aetherise 1.1

Sebastian Pliet*

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Aetherise is a tool for analysing the data sheets produced by Dayton C. Miller's experiments on Mount Wilson in the years 1925–1926. The name is a play on words from the words *ether*, *analyse* and *rise*.

Aetherise is programmed in C++11 and is open source.
https://github.com/aetherise/aetherise

*aetherise@gmx.de

Contents

1 Functionality

Aetherise is used from the console. Aetherise reads in the data sheets and generates outputs on the standard output channel in various text formats. The main functions are data reduction, curve fitting and data visualisation. For data visualisation Aetherise generates output in Gnuplot format.[1]

There are two basic modes of data processing. Batch processing and aggregation (-aggregate). In batch processing, all files are processed in the specified order independently of all others. With aggregation, all specified files are processed in a context. For example, a mean value can be calculated.

1.1 Call

Aetherise expects a list of CSV files (Miller's data sheets) as parameters. The simplest call is:

```
aetherise *.csv
```

The result is a list of the specified file names. The expression '*.csv' is processed by the operating system, not by `aetherise`. Output from Aetherise is made directly to the console and can be redirected to a file with >. For example:

```
aetherise *.csv -month [9,9] -no [49,56] -reduce > s.dat
```

The standard output format for data is Gnuplot format. With various scripts you can then display this data with Gnuplot. For the example above:

```
plot_signal.sh s.dat
```

[1] http://www.gnuplot.info

2 Data sheets

The data sheets are available individually as text files in CSV format. Each file was created from a transcription of the digitised original data sheets by Miller [1]. The first 4 lines contain metadata, followed by any number of data lines. The metadata has the following structure:

No	Date	tm	tlm	theta	Weight	Fringes	sc	rem
th0	TN0	TE0	TS0	TW0	Weather			
th1	TN1	TE1	TS1	TW1				
t0	t1	Attributes						

Table 1: Metadata

Label	Field	Description
No	Data sheet number	Sequentially assigned number, unique per epoch.
Date	Date of observation	Refers to the mean observation time.
tm	Mean observation time	
tlm	Local mean time	
theta	Local sidereal time	
Weight	Number of weights	Presumably, this value indicates the number of weights on the arms of the interferometer.
Fringes	Number of fringes	Number of interference fringes.
sc	Sign correct?	The character x is entered here if the note 'sign correct' appears in the remarks.
rem	Remarks	
th0	Reading time	Time of reading the four thermometers before the measurements.
TN0–TW0	Temperatures	Temperatures in °C of the four thermometers on the walls of the hut. Read off before the measurement.
th1	Reading time	Time of reading the four thermometers after the measurements.
Weather	Weather conditions	A combination of the codes: c=clouds, w=wind, r=rain, f=fog, m=mist, h=haze. No code means: clear.
TN1–TW1	Temperatures	Temperatures in °C of the four thermometers on the walls of the hut. Read off after the measurement.
t0	Start time	Start of measurements.
t1	End time	End of measurements.
Attributes	Data sheet attributes	A combination of the codes: s=Desk in the southwest instead of the northwest, r=Sign reversed, v=Visitor, p=Corrugated paper up.

The data rows form a table with 18 columns. The first 17 columns contain the measured values. The measured values are integers that indicate the distance from the reference strip to a marker. The distance is given in $^1/_{10}$ fringes. The last column (Meta) can contain metadata or codes for data manipulation, which refer to this row. A data row has the following structure:

q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11	q12	q13	q14	q15	q16	q17	Meta

The fields q1-q16 contain the readings at the corresponding azimuths. The field q17 contains the second reading of azimuth 1 after one full rotation and is identical with the value of the field q1 of the next line if there was no readjustment.

Table 2: Codes in the field Meta [a]

Code	Description
a	Adjustment
+, -	Sign (Meaning unclear)
r	Reverse the sign of the measurement
c	Cancel measurement
R	Disabled r
C	Disabled c
i	Reverse the sign of the measurement
b	Cancel measurement

[a] The codes R, C, i, b are new and do not appear in the original data sheets. They are used for data manipulation.

Example: Data sheet Sep-20 with the first 5 data lines.

```
20;1925-09-12;17:21;17:29;16:54;8;6;x;"slight fog overhead. sun low. ..."
17:05;16.1;15.9;16;16;f
17:23;15.8;15.6;15.7;15.8
17:07;17:22;
8;8;7;6;6;6;5;5;6;5;5;5;6;6;6;5;5;
5;5;5;5;5;5;4;4;4;4;3;3;2;2;1;1;0;
0;0;0;0;0;-1;-2;-3;-3;-3;-3;-2;-2;-3;-4;-5;-5;b
-5;-5;-6;-6;-6;-7;-7;-7;-7;-8;-8;-8;-9;-9;-8;-8;-8;a-
1;1;1;0;0;0;0;0;0;0;0;0;0;0;-1;-1;-1;
```

3 Filter

Normally, one always works with the complete list of all data sheets and then uses the filter options. A data sheet from Miller's experiments on Mount Wilson can be unambiguously determined by the month of the date and the data sheet number. Miller's data sheets contain more metadata than just date and data sheet number, and almost all of this metadata can be filtered by.

Filters usually expect an interval, i.e. a range of values. Single values cannot be specified. Different filters are logically and-linked. Identical filters are logically or-linked. Intervals are indicated by two decimal numbers, separated by a comma, in square brackets and without spaces. It is possible to specify unlimited intervals by omitting a value.

In the following example, the filters `-month` and `-no` are used. Only data sheets from the month of September with numbers 49 to 56 are to be selected:

```
aetherise dcm/csv/*.csv -month [9,9] -no [49,56]
```

The result is a list of the file names of the selected data sheets.

Here is an example of how to filter by times. Only data sheets are selected with a mean observation time from 13:30:

```
aetherise -time [13.5,] dcm/csv/*.csv
```

The result is again only a list of the selected file names.

3.1 -no *interval*

Number of the data sheet.

3.2 -year *interval*

Year of the date.

3.3 -month *interval*

Month of the date.

3.4 -day *interval*

Day of the date.

3.5 -weight *interval*

Probably the number of weights.

3.6 -fringes *interval*

Number of interference fringes.

3.7 -time *interval*

Mean observation time.

3.8 -sidereal *interval*

Local sidereal time.

3.9 -T *interval*

Temperature (°C). All temperatures on the data sheet must be within the specified interval.

3.10 -dT *interval*

Temperature change, related to the reading times. All temperature changes of the four thermometers must lie within the specified interval.[2]

3.11 -mean_dT *interval*

Mean temperature change (°C per $\frac{1}{4}$h).[2]

3.12 -TD *interval*

Maximum temperature difference (°C) of the four thermometers at one time. The value must be in the interval for both readings.

[2]There are data sheets where the thermometers have only been read once (or not at all) and therefore no change can be determined. These data sheets do not pass through this filter.

3.13 -adjust *interval*

Number of adjustments.

3.14 -sign_correct

Note 'sign correct' present.

3.15 -sign_correct_missing

Note 'sign correct' missing.

3.16 -nw

Desk in the northwest.

3.17 -sw

Desk in the southwest.

3.18 -amplitude *interval*

Amplitude of the measured displacement.

3.19 -drift *interval*

The mean drift. See -stats.

3.20 -abs_drift *interval*

The mean absolute drift. See -stats.

3.21 -uncertainty *interval*

The mean standard uncertainty.

3.22 -theory_amp *interval*

Amplitude of the theoretical displacement.

4 Actions

In order to display certain data from the data sheets or to process them in a certain way, there are actions. Without specifying an action, the file names are simply output.

4.1 -header

Displays the metadata in the header of a data sheet approximately as it was written down in the original. The call

```
aetherise dcm/csv/*.csv -month [9,9] -no [50,50] -header
```

generates the output

```
(50)   Mt. Wilson, 1925-09-17
 19:58 20:15
 15.7  15.7     20:07 20:15
 15.7  15.4        θ = 20h 0m
 15.7  15.7    weight: 9.0    fringes: 6
 15.7  15.8
Cloudy. Fringes wide, straight steady (6 to field).
19:59 - 20:15    sign correct
```

The first line shows the data sheet number in brackets. Next to it is always the same text ‘Mt. Wilson’, followed by the date in ISO notation. Below this is a line with two times, which refer to the table with temperatures below. The times are the times of the temperature readings of the four thermometers on the walls of the hut. From top to down the cardinal directions: N, E, S, W. Next to them in the middle you see the mean observation time and the local mean time, and below that the local sidereal time in hours, which was calculated from this. Miller determines the local mean time for the epochs August, September and February from the mean observation time +8 minutes. In the epoch April, no local mean time is given. Below the times one sees ‘weight’ and ‘fringes’. The value for ‘fringes’ indicates a number, the value for ‘weight’ probably also. Values for weight and fringes are not consistently present. The penultimate line contains Miller’s comments. Usually descriptions of the weather and the fringe system, or special events. In the last line are the times of the beginning and the end of the measurements and possibly the note ‘sign correct’.

4.2 -raw

Outputs the raw data of a data sheet. This data can then be plotted with the script `plot_raw.sh`.

4.3 -raw_reduced

Frees the individual measurements from drift and offset, but does not reduce them into one record. The data can be plotted with the script `plot_raw.sh`.

4.4 -raw_spectrum

A frequency spectrum of the measurement data is generated with a Discrete Fourier Transform. The raw data are used. However, the jumps that occur due to the adjustment are removed, so that a continuous drift is created. A constant is added to all measured values so that the first measured value is always 0. The spectrum can be plotted with the script `plot_spectrum.sh`.

4.5 -reduce

Reduces the measurement data of a data sheet to a single record with uncertainties. The measurement data are freed from drift and offset. The double period can be reduced to a single period with the option -single. The data can be plotted with the scripts `plot_signal.sh` and `plot_signal3d.sh`.

4.6 -spectrum

A frequency spectrum of the measurement data is generated with a Discrete Fourier Transform. The data of each individual measurement is freed from drift and offset beforehand. The spectrum can be plotted with the script `plot_spectrum.sh`.

4.7 -test

Makes the Anderson-Darling test for normality for all azimuths. A table is output with the number of rejected azimuths per significance level. After the date and data sheet number in the first row, the number of samples per azimuth is shown. Example:

```
aetherise dcm/csv/*.csv -month [9,9] -no [49,50] -test
```

```
1925-09-17,  49   (19 samples)
Level   :     50%      25%      10%       5%       1%
Rejected:    8/16     6/16     2/16     2/16     0/16

1925-09-17,  50   (20 samples)
Level   :     50%      25%      10%       5%       1%
Rejected:    4/16     2/16     0/16     0/16     0/16
```

The output reads, for example, as follows: In data sheet Sep-49, at a significance level of 5 %, the measured values at 2 of 16 azimuths are not normally distributed.

4.8 -aggregate *method*

Processes all specified files in a context. Aggregates are normally own actions, but may also require a selected action.

4.8.1 list

Generates a list/table of all important data and statistics. Each line represents a data sheet. This list is suitable as an overview for a data analysis. The output is only available in CSV format and is intended to be loaded from a spreadsheet. The first line of the output contains the headings of the individual columns. In Table 3 you will find a description.

4.8.2 test

Makes the Anderson-Darling test for normality for all azimuths of all data sheets and displays the results summarised in a statistic. A table is output with the number of rejected azimuths per significance level and the resulting rejection rate. The rejection rate can only be estimated and is given as a confidence interval for 95 % confidence, determined according to Agresti-Coull. Example:

```
aetherise dcm/csv/*.csv -month [9,9] -aggregate test
```

```
Mean number of samples per azimuth: 18.9
 Level    Rejected      Quota
  50%    382 / 720   53.0 ± 3.6 %
  25%    204 / 720   28.4 ± 3.3 %
  10%     73 / 720   10.4 ± 2.2 %
   5%     34 / 720    5.0 ± 1.6 %
   1%      4 / 720    0.8 ± 0.7 %
```

The reading is the same as for -test.

Table 3: Columns of the list

Column	Description
date	Date
no	Data sheet number
time	Mean observation time
sidereal time	Local sidereal time
time of day	See -stats.
duration	Duration of the measurement in minutes.
turns	Number of turns.
duration/turn	Duration per turn in minutes. Adds +1 turn per adjustment.
attributes	See Table 1.
weather	See Table 1.
uncertainty	Mean standard uncertainty of the measurements at the azimuths.
sign correct	See Table 1, Label *sc*.
T	
TD	
dT	
adjust	See -stats
sign	
drift	
abs drift	
notes	Notes in the header.

4.8.3 mean

Forms the mean value of the results of the selected action. Currently supports -reduce, -raw_spectrum, -spectrum. Beispiel:

```
aetherise dcm/csv/*.csv -month [9,9] -no [49,51] -reduce -aggregate mean > s.dat
```

If you do not specify an action, you will get an error message because the default action does not generate any data from which you can calculate the mean value.

```
Given action can not be aggregated
```

4.8.4 sidereal

Output only the amplitude per sidereal time instead of the whole signal. The data sheets are divided into the sidereal time into bins with a width of 0.5 hours. The can be plotted with the script `plot_sidereal.sh`.

4.8.5 diff

Determines the similarity of successive data sheets via the quantity R^2. The R^2 is the sum of the squares of the error-normalised differences of the values at the azimuths. The smaller the R^2 is, the more similar the two measured signals are. For N data sheets, $N-1$ values of the quantity R^2 and the mean value are output. At least two data sheets must be specified. Example:

```
aetherise -single -ignore all dcm/csv/*.csv -month [2,2] -no [69,73]
          -aggregate diff
```

```
{22.18, 31.52, 24.26, 8.40}
mean R² = 21.59
```

4.8.6 signals

Select the best difference signals. The submitted data sheets are divided into groups. The groups are formed on the basis of epoch, desk location and time interval between successive data sheets. The algorithm tries by means of permutation in groups or across groups, to find the two most similar sequences of data sheets. Two sequences are similar if the temperature conditions match within certain tolerances. The algorithm does not detect outliers or anomalies. With the options -signals_dTD, -signals_ddT, -signals_dt, -day_and_night, -low_sun the algorithm can be set. Example:

```
aetherise -single -ignore all dcm/csv/*.csv -aggregate signals -signals_dt 1
          -signals_ddT 0.1 -signals_dTD 0.15
```

```
##################################################
# Generated signal extractions using options
# -signals_dTD   0.15 °C
# -signals_ddT   0.1 °C per ¼h
# -signals_dt    1 h
# -day_and_night no
# -low_sun       no
##################################################

### Group signals ###

sep [49,51] - [53,55]
sep [57,58] - [60,61]
sep [78,79] - [81,82]
feb [48,49] - [51,52]

### Intergroup signals ###

aug [31,33] - [60,62]
```

A signal extraction expression has the form:

Epoch [*from*,*to*] - [*from*,*to*]

The epoch is one of the codes: apr, aug, sep, feb. Therefore only data sheets of the same epoch can be computed. The intervals are used to select data sheets by their numbers. The minus sign represents the subtraction. Each side of the subtraction can contain several intervals separated by a comma. The expression must be in one line and can also contain a comment, which is introduced with the character #. Each expression will be computed as in the example to -subtract_data to extract the signal.

4.8.7 fit

By means of curve fitting, the values for the parameters (v, α, δ) of the theory are determined. This action expects an additional input of expressions, which extract the signal from the data. Usually one summarises all expressions in a text file and then redirect them to the standard input channel. With the minimiser selected (-minimizer), the quantity χ^2 is minimised. The values of the parameters at the minimum then provide the best agreement between data and theory. Before minimisation, a Monte Carlo search is used to try to find parameter values in the vicinity of the global minimum. The values found are the starting point for the minimiser. This step can be skipped by setting a starting point with -start_params. If the minimiser fails, a warning is issued:

```
WARNING: Minimizing did not converge
```

The result is the parameter values at the minimum with uncertainties and a χ^2 statistic. The uncertainties can be configured with -delta_chi2. With the option -contour one has the possibility to generate the data for a contour plot. Example: Automated input of expressions:

```
aetherise -single -ignore all dcm/csv/*.csv -aggregate fit < selected_signals.txt
```

```
Enter expressions to extract the signals from the data sheets.
Type 'fit' to commit and start the fitting process.
Type 'cancel' to cancel the input.
: : : : : : : : : : : : : : : : : : : : : : : : : : : : : : : : : : : :
Extracting signals...
Fitting theory to 11 signals.

Scanning for good starting point...100%
v = 270665 m/s
α = 10.6775 h
δ = -3.4988 °

Fitting...100%
v = 281664 ± 13724.4 m/s
α = 10.927 ± 0.179104 h
δ = -9.31387 ± 4.06042 °

χ² = 87.432
f  = 74
χ²/f = 1.182
p-value = 0.136176
```

If the option -stats is used, additional statistics are output:

```
 #    χ²      Signal
 1   5.661  sep 49,50,51 - 53,54,55
 2  10.905  sep 58,59 - 61,62
 3   4.352  sep 78,79 - 81,82
 4   7.390  feb 48,49 - 51,52
 5   7.230  feb 85,86,87 - 89,90,91
 6   9.944  apr 110,111 - 113,114
 7  10.298  sep 39,40,41,42 - 53,54,55,56
 8   3.549  feb 25,26 - 44,45
 9   9.106  feb 25,26 - 50,51
10  11.223  feb 44,45,46 - 50,51,52
11   7.773  feb 74,75 - 77,78

     7.948  Mean
     7.773  Median

Residuals distribution: μ = -0.016, σ² = 0.960, p-value = 0.326
```

The first column contains the signal number. In the second column is the unreduced value of the quantity χ^2. This is followed by the expression for signal extraction. Below this table the mean and the median of the χ^2 values are given. This statistic is useful, for example to find outliers. The last line shows the expected value μ and the variance σ^2 of the residuals. The p-value is the result of an Anderson-Darling test for normality.

5 Options for actions

5.1 -reduction *method*

When reducing data with -reduce, use the specified method. The default setting is method Miller.

5.1.1 Miller

Miller's algorithm. To determine the uncertainties, another equivalent algorithm is used, which removes drift and offset from the individual measurements.

5.1.2 DFT

With a Discrete Fourier Transform (DFT), the harmonic components with the frequencies 1 and 2 are determined. Before this, drift and offset are removed from the individual measurements. The Goertzel algorithm [2] is used.

5.2 -theory *name*

Selects a theory with which the theoretical signal is calculated. With the aether theories some parameters can be changed with -theory_params. The default setting is aether. For example, the theoretical signal is always output with action -reduce, unless you turn it off with -no_theory.

5.2.1 classic

The classical aether theory without Lorentz contraction and without anisotropic refractive index in moving gases.

5.2.2 aether

The aether theory of Lorentz [3] with the hypothesis [4] of an anisotropic refractive index in moving gases.

5.2.3 relativity

The special theory of relativity [5].

5.3 -single

Average the double period to a single period. However, 17 azimuths q_i will still be output and displayed. The values of the single period are copied so that the following holds true:

$$(q_1, ..., q_9) = (q_9, ..., q_{17}) \ . \tag{1}$$

5.4 -subtract_theory

Subtract theory from data.

5.5 -add_theory

Add theory to data.

5.6 -invert_data

Change the sign of the data of a data sheet.

5.7 -invert_theory

Change the sign of the theory.

5.8 -data *filename*

Read in a file in CSV format. The data can then be computed in various ways. Depending on the action and specified options, a certain format is required. Typically, one creates this file with a call to Aetherise using `-aggregate mean`, because this is the only way to get a format that can be read in.

5.9 -subtract_data

Subtract the data loaded with `-data` from the data generated with a specific action from a data sheet.

Example: Extract the signal from the aether from the group Sep-49.

```
aetherise -single -ignore all dcm/csv/*.csv -month [9,9] -no [53,54] -reduce
          -aggregate mean -csv > data.csv

aetherise -single -ignore all dcm/csv/*.csv -month [9,9] -no [49,50] -reduce
          -aggregate mean -data data.csv -subtract_data > s.dat
```

5.10 -disable_earth

Do not include the velocity vector of the Earth in its orbit around the Sun in the theory.

5.11 -signals_dTD *value*

Maximum difference of the temperature difference ΔTD in °C between data sheets.
Default is 0.1 °C.

5.12 -signals_ddT *value*

Maximum difference in temperature change ΔdT in °C per $\frac{1}{4}$h between data sheets.
Default is 0.1 °C.

5.13 -signals_dt *value*

Minimum time interval Δt in h between two sequences of data sheets. Default is 1.0 h.

5.14 -day_and_night

Extract difference signals even between data sheets measured during the day and at night.

Table 4: Overview of some $\Delta\chi^2$ values

	$\Delta\chi^2$ at number of parameters		
Confidence / %	**1**	**2**	**3**
68.3	1.0	2.3	3.5
90.0	2.7	4.6	6.3
95.5	4.0	6.2	8.0
99.0	6.6	9.2	11.3
99.7	9.0	11.8	14.2

5.15 -low_sun

Difference signals can also be extracted from data sheets measured at sunrise or sunset.

5.16 -fit_amplitude

In the curve fitting with `-aggregate fit` use only the amplitude, not the whole signal.

5.17 -fit_sine

Fitting to the parameters phase and amplitude of a signal.

5.18 -fit_disable *numbers*

In the curve fitting with `-aggregate fit`, the specified signals are not used. A list of numbers is expected. The separator is the comma. The signal numbers correspond to those in the statistics displayed when using `-stats` in conjunction with the curve fitting.

5.19 -minimizer *name*

Selects one of the given minimisers. Evaluated by `-aggregate fit`. The default is `grad`.

5.19.1 grad

A simple gradient method which finds a local minimum. The implementation is still somewhat experimental, but gives good results. The uncertainties are determined without covariances.

5.19.2 Minuit2

Minuit2 from the *ROOT - Data Analysis Framework* [6] of *CERN*.[3]

5.20 -delta_chi2 *value*

With the value for $\Delta\chi^2$ one sets the confidence interval for the uncertainties of the parameters at the minimum. The default value is 1. This means that the individual parameters have an uncertainty which gives an interval for a confidence of 68.3 %. This is the 1-sigma standard uncertainty. Values for other confidence levels can be found in Table 4 in the column for 1 Parameter.

The value for $\Delta\chi^2$ is also used for `-contour`. There it defines the range around the minimum, for which values are calculated in order to display $\Delta\chi^2$ isolines. The values for this can be found in Table 4 in the column for 2 parameters.

[3] https://root.cern

5.21 -chi2_scale *value*

The uncertainties are multiplied by this scaling factor. In order to scale the quantity χ^2 to the desired value w, the factor is

$$\sqrt{\frac{\chi^2}{w}}\,. \tag{2}$$

5.22 -theory_params v, α, δ

Set parameters of the theory. The parameters (v, α, δ) form the velocity vector of the solar system in the aether. Where v is the velocity and (α, δ) indicates the direction in equatorial coordinates. The units are (m/s, h, °). The default is (369000, 11.2, -6.9), which are the values that can be calculated from the dipole in the CMB [7]. The individual values are separated by commas and written one after the other without spaces. Example:

```
aetherise dcm/csv/*.csv -month [9,9] -no [49,49] -reduce
          -theory_params 200000,23.2,6.9 > s.dat
```

5.23 -start_params v, α, δ

Start parameters for the minimiser. With this option, you can skip the Monte Carlo search for a good starting point near a minimum. Further explanations of the parameters can be found at -theory_params.

5.24 -n *value*

Set the refractive index to a fixed value. If this option is not specified, the refractive index for each data sheet is calculated from the temperature and the estimated humidity.

5.25 -latitude *value*

Latitude (°) of the location. Default is latitude 34.225° from Mount Wilson.

5.26 -longitude *value*

Longitude (°) of the location. Default is longitude -118.057° from Mount Wilson.

5.27 -contour

Generates in conjunction with -aggregate fit the data, to display the isolines for $\Delta\chi^2$ in a region around the minimum found. The output must be redirected to a file. The data is plotted with the scripts `plot_contour.sh` and `plot_contour_apex.sh`

5.28 -residuals

Generates the output of the residuals in conjunction with -aggregate fit, whose squares were used for the calculation of the quantity χ^2. The output is sorted in ascending order.

5.29 -ignore *code*

Ignore specified codes of a data sheet. A combination of individual codes or the name of a set.

Table 5: Codes that can be ignored

Code	Description
-	Reverse the sign of all measured data [a]
i	Reverse the sign of a measurement
b	Cancel measurement
r	Reverse the sign of a measurement (Miller)
c	Cancel measurement (Miller)
R	Disabled r
C	Disabled c

[a] In the CSV file of a data sheet, however, the code r is used.

Table 6: Code set names

Name	Description
all	All codes, except Miller's r and c
all!	All codes

6 Other options

6.1 -validate

Check for consistency. Validates the metadata and the measurement data of a data sheet for errors and unusual values. Error messages and warnings are output on the standard error channel. Further processing is not interrupted.

6.2 -simulation

All measured values of the data sheets are replaced by the theoretical values plus normally distributed statistical errors. In the simulation, all specified data sheet attributes are assumed to be true and the data is generated accordingly, e.g. with a reversed sign. CAUTION: In connection with -ignore, false data can thus be generated! At the start, the set start value for the random generator is output. Example:

```
Simulation seed = 2160789540
```

6.3 -sim_seed *number*

Start value for the random generator of the simulation. If this option is not specified, a random start value is selected.

6.4 -sim_simple

The phase and amplitude of signals and systematic errors are no longer changed by statistical errors.

6.5 -sim_sys

Adds a constant periodic systematic error, whose phase and amplitude, however, receive deviations due to statistical errors.

7 Output

These options can be used to change the output or display of data.

7.1 -stats

Display statistics on the data generated by an action. Statistics can replace or extend the original output. Example:

```
aetherise dcm/csv/*.csv -month [9,9] -no [49,51] -stats
```

```
1925-09-17,  49    mean T    max TD    mean dT    adjust    drift    abs drift
 19:30 19h23m n   15.87      0.30      -0.06     -+  2    -0.71        4.84

1925-09-17,  50    mean T    max TD    mean dT    adjust    drift    abs drift
 20:07 20h 0m n   15.68      0.38      -0.06      +  2     1.01        3.60

1925-09-17,  51    mean T    max TD    mean dT    adjust    drift    abs drift
 20:49 20h42m n   15.49      0.40      -0.03     +-  3     0.00        4.11
```

Without specifying an action, general statistics are now displayed instead of the file names. If an action is specified, these statistics are expanded or changed. Special statistics have their own action. The field structure is as follows:

Date		No	*Headings of the columns of the next row.*					
tm	theta	tz	T	TD	dT	adjust	drift	abs drift

Table 7: Fields of the statistics

Label	**Field**	**Description**
Date	Date	
No	Data sheet number	
tm	Mean observation time	
theta	Local sidereal time	
tod	Time of day	The time of day is indicated by one of the characters d, n, s. The d stands for day, the n stands for night, and s stands for sunrise or sunset. Sunrise and sunset last one hour during the day. The time of day has an accuracy of $\sim$ 15 min.
T	Mean temperature	In °C.
TD	Maximum temperature difference	The largest temperature gradient in °C.
dT	Mean temperature change	In °C per $\frac{1}{4}$h.
adjust	Number of adjustments	The signs + and - in the adjust column indicate which sign occurred. If both characters appear, the first is the character that affects a larger number of rows.
drift	Mean drift	In $^1/_{10}$ fringe. The drift of a single turn is calculated from $q17 - q1$. See section 2.
abs drift	Mean absolute drift	In $^1/_{10}$ fringe.

7.2 -no_data

Prevent output of the measurement data.

7.3 -no_theory

Prevent output of the theory.

7.4 -csv

Change the output format to CSV. The separator is a semicolon. The option does not work for every action. Outputs in CSV format are mainly needed to read them back in with `-data`.

References

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19IM2 6:17 Research. Interferometer. Mt. Wilson, April 1925
19IM2 6:18 Research. Interferometer. Mt. Wilson, July-August 1925
19IM2 6:19 Research. Interferometer. Mt. Wilson, July-August 1925
19IM2 7:1 Research. Interferometer. Mt. Wilson, September 1925
19IM2 7:2 Research. Interferometer. Mt. Wilson, September 1925
19IM2 7:3 Research. Interferometer. Mt. Wilson, February 1926
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