
Detrital MC

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USER GUIDE

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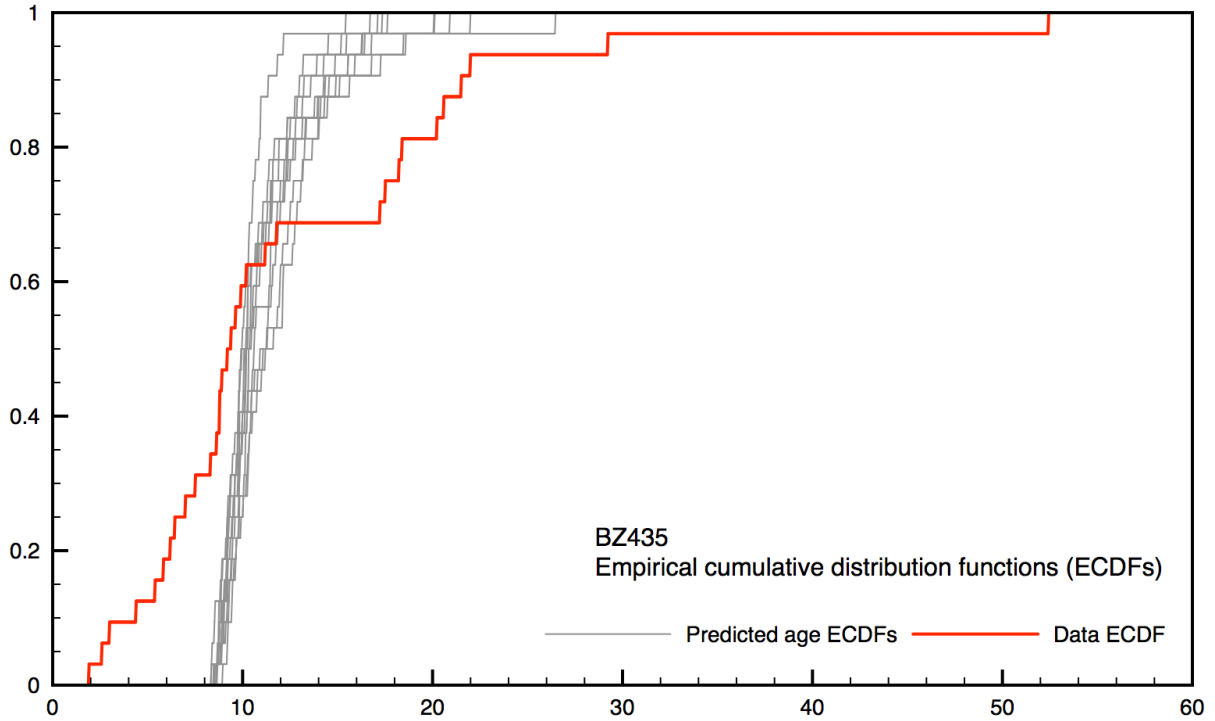


Fig. 1: Predicted and observed detrital thermochronometer age distributions plotted as empirical cumulative distribution functions

Detrital MC is a Monte Carlo code for comparing predicted and observed detrital thermochronometer ages. This website contains documentation for Detrital MC. If you are interested in the code itself, you can download Detrital MC from its GitHub repository at <https://github.com/HUGG/Detrital-MC/>.

QUICK START

This is a quick introduction to how to use Detrital MC. Please check the rest of the documentation for more detailed explanations of how the software operates.

Quick intro coming soon...

CODE OVERVIEW

This is a general overview of Detrital MC. Please check the rest of the documentation for more detailed explanations of how the software operates.

Code overview coming soon...

INPUT FILE

Here we explain the input file used to control Detrital MC, where all parameters for a Detrital MC model and the locations of input data files are specified. The **input file** is located in the `input` subdirectory. Note that you can freely add comments in your copies of the Detrital MC input file by starting lines with the `$` character.

Below, we describe the different sections of the Detrital MC input file and how they work. The general format of this documentation gives information about what should be listed on each line of each section of the input file. The sections and lines are given by number, while the values on each line are given using letters. An example of two lines containing 3 and 5 values is given below.

Listing 1: Example format of the Detrital MC input file.

```
$=== [3] - Section name =====  
VALUE_A VALUE_B VALUE_C  
VALUE_A VALUE_B VALUE_C VALUE_D VALUE_E
```

Please check the rest of the documentation for more detailed explanations of how other parts the software operate.

3.1 Section 1: Basin summary information

The first section of the Detrital MC input file is for specifying how many basins are being analyzed, and the names, formats, and associated parameters for the input data files. The input values are described in more detail below.

Listing 2: Section 1 of the Detrital MC input file (without comments)

```
$=== [1] - Basin summary information =====  
1  
BH398-AFT 3 BH398-WB009-1km_Pecube_and_topometrics_250m 8 97 1.0 1.0 1.0 1.0 1.0 1.0  
→1.0 1.0 1.0 1.0 1.0 1.0 1
```

3.1.1 Section 1, line 1 (1 required value)

- **Value a:** Number of basins to analyze. Type: `int`

The only input value here is the number of basins to analyze.

3.1.2 Section 1, line 2+ (4+ required values)

In section 1, the remaining line(s) are used to provide information about each of the basins that should be analyzed. You should use one line per basin.

- **Value a:** Name of the observed age data file in the `data/observed_ages` subdirectory. Type: `char`
Listing `ba1` would tell Detrital MC to read measured ages from the `data/observed_ages/ba1.dat` file. This should be a character string.
- **Value b:** Predicted age file format. Type: `int`

Note: Values `c`, `d`, ... differ depending on the value selected for value 2 on this line. As a result, we list the corresponding descriptions of those values below each number below.

If value `b = 1`: `Comparison.txt` file generated by [HUGG version of Pecube](#). Complete this line with the following values:

- **Value c:** Name of the Pecube model run output directory (e.g., `RUN00`) in the `data` subdirectory. Type: `char`
- **Value d:** The predicted thermochronometer age system to use (1 = AHe, 2 = AFT, 3 = ZHe, 4 = ZFT, 5 = MAr). Type: `int`

If value `b = 2`: Generic CSV file. Complete this line with the following values:

- **Value c:** Name of the predicted age file in the `data` subdirectory (e.g., `DW001` for `DW001.csv`). Type: `char`
- **Value d:** The number of the column containing predicted ages in the CSV file. Type: `int`
- **Value e:** The number of the column containing predicted erosion rates in the CSV file. Type: `int`

Note: If value `e` is equal to 16, 17, 18, 19, 98, or 99, additional information is required.

If value `e = 16`:

- * **Value f:** Bedrock fertility scaling factor 1 (TSS). Type: `float`
- * **Value g:** Bedrock fertility scaling factor 2 (GHS). Type: `float`
- * **Value h:** Bedrock fertility scaling factor 3 (LHS). Type: `float`
- * **Value i:** Bedrock fertility scaling factor 4 (Siwaliks). Type: `float`
- * **Value j:** Bedrock fertility scaling factor 5 (Leucogranites). Type: `float`
- * **Value k:** Bedrock fertility scaling factor 6 (LHS-C). Type: `float`
- * **Value l:** Erosion scaling factor. Type: `int`
 - 0: None
 - 1: Instantaneous exhumation rates from Pecube
 - 2: Normalized channel steepness
 - 3: Specific stream power

If value `e = 17`:

* **Value f:** Glacier scaling factor 1 (Glacier-covered areas). Type: float

* **Value g:** Glacier scaling factor 1 (Glacier-free areas). Type: float

* **Value h:** Erosion scaling factor. Type: int

- 0: None
- 1: Instantaneous exhumation rates from Pecube
- 2: Normalized channel steepness
- 3: Specific stream power

If value e = 18:

* **Value f:** Moraine scaling factor 1 (Moraine-covered areas). Type: float

* **Value g:** Moraine scaling factor 1 (Moraine-free areas). Type: float

* **Value h:** Erosion scaling factor. Type: int

- 0: None
- 1: Instantaneous exhumation rates from Pecube
- 2: Normalized channel steepness
- 3: Specific stream power

If value e = 19:

* **Value f:** Rock glacier scaling factor 1 (Rock glacier-covered areas). Type: float

* **Value g:** Rock glacier scaling factor 1 (Rock glacier-free areas). Type: float

* **Value h:** Erosion scaling factor. Type: int

- 0: None
- 1: Instantaneous exhumation rates from Pecube
- 2: Normalized channel steepness
- 3: Specific stream power

If value e = 98:

* **Value f:** Bedrock fertility scaling factor 1 (Checkha/TSS). Type: float

* **Value g:** Bedrock fertility scaling factor 2 (GHS). Type: float

* **Value h:** Bedrock fertility scaling factor 3 (LHS). Type: float

* **Value i:** Bedrock fertility scaling factor 4 (Siwaliks). Type: float

* **Value j:** Bedrock fertility scaling factor 5 (Leucogranites). Type: float

* **Value k:** Bedrock fertility scaling factor 6 (Paro). Type: float

* **Value l:** Glacier scaling factor (Glacier-covered areas). Type: float

* **Value m:** Moraine scaling factor (Moraine-covered areas). Type: float

* **Value n:** Rock glacier scaling factor (Rock glacier-covered areas). Type: float

* **Value o:** Non-glacial scaling factor (Areas free of glacial formations). Type: float

* **Value p:** Erosion scaling factor. Type: int

- 0: None

- 1: Instantaneous exhumation rates from Pecube
- 2: Normalized channel steepness
- 3: Specific stream power

If value e = 99:

- * **Value f:** Glacier scaling factor (Glacier-covered areas). Type: float
- * **Value g:** Moraine scaling factor (Moraine-covered areas). Type: float
- * **Value h:** Rock glacier scaling factor (Rock glacier-covered areas). Type: float
- * **Value i:** Non-glacial scaling factor (Areas free of glacial formations). Type: float
- * **Value j:** Erosion scaling factor. Type: int
 - 0: None
 - 1: Instantaneous exhumation rates from Pecube
 - 2: Normalized channel steepness
 - 3: Specific stream power

If value b = 3: Newer generic CSV file. Listed values are the same as for Value b = 2, with the addition below:

Note: If value e is equal to 97, additional information is required.

If value e = 97:

- **Value f:** Bedrock fertility scaling factor 1 (Checkha/TSS). Type: float
- **Value g:** Bedrock fertility scaling factor 2 (GHS). Type: float
- **Value h:** Bedrock fertility scaling factor 3 (LHS). Type: float
- **Value i:** Bedrock fertility scaling factor 4 (Siwaliks). Type: float
- **Value j:** Bedrock fertility scaling factor 5 (Leucogranites). Type: float
- **Value k:** Bedrock fertility scaling factor 6 (Paro). Type: float
- **Value l:** Glacier scaling factor (Glacier-covered areas). Type: float
- **Value m:** Moraine scaling factor (Moraine-covered areas). Type: float
- **Value n:** Rock glacier scaling factor (Rock glacier-covered areas). Type: float
- **Value o:** Non-glacial scaling factor (Areas free of glacial formations). Type: float
- **Value p:** Scaling factor for regions with hillslopes >30 degrees. Type: float
- **Value q:** Scaling factor for regions with hillslopes <10 degrees. Type: float
- **Value r:** Erosion scaling factor. Type: int
 - * 0: None
 - * 1: Instantaneous exhumation rates from Pecube
 - * 2: Normalized channel steepness
 - * 3: Specific stream power

3.2 Section 2: Number of grains to consider in predicted age PDFs

The second section of the Detrital MC input file contains information about the number of “samples” to consider when calculating age distributions. The input values are described in more detail below.

Listing 3: Section 2 of the Detrital MC input file (without comments)

```
$=== [2] - Number of grains to consider in predicted age PDFs =====
0
0
```

3.2.1 Section 2, line 1 (1 required value)

- **Value a:** Number of different sample sizes to consider. Type: `int`

Detrital MC has the option to calculate age distributions using different numbers of ages in the distribution.

- If $a < 1$, the code will use the number in the observed age file
- If $a > 0$, you should list the number of different samples sizes on the second line

3.2.2 Section 2, line 2 (1 required value, additional optional values)

- **Value a:** Number of ‘grains’ in each sample, separated by a single space. Type: `int [int int ...]`

If value a on line one of this section is less than 1, this value is read, but ignored

3.3 Section 3: PDFs to calculate

Section three of the Detrital MC input file contains flags for which age distributions should be calculated. The input values are described in more detail below.

Listing 4: Section 3 of the Detrital MC input file (without comments)

```
$=== [3] - PDF generation =====
1 0 1
```

3.3.1 Section 3, line 1 (3 required values)

- **Value a:** Flag for whether or not to calculate age distributions for the observed age data. Type: `int`

The input value must be either 1 or 0.

- 1 = yes
- 0 = no

- **Value b:** Flag for whether or not to calculate age distributions for the entire predicted age population. Type: `int`

The input value must be either 1 or 0.

- 1 = yes

- 0 = no

- **Value c:** Flag for whether or not to calculate age distributions from Monte Carlo random samples from the predicted age population. Type: `int`

The input value must be either 1 or 0.

- 1 = yes

- 0 = no

INPUT DATA FILE FORMATS

Here we explain the formats of data files that can be read for Detrital MC.

In addition to the input file (`input/det_mc_input.txt`), Detrital MC can read observed/measured age data and three different formats of predicted age data. Each are described in more detail below.

Please check the rest of the documentation for more detailed explanations of how other parts the software operate.

4.1 Observed age data file format

4.2 Predicted age data file format

4.2.1 Pecube Comparison.txt file

Listing 1: Format of the Pecube Comparison.txt file for Detrital MC

NLINES	LON	LAT	ELEV	PECUBE_ELEV	PECUBE_VZ	AHE_OBS	AHE_
→ PRED	AFT_OBS	AFT_PRED	ZHE_OBS	ZHE_PRED	ZFT_OBS	ZFT_PRED	→
→ KAR_OBS	KAR_PRED	BAR_OBS	BAR_PRED	MAR_OBS	MAR_PRED	HAR_OBS	→
→ HAR_PRED	FTL_OBS01	FTL_OBS02	FTL_OBS03	FTL_OBS04	FTL_OBS05	FTL_OBS06	→
→ FTL_OBS07	FTL_OBS08	FTL_OBS09	FTL_OBS10	FTL_OBS11	FTL_OBS12	FTL_OBS13	→
→ FTL_OBS14	FTL_OBS15	FTL_OBS16	FTL_OBS17	FTL_PRED01	FTL_PRED02	FTL_PRED03	→
→ FTL_PRED04	FTL_PRED05	FTL_PRED06	FTL_PRED07	FTL_PRED08	FTL_PRED09	FTL_PRED10	→
→ FTL_PRED11	FTL_PRED12	FTL_PRED13	FTL_PRED14	FTL_PRED15	FTL_PRED16	FTL_PRED17	→
→ RAMAN_OBS	RAMAN_PRED						
...							

4.2.2 CSV file format 1

Listing 2: Format of CSV file 1 for Detrital MC

NLINES
UNUSED, UNUSED, UNUSED, UNUSED, SCALE1, AGE_PRED1, AGE_PRED2, AGE_PRED3, AGE_PRED4, UNUSED,
→ UNUSED, AGE_PRED5, UNUSED, UNUSED, UNUSED, UNIT_ID1, UNIT_ID2, UNIT_ID3, UNIT_ID4, SCALE2,
→ SCALE3, SCALE4, SCALE5, UNUSED, UNUSED, UNUSED, UNUSED, UNUSED, UNUSED, SCALE6, SCALE7

4.2.3 CSV file format 2

Listing 3: Format of CSV file 2 for Detrital MC

```
NLINES
UNUSED,UNUSED,UNUSED,UNUSED,SCALE1,AGE_PRED1,AGE_PRED2,AGE_PRED3,AGE_PRED4,UNUSED,
↪UNUSED,AGE_PRED5,UNUSED,UNUSED,UNUSED,UNIT_ID1,UNIT_ID2,UNIT_ID3,UNIT_ID4,SCALE2,
↪SCALE3,SCALE4,SCALE5,UNUSED,UNUSED,UNUSED,UNUSED,UNUSED,UNUSED,SCALE6,SCALE7,
↪SCALE8,UNIT_ID5,UNIT_ID6
```

CALCULATION OF AGE DISTRIBUTIONS

This page presents an overview of how age distributions in Detrital MC are calculated. Distributions of ages from detrital samples can be assembled and visualized in several different ways. Below I describe the different distributions and their meanings, as well as how they are used in Detrital MC.

5.1 Measured age PDFs and sample age distributions

5.1.1 Measured age PDFs

In order to calculate age distributions for all grain ages in a sample, the first step is to calculate the **probability distribution function** $\text{PDF}(x)$ for a single age assuming a normal distribution of error about the mean age μ with the standard deviation σ , and with a kernel width scaling factor α .

$$\text{PDF}(x) = \frac{1}{\alpha\sigma_i\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\alpha\sigma}\right)^2\right)$$

The default value for α in Detrital MC is 0.6, but this value can be modified as described in Brandon (1996).

5.1.2 Sample age distributions (SPDFs)

Age distributions for measured sample ages can be generated by calculating the sum of the individual measured age PDFs and normalizing that sum to the number of measured ages,

$$\text{SPDF}(x) = \frac{1}{n} \sum_{i=1}^n \text{PDF}_i(x).$$

This is referred to as the **synoptic probability density function** (SPDF) by Ruhl and Hodges (2005)

5.2 Predicted age PDFs and age distributions

5.2.1 Predicted age PDFs

The calculation of individual predicted age PDFs is similar to that above, but the predicted age PDFs are scaled by one or more scaling factors collectively referred to as f_{eff} in order to account for factors that might increase the probability of an age being present in a catchment predicted age distribution, such as differences in the tectonic uplift rate or bedrock mineral fertility. Thus, the age PDF for a given predicted age can be calculated as

$$\text{PDF}_p(x) = f_{\text{eff}} \times \text{PDF}(x)$$

The values for the scaling factors that are combined as f_{eff} are given in the input data file for Detrital MC. Further detail about this is given in the [section describing the Detrital MC input file](#).

Another important difference for the predicted age PDFs is that there are no mean ages or standard deviations for the predicted ages. Instead, the predicted age is used as the mean age μ_p and the standard deviation σ_p can be calculated as a function of the uncertainties in the measured ages or a constant percentage of the mean age. For example, it is often the case that the mean uncertainty fraction in the measured ages is used to calculate the predicted age standard deviations such that the calculated standard deviation would be

$$\sigma_p = \mu_p \times \sum_{i=1}^n \frac{\sigma_i}{\mu_i},$$

where σ_i and μ_i are the mean age and standard deviation for the n measured ages.

5.2.2 Predicted age distributions (SPDFs)

The predicted age SPDFs are also calculated similar to those for the sample measured ages, but scaled once again by the scaling factor f_{eff} . In this case, the age distribution should be normalized to have an area of 1.0, so the predicted SPDF is simply the SPDF divided by the average scaling factor $\overline{f_{\text{eff}}}$. In other words,

$$\text{SPDF}_p(x) = \frac{1}{\overline{f_{\text{eff}}}} \times \text{SPDF}(x).$$

5.3 Catchment cumulative distributions

In order to compare the measured and predicted age distributions, both need to be converted to **cumulative density functions** (CDFs) of some form. There are two options for this in Detrital MC, described below.

5.3.1 Smoothed distributions

The standard CDF used in Detrital MC is simply an integrated version of the SPDF, integrated using the trapezoid rule. This produces a smooth CDF, since the ages in the SPDF have been smoothed by their measurement uncertainties.

5.3.2 Unsmoothed distributions

Option two is to calculate an unsmoothed cumulative distribution function. This function is referred to as the **empirical cumulative distribution function** (ECDF), which is the same as the cumulative age distribution described by Vermeesch (2007). The result is a step function, where the function value increases by $1/n$ for each age in the sorted distribution.

5.4 References

- Brandon, M. T. (1996). Probability density plot for fission-track grain-age samples. *Radiation Measurements*, 26(5), 663–676.
- Ruhl, K. W., & Hodges, K. V. (2005). The use of detrital mineral cooling ages to evaluate steady state assumptions in active orogens; an example from the central Nepalese Himalaya. *Tectonics*, 24, no.4, 14.
- Vermeesch, P. (2007). Quantitative geomorphology of the White Mountains (California) using detrital apatite fission track thermochronology. *Journal of Geophysical Research*, F, Earth Surface, 112(F3), F03004.

MONTE CARLO AGE SAMPLING

Here we explain how Monte Carlo age sampling works in Detrital MC. Please check the rest of the documentation for more detailed explanations of how other parts the software operate.

Monte Carlo code description coming soon...

COMPARING AGE DISTRIBUTIONS

Here we explain how predicted and measured age distributions are compared in Detrital MC. Please check the rest of the documentation for more detailed explanations of how other parts the software operate.

Data comparison description coming soon...

OUTPUT FILES AND FORMATS

Here we explain the files and formats produced by Detrital MC. Please check the rest of the documentation for more detailed explanations of how other parts the software operate.

Output file format description coming soon...

REFERENCES

Below is a collection of references related to Detrital MC.

Reference list coming soon...

USING DETRITAL MC WITH PECUBE

Instructions for using Detrital MC with Pecube will be added soon. . .

INDICES AND TABLES

- `genindex`
- `modindex`
- `search`