Fasteps

Quick-look Data Processing Tool

User manual

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1 General

Fasteps calculates the rate of turbulent kinetic energy dissipation ε [W kg^{-1}] and a number of derived hydrographic parameters in a single step. It can be used for fast calculation of TKE dissipation during the MSS measurements, to get an impression of the proper operation of all MSS sensors. ***Fasteps*** can be applied for vertical sinking and rising measurements, but also for horizontal measurements carried out with the MSS profiler.

Fasteps provides a standard processing of MSS profiles that is applicable for the most environments and measurement strategies. However, for an advanced data processing the use of the ***MSSpro*** processing tool is recommended.

2 Description of data processing

The following processing steps are applied by ***fasteps***:

1. Convert of *.mrd file using the calibration coefficents obtained from the *.mrd file file header. In case of vertical profiles this step includes an automatic cut at the point where the vertical velocity becomes zero.

2. Elimination of spikes using the section wise calculation of standard deviation of the sensors “press, she1, she2, acc, temp, cond” within intervals of 40 lines. Values which exceed a threshold of 2.7 of standard deviation are rejected and replaced by an interpolated value. The unselected sensors are not affected. The standard deviation is calculated as follows:

$$s = \sqrt{\frac{1}{n-1}\left(\sum_i x_i^2 - \frac{1}{n}\left(\sum_i x_i\right)^2\right)}$$

3. Smooth of pressure sensor by applying a moving average filter twice with filter windows of 2357 and 983. At the beginning and the end of the profile, a half window length is mirrored in order to keep the filtered file in the original length.

4. Extraction of the given pressure/distance range according to the specified processing parameter.

5. Creation of a channel “time” of elapsed seconds.

6. Calculation of shear du/dz from not differentiated shear probe data according to the equation:

$$\frac{\partial u}{\partial z} = \frac{1}{2\sqrt{2}\rho GSV^2}\frac{\partial U}{\partial t}$$

with U Sensor output voltage [V]
G gain of sensor electronic
S shear probe sensitivity [Vms^2 kg^{-1}]
ρ density of water [kg m^{-3}]
V profiler velocity [m s^{-1}]

The standard settings of the MSS profiler (gain, conversion from ADC output to voltage) are applied. For vertical profiles, the profiler velocity is computed from pressure and time. For horizontal profiles, the velocity is taken from a separate velocity sensor given as user specified sensor.

7. Calculation of pseudo shear a/V. a is the horizontal acceleration (measured by the acceleration sensor "acc") and V is the profiler velocity

8. Calculation of TKE dissipation rate ε [W kg^{-1}] from shear and pseudo shear sensors using a fit to Nasmyth spectrum, with section interval of 512 lines and 256 lines overlap. The fit to the Nasmyth spectrum is carried out in an self adapting wave number range $k_1 - k_2$. While the low wave number cut off k_1 is fixed to 2 cpm, the high wavenumber cut off for the fit is determined in an iterative procedure. The wave number range for the fit to the Nasmyth spectrum can be set manually. The details of the iteration procedure is given in section 3.

9. Averaging over the user specified pressure/distance interval.

10. Smooth of epsilon with a smooth threshold = 5. This processing step calculates the average of the two shear sensors. A spike in one sensor is assumed if the value of one sensor exceeds the value of the other sensor by a factor of 5. In that case, the minimum value of both sensors will be used as result. The purpose of this procedure is the rejection of bad shear values, which are caused by collisions of particles with a shear sensor.

11. Calculation of log(epsilon)

12. Calculation of salinity sensor "sal" following EOS80

13. Calculation of density anomaly sensor "sig_t" following EOS80

14. Calculation and sort of density sensor "dens" from "sig_t" sensor. "dens" is the re-ordered density profile with monotonic increasing density with depth (only computed if measuring mode = free falling probe)

15. Calculation of square of Brunt Vaisälä frequency sensor "BVF" in [s^{-2}], using the depth values of pressure and density (or density anomaly). The following formula is applied:

$$N^2 = -\frac{g}{\rho(z)}\frac{d\rho}{dz}$$ using gravity acceleration g = 9.80665m/s²

("BVF" is only computed if measuring mode = free falling probe).

3 Calculation of dissipation rate

The calculation of TKE dissipation rate ε [W kg^{-1}] from shear and pseudo shear sensors is carried out by an iterative fit to Nasmyth spectrum, with section interval of 512 lines and 256 lines overlap. The fit is applied in a self adapting wave number range $k_1 – k_2$. Alternatively, the limits for the wave number range can be set by the user .

While the low wave number cut off k_1 is fixed to 2 cpm, the high wavenumber cut off for the fit is determined during the iterative procedure.

The Kolmogorov wave number is calculated according:

$$k_c = \frac{1}{2\pi}\left(\varepsilon/\nu^3\right)^{1/4}$$

For the Nasmyth spectrum the analytical approximation proposed by Lueck (Prandke et al. 2000) is used.

$$E(k_n) = -\frac{8.05k_n^{0.33}}{1+(20k_n)^{3.7}} \qquad with \qquad k_n = \frac{1}{2\pi}\frac{\kappa}{\varepsilon/\nu^3}$$

The iterative fit of the observed shear spectrum to the Nasmyth spectrum starts with an dissipation rate ε_0 = 1e-10 W/kg. The Nasmyth spectrum for ε_0 is calculated. The upper wave number for the intertial sub range number k_{2c} is estimeted as k_c /10 using ε_0. Then the mean difference Δe_0 between the observed shear spectrum and the Nasmyth spectrum is calculated in the wave number range $k_1 – k_{2c}$. If the user specified $k_2 < k_{2c}$ then k_2 is used instead of k_{2c}.
The next iteration starts with a modified value $\varepsilon_1 = \varepsilon_0 + \Delta e_0$. The Nasmyth spectrum for ε_1 is calculated. The upper wave number for the intertial sub range number k_{2c} is estimeted as k_c /10 using ε_1. Then the mean difference Δe_1 between the observed shear spectrum and the Nasmyth spectrum is calculated.
This iteration procedure is continued until either $\log_{10}(|\Delta e_n|) < 0.05$ or the number of iterations n exceeds 50. The final ε_n is the estimated dissipation rate.

4 How to use *Fasteps*

Fasteps is very easy to use. As the first step, in the “Configuration” dialog the necessary settings have to be made for sensor names, processing parameters, deployment mode and output file options.

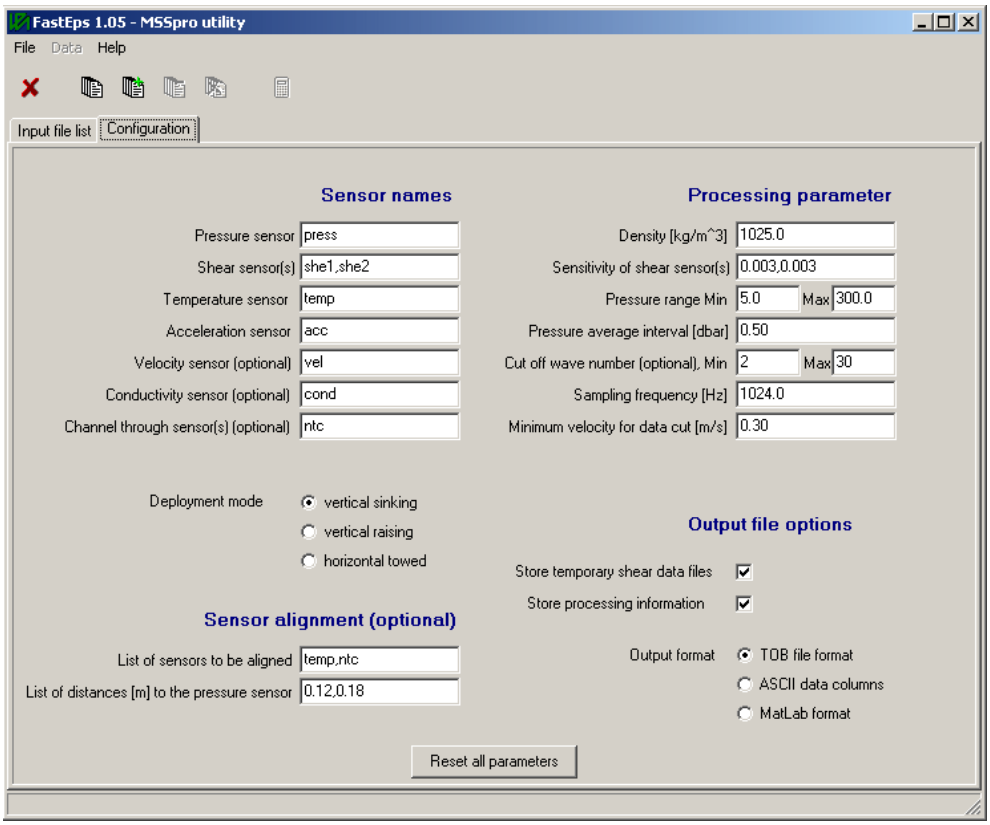


figure 1: Configuration sheet of Fasteps. All user options will bw displayed and edited at this sheet.

We recommend to work with the following processing parameters:

Minimum cut off wavenumber: 2
Maximum cut off wavenumber: 20
Minimum velocity for data cut: 0,2

If the option “Store temporary shear data file” is selected, additional to the final output file with dissipation rates, an intermediate file with the computed shear data is stored. This file is required for checking the shear spectrum and can be used as the starting point for other computations based on the fully resolved data (e.g., thermal dissipation rate).

As the second step, the input files for processing have to be selected. Only MSS raw data files (*.mrd) can be used. The file selection dialog is assessable from the "File" menu or from the tool bar buttons below the main menu of the program. The tool bar buttons allow also the modification of the input file list. The available sensors of an input file are displayed in a list box on the right hand side of the window if an input file was selected in the input file list.

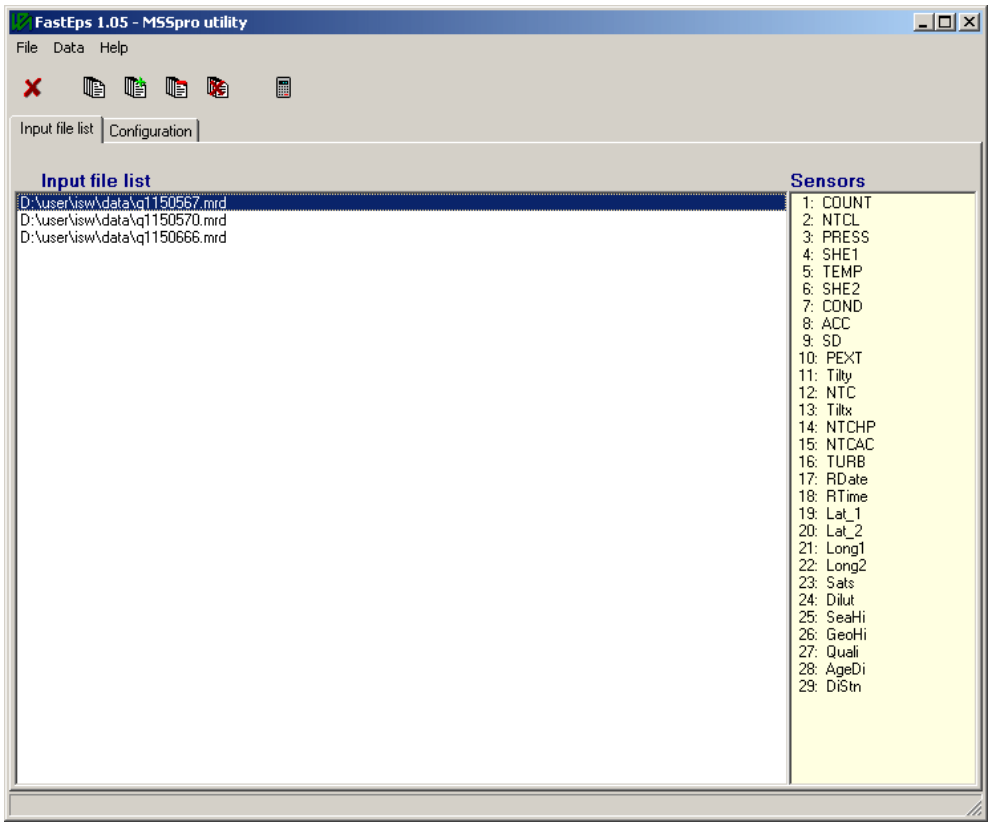


figure 2: Input file sheet of Fasteps.

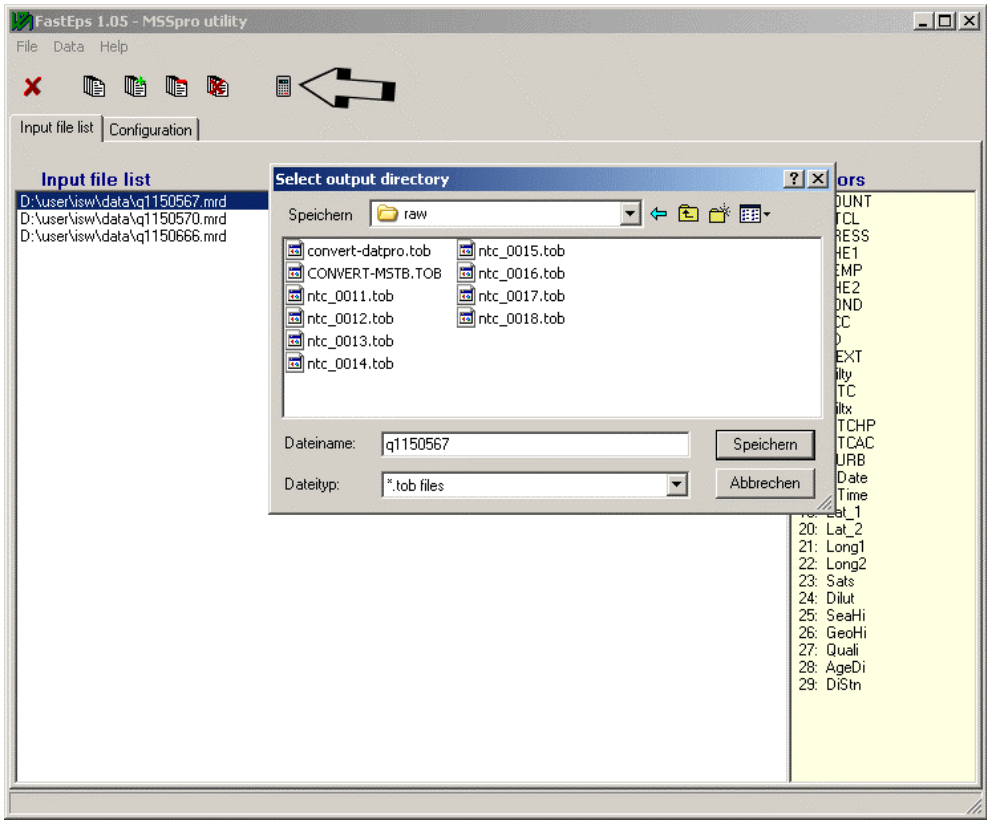


figure 3: Selection of output directory.

As the third step, click the calculator icon to start with the computation. An file selection dialog

appears where the output directory must be selected. After pressing the "save" button the processing of all input files starts.

References

Prandke, H., Holtsh, K., Stips, A., 2000. MITEC technology development: the microstructure-turbulence measuring system MSS. EUR 19733 EN. Ispra Joint Research Center, European Comission.

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