CWT_profile_dual.py User Guide

User Guide for Dual-Signal Continuous Wavelet Transform (CWT) Analysis and Frequency-Slice Output

Purpose. This script visualizes two selected acceleration-derived signals together with depth and computes continuous wavelet transforms (CWTs) over a user-defined interval. It then performs a second-step zoom analysis centred on a selected event and exports time–frequency figures that allow oscillatory structure and signal-specific frequency peaks to be examined visually.

1. Overview

• The script is intended for biologging datasets that contain at least time, depth, and two acceleration columns. It is particularly useful for exploratory analyses of dive kinematics because it links depth profiles with time–frequency structure in two selected signals within a single workflow.

• Because CWT analysis over a long continuous record can be computationally expensive and visually diffuse, the recommended workflow is to restrict the first-step analysis to a period in which dives are known to occur, inspect the overview figure, and then perform a second-step zoom analysis around a focal dive or behavioural event.

Required columns: time, depth

Acceleration columns: at least two available axes among acceleration_longitudinal, acceleration_dorso_ventral, acceleration_lateral, and any equivalent BiP-standardized acceleration channels used to construct the selected signals

3. Input Parameters

Prompt	Default	Use in most cases	Adjust when…
Enter the CSV filename to display	—	Enter the target CSV file. The .csv extension may be omitted.	Only if the file is stored under a different name or path.
UTC-local time offset in hours	9.0	Use +9 for Japan Standard Time.	Change only when the deployment should be interpreted in another local time zone.
Two signals for CWT analysis	No fixed default; user defined	Select the two signals of interest (e.g. dorso_ventral and longitudinal).	Choose another pair when a different body axis or VeDBA is more relevant to the question.
Start and end of analysis interval	Full range if blank	Restrict the interval to the period containing dives or focal behaviour.	Narrow the interval whenever the full record is long, because whole-record CWT can take longer to compute and may be harder to interpret.

Sampling frequency fs [Hz]	Estimated from the selected interval	Use the automatically estimated value when it matches the logger settings.	Override the estimate only when the deployment used a known fixed sampling rate and the estimate is clearly affected by data gaps.
Lower frequency f_min [Hz]	0.2	Use the default or raise it slightly when low-frequency structure is not of interest.	Increase it when very slow components dominate the plot and obscure the frequencies relevant to stroke or body-oscillation patterns.
Upper frequency f_max [Hz]	min(8.0, 0.45 × fs)	Use a biologically reasonable upper limit while staying below the safe Nyquist range.	Lower it when high-frequency content is uninformative or noisy; raise it only within the valid range when finer high-frequency structure is required.
Wavelet	cmor1.5-4.0	Use the default complex Morlet wavelet for routine analysis.	Change only when a different time–frequency trade-off is explicitly desired.
Number of frequency divisions n_freq	256	Use the default for smooth frequency resolution.	Increase for finer frequency resolution or decrease when faster computation is preferred.
Center time for zoom plot	Start of the selected interval if blank	Enter the time of the focal event while viewing the overview figure.	Change it to the time of the deepest dive or another event of interest.
Display window length (seconds)	20	Use 20 s for a compact event-centred view.	Increase for longer events or decrease for tighter inspection around rapid oscillations.

4. Example Run

python CWT_profile_dual.py
Enter the CSV filename to display (.csv can be omitted): 9A96021_W190-D2GT_36_20050830_standardize
UTC-local time offset in hours (e.g., Tokyo = +9) (blank = 9.0):

Enter two signals for CWT analysis (e.g., dorso_ventral longitudinal)
Options: longitudinal / dorso_ventral / lateral / vedba
Two signals: dorso_ventral longitudinal

Enter the analysis interval (local time). Leave blank to use the full range.
Full range: 2005-08-30 22:00:00 — 2005-09-02 18:56:48
Start (local time) (blank = full range) [2005-08-30 22:00:00]: 2005-09-01 11:15:00
End (local time) (blank = full range) [2005-09-02 18:56:48]: 2005-09-01 11:30:00
[Info] depth points: 901
[Info] acc points : 14401
[Info] Estimated fs ~ 16 Hz
Enter sampling frequency fs [Hz] (blank = 16):
Lower frequency f_min [Hz] (blank = 0.2): 0.4
Upper frequency f_max [Hz] (blank = 7.2): 3.6
Wavelet (e.g., cmor1.5-4.0) (blank = cmor1.5-4.0):
Number of frequency divisions n_freq (e.g., 256) (blank = 256):
[Saved] Overview figure: 9A96021_W190-D2GT_36_20050830_standardize_20050901111500_20050901113000_CWT_overview.png

--- Step 2: Frequency slice plot (frequency distribution at the selected time) ---
While viewing the overview figure, enter the center time (local time).
Center time (local), e.g., 2005-09-01 11:15:00 (blank = 2005-09-01 11:15:00） : 2005-09-01 11:21:40
Display window length (seconds; total width including both sides), e.g., 20 (blank = 20):
[Saved] Zoom/slice figure: 9A96021_W190-D2GT_36_20050830_standardize_20050901112130_20050901112150_CWT_zoom_slice.png

5. Output Files

*_CWT_overview.png Overview figure showing depth, the two selected signals, and their CWT power spectra over the selected analysis interval.

*_CWT_zoom_slice.png Event-centred zoom figure showing depth, the same two signals, their CWT power spectra, and a frequency slice at the selected centre time.

6. Reading the Output Figures

Figure 1: Overview CWT plot

This figure is the first diagnostic to inspect. It shows the selected analysis interval together with the depth profile, the two selected signals, and their CWT power spectra. In the present example, the interval was deliberately restricted to 2005-09-01 11:15:00–11:30:00 local time because dives were known to occur during this period. Restricting the interval in this way reduces computation time and makes the dominant time–frequency structure easier to interpret than analysing the full multi-day record.

Figure 2: Zoom and frequency-slice plot

This figure corresponds to the second step of the workflow. After identifying the focal event in the overview figure, the analysis is repeated in a narrow window centred on the selected time. In the present example, the centre time was 2005-09-01 11:21:40, corresponding to the deepest dive in the selected interval, and the plot was generated for ±10 s around that event (20 s total). The lower panel shows the CWT power slice at the selected centre time, allowing direct comparison of dominant frequencies between the two signals.

7. Interpretation of the Present Example

For this file, the workflow first isolated a short period containing multiple dives and then focused on the deepest dive for event-scale inspection. The overview plot shows that high CWT power is concentrated during periods of submergence rather than uniformly throughout the record, indicating that the selected signals contain dive-related oscillatory structure. The zoom plot then resolves the detailed time–frequency pattern around the deepest dive and shows that the two selected signals differ in the frequency range and intensity of their power peaks. This example therefore illustrates a practical two-step strategy for applying CWT to biologging acceleration data: broad overview first, followed by targeted event-centred analysis.

8. Practical Notes

• CWT analysis should generally be restricted to periods containing dives or other focal behaviours, because computing over the full deployment can be time-consuming and may dilute the signal of interest.

• The overview figure should be inspected before selecting the centre time for the zoom plot; this ensures that the second-step analysis is anchored to a biologically meaningful event.

• The choice of signals matters. Dorso-ventral and longitudinal axes are often informative for stroke-related motion, but alternative axes or VeDBA may be more appropriate depending on logger orientation and study species.

• Frequency bounds should be set with reference to both biological expectations and sampling limitations. Extremely low or high ranges may obscure the most interpretable structure.

Example Output Figures

These figures (Figs 1–2) show an example of the two-step CWT workflow applied to a Streaked Shearwater dataset. The first figure summarizes the selected interval containing dives, and the second figure shows a zoomed analysis centred on the deepest dive within that interval.

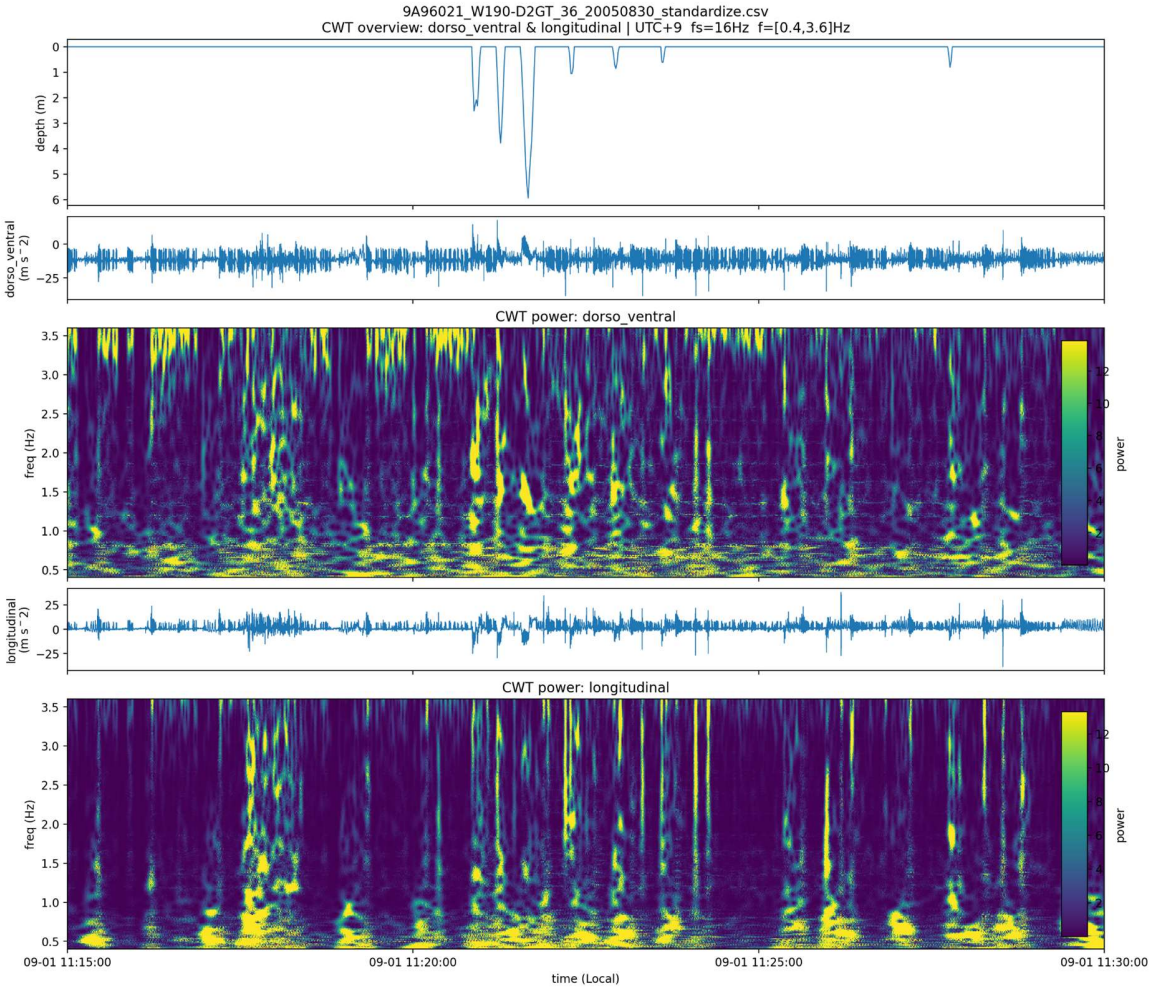

Fig. 1. Overview CWT output from CWT_profile_dual.py. The upper panel shows depth, the next panels show the two selected signals (dorso-ventral and longitudinal), and the corresponding CWT power spectra are displayed beneath each signal. In this example, the analysis interval was restricted to 2005-09-01 11:15:00–11:30:00 local time so that the computation focused on the period containing dives.

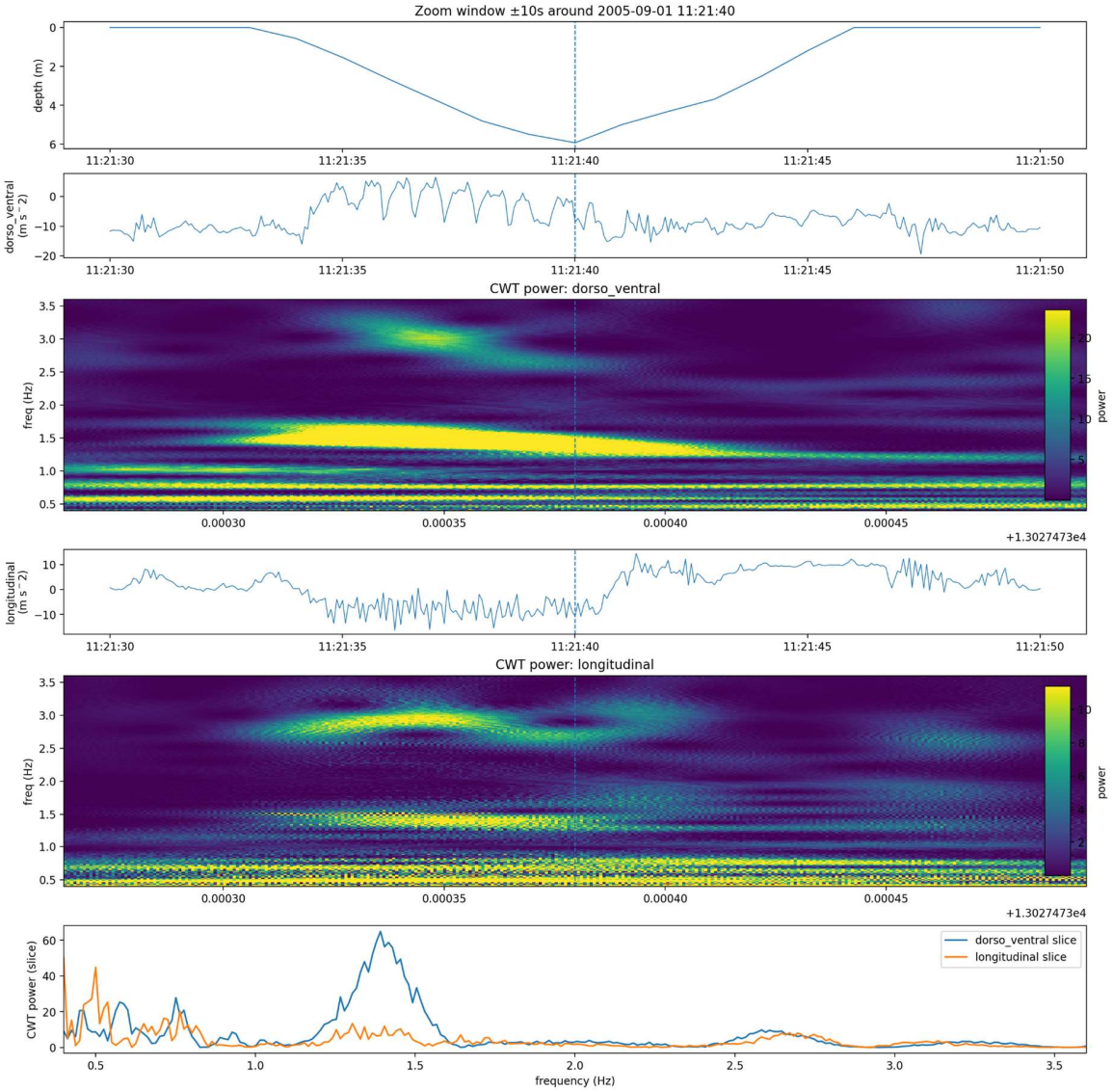

Fig. 2. Zoom and frequency-slice output from CWT_profile_dual.py. This figure shows the second-step analysis centred on 2005-09-01 11:21:40 local time, corresponding to the deepest dive in the selected interval, using a ±10 s window. The lower panel compares the CWT power slices of the two selected signals at the centre time and highlights their dominant frequencies during the focal event.