters are defined.

Secondary parameters are defined by an equation. Their presence on any line of the "parameter data" section of a PEST control file is recognized by the fact that an "=" symbol follows their name.

An equation must follow the "=" symbol. This equation can be of arbitrary complexity; see documentation of PAR2PAR and PLPROC (both of which feature parameter equations) for examples. The right side of the equation can feature any primary PEST parameter, file parameter, or previously-defined secondary parameter. As in any programming language, a secondary parameter can appear on both sides of an equation, provided a value has already been calculated for it; its value can thus be updated by the equation.

If desired, the equation through which a secondary parameter is given a value can have a logical outcome and involve logical operators; see "selection equations" in documentation of the PLPROC program. If the outcome of an equation is logical, then a calculated value of TRUE endows the secondary parameter with a value of 1.0, while a calculated value of FALSE endows the secondary parameter with a value of 0.0.

The values calculated for secondary parameters are transferred from the PEST_HP manager to its agents at the same time, and in the same manner, as are the values of primary parameters. These values are then transferred to model input files using template files. Hence template files which are listed in the "model input/output" section of a PEST control file in which secondary parameters are defined can also feature secondary parameters. Note that it is not necessary for all secondary parameters defined in a PEST control file to appear in one or more template files which are cited in that file. Some secondary parameters may thus be used only for intermediate calculations whose ultimate goal is the assignment of a value to another secondary parameter whose value is then written to a model input file.

12.3 Number of Secondary Parameters and Equations

PEST_HP (and other HP suite programs) must be informed of the existence of secondary parameters, and of equations which define them, in the "control data" section of the PEST control file which they read. This information is used to dimension arrays which hold data pertaining to these entities. See figure 12.2.

```
pcf
* control data
restart estimation
10 19 2 10 3 nparsec=2 nequation=3
3 3 single point  1 0 0
Etc
```

Figure 12.2 First part of the "control data" section of a PEST control file which features secondary parameters.

On the fourth line of the PEST control file depicted in figure 12.2, the string "nparsec=2" informs PEST_HP that there are 2 secondary parameters. The string "nequations=3" informs PEST_HP that there are 3 equations. (A space can precede or follow the "=" symbol in each case.) As is obvious from the above discussion, the existence of secondary parameters implies the existence of equations, and vice versa. Also, the number of equations must equal or exceed the number of secondary parameters. It is important to note that the NPAR variable (first variable featured on the fourth line of the PEST control file) must refer only to the number of primary PEST parameters. (Note also that, as well as featuring the NPARSEC and NEQUATION control variables, the fourth line of a PEST control file may also feature the NPARFILE and FILEPARFILE variables. These variables pertain to file parameters. As stated above, at the time of writing, only CMAES_HP can employ file-parameters.)

The following should also be noted.

- PEST_HP will cease execution with an appropriate error message if secondary parameters are defined in a PEST control file that asks it to undertake SVD-assisted inversion.
- Prior information equations cannot cite secondary parameters.
- The values of secondary parameters are not listed in parameter value files recorded by PEST_HP in which progressively optimised values of primary parameters are recorded. As secondary parameters are not optimised, but are functions of primary parameters, there is no need to record their values in these files.
- The values of secondary parameters associated with optimised primary parameters are listed at the end of the PEST_HP run record file.
- A primary parameter cannot appear on the left side of an equation.

12.4 Operation of PEST_HP with Secondary Parameters

Outwardly, the operation of PEST_HP when using secondary parameters is no different from its operation without them. The values of secondary parameters are calculated by the run manager prior to these values being transferred to run agents for transfer to model input files. If any problems are encountered in parsing the equation through which a secondary parameter is assigned its value, or with calculating the value of a secondary parameter, an error message is recorded and PEST_HP ceases execution.

The following features of PEST_HP operations when using secondary parameters should also be noted.

- If PEST_HP is run with the "/f" switch, it will accept secondary parameters in the PEST control file. However it does not record the values of secondary parameters in the run results file. (As stated above, even though these are featured in the PEST control file, they are not adjustable; hence they can be considered to be the outcome of intermediate calculations undertaken by the model.)
- Only PEST_HP, but not PEST, can parse and evaluate equations. Therefore PEST cannot be used to write a hp starter file for the use of PEST_HP if a PEST control file features secondary parameters.