Vers un outil gratuit pour une identification acoustique automatisée et standardisée des chauves-souris en Amérique du Nord

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Background and Rationale

Bioacoustics: acoustic sampling of animals

Birds

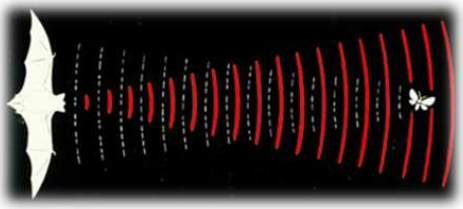
Anourans

Bats

- Fast and non-invasive method
- Biodiversity monitoring
- Ecology and behaviour

Technological advances

GML Remote Download System



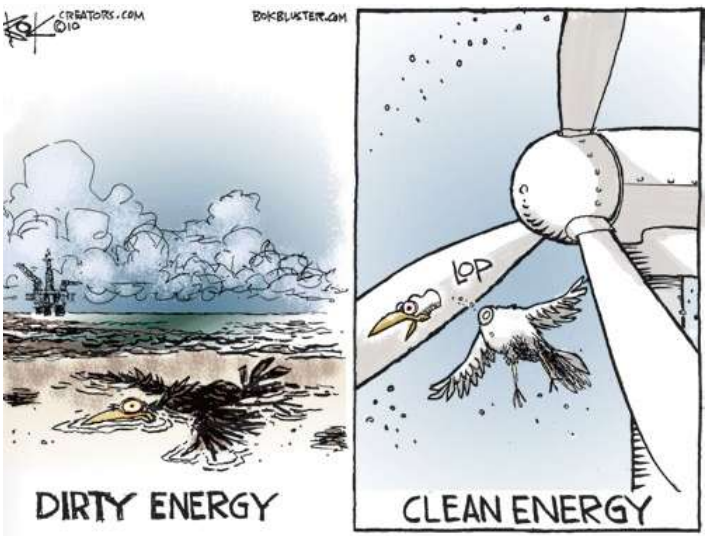
Increasing data storage capabilities: sampling calls over long periods

Autonomous recording units

Increasing data transmission rate: 4G networks, 5G by 2020...

- Real time monitoring, 24/7, from the office

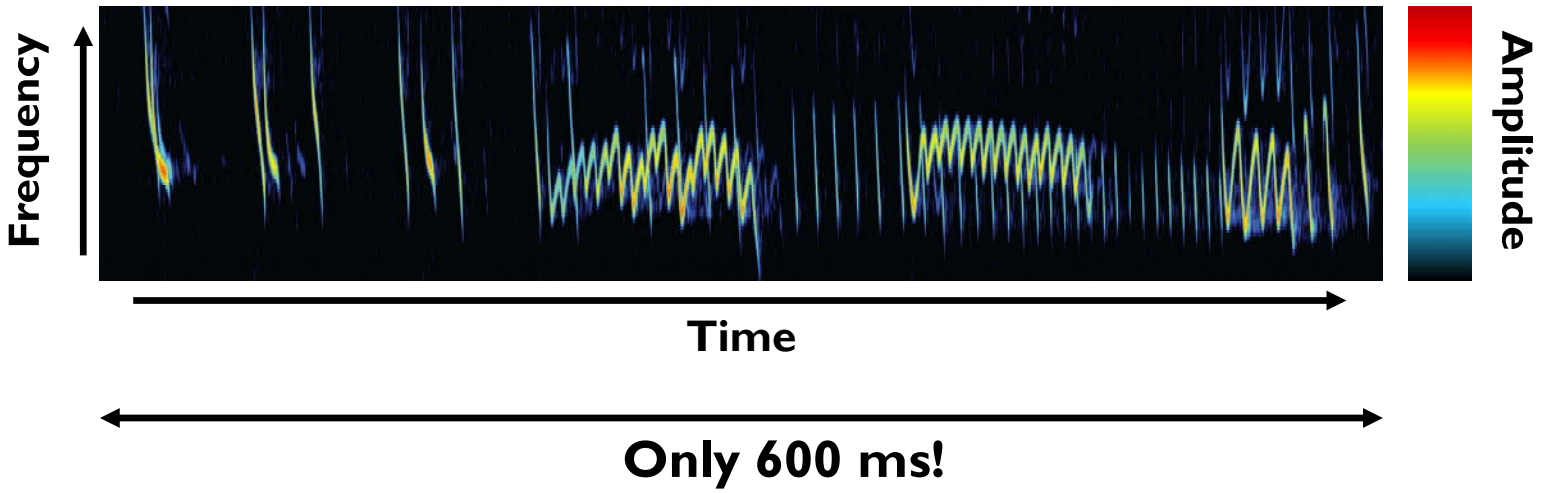
Increasing demand for acoustic inventories of bats



Large population declines induced by white nose syndrome and

2014: Bats entered in the Species At Risk Act (SARA)

Problem



Big (acoustic) **Data**

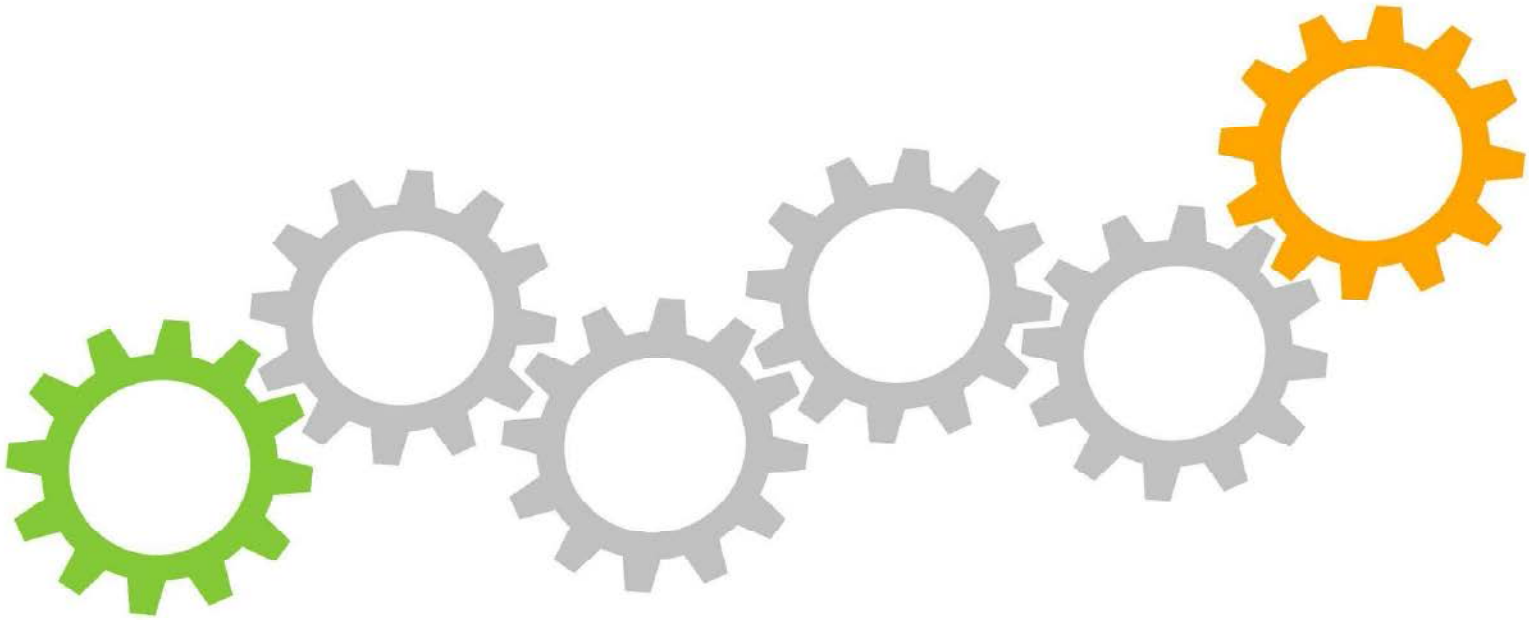
Manual analyses of data are time consuming

Subjective identifications

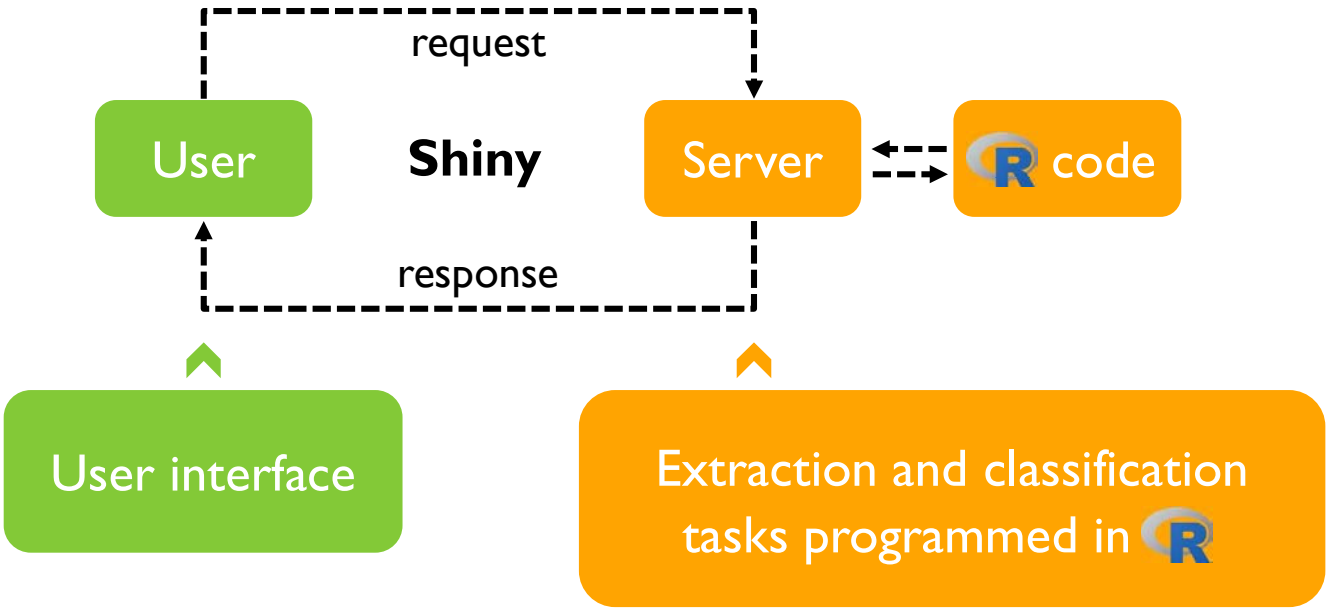
Need to

- Develop standard procedures for call extraction / classification
- Automate analyses

How it works ?



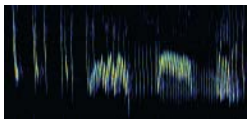
Software architecture



Free and open source bat call classifier

Web application: ease of access, virtually no requirement

Does 3 things: extraction, classification, provides a visual

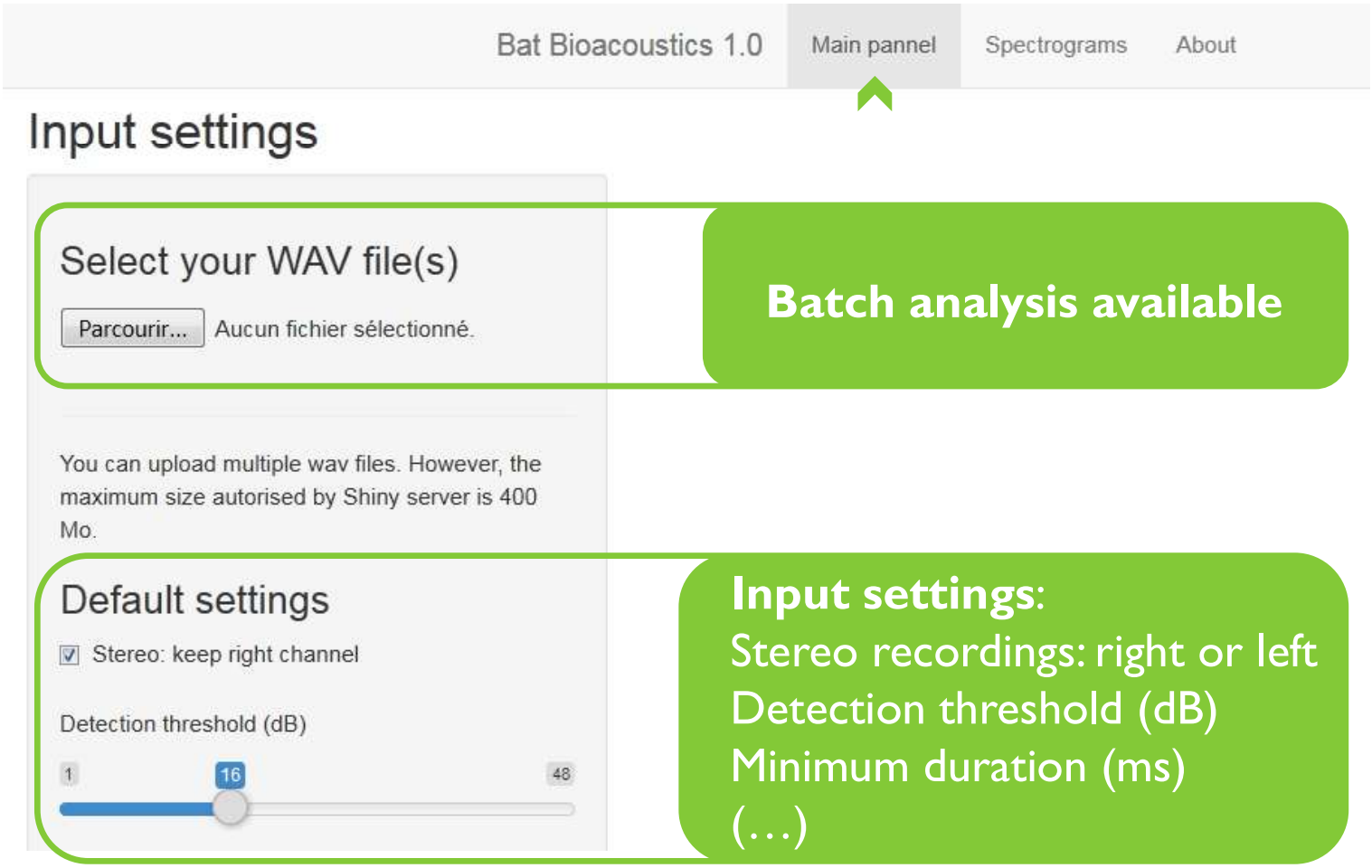


Classification procedure : Random Forest (Armitage & Ober, 2010)

Species	EPFU	EPNO	LABO	LACI	LANO	MYLU	MYSE	MYSP	PESU	Classification error
EPFU	**1313**	145	0	6	12	2	1	0	0	0.11
EPNO	100	**1048**	3	27	54	0	0	0	0	0.15
LABO	6	0	**433**	1	1	18	2	22	31	0.16
LACI	7	21	0	**2095**	2	0	0	0	0	0.02
LANO	1	95	0	7	**412**	0	0	0	0	0.20
MYLU	7	0	25	0	0	**593**	31	69	4	0.19
MYSE	1	0	0	0	0	49	**231**	15	0	0.22
MYSP	1	0	16	0	0	64	11	**267**	16	0.29
PESU	0	0	24	0	0	8	0	13	**368**	0.11

What it looks like ?

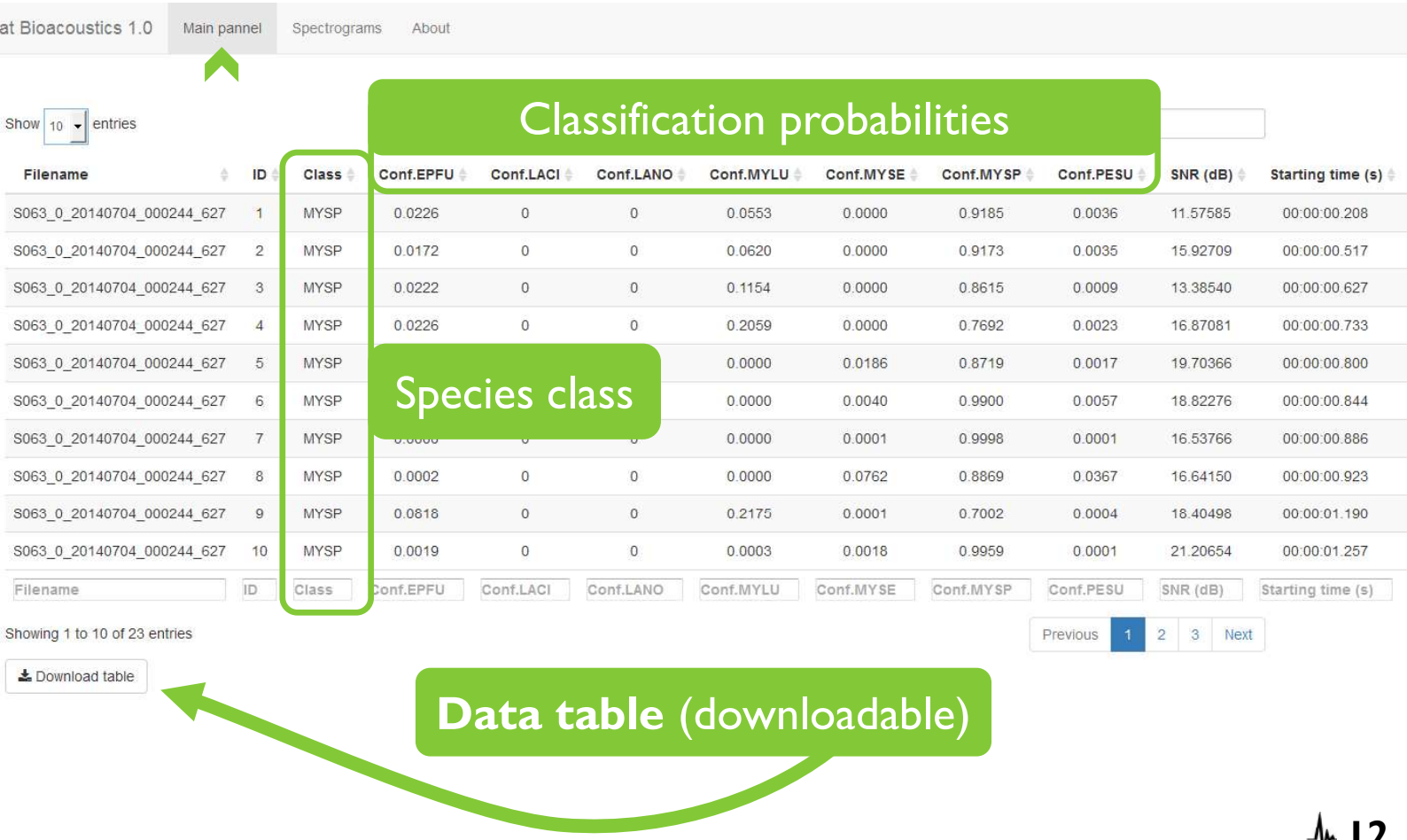
User interface



Batch analysis available

Input settings:
Stereo recordings: right or left
Detection threshold (dB)
Minimum duration (ms)
(…)

User interface



Filename	ID	Class	Conf.EPFU	Conf.LACI	Conf.LANO	Conf.MYLU	Conf.MYSE	Conf.MYSP	Conf.PESU	SNR (dB)	Starting time (s)
S063_0_20140704_000244_627	1	MYSP	0.0226	0	0	0.0553	0.0000	0.9185	0.0036	11.57585	00:00:00.208
S063_0_20140704_000244_627	2	MYSP	0.0172	0	0	0.0620	0.0000	0.9173	0.0035	15.92709	00:00:00.517
S063_0_20140704_000244_627	3	MYSP	0.0222	0	0	0.1154	0.0000	0.8615	0.0009	13.38540	00:00:00.627
S063_0_20140704_000244_627	4	MYSP	0.0226	0	0	0.2059	0.0000	0.7692	0.0023	16.87081	00:00:00.733
S063_0_20140704_000244_627	5	MYSP				0.0000	0.0186	0.8719	0.0017	19.70366	00:00:00.800
S063_0_20140704_000244_627	6	MYSP				0.0000	0.0040	0.9900	0.0057	18.82276	00:00:00.844
S063_0_20140704_000244_627	7	MYSP				0.0000	0.0001	0.9998	0.0001	16.53766	00:00:00.886
S063_0_20140704_000244_627	8	MYSP	0.0002	0	0	0.0000	0.0762	0.8869	0.0367	16.64150	00:00:00.923
S063_0_20140704_000244_627	9	MYSP	0.0818	0	0	0.2175	0.0001	0.7002	0.0004	18.40498	00:00:01.190
S063_0_20140704_000244_627	10	MYSP	0.0019	0	0	0.0003	0.0018	0.9959	0.0001	21.20654	00:00:01.257

User interface

Duration (ms)	F-maxE (kHz)	maxFreq (kHz)	minFreq (kHz)	midOffset (kHz)	Bandwidth (kHz)	Slope (kHz/ms)	curvePosStart	curveNeg	curvePosEnd
7.168	41.59862	62.74611	36.41535	1.016244	26.33075	2.761787	-55.92200	89.32894	-33.40694
7.232	42.18257	64.70628	36.54219	1.435535	28.16409	3.148843	-58.34600	91.73773	-31.90290
5.632	42.49597	64.34838	36.96294	1.431439	27.38544	4.479513	-37.84152	65.51522	-27.67370
7.616	41.64436	68.17714	34.90190	1.788877	33.27525	3.345741	-77.27869	123.95405	-44.90662
3.904	45.70775	76.06252	34.67731	2.744825	41.38521	9.965608	-31.47841	58.16713	-24.49339
3.648	45.99002	80.01280	35.54550	3.153541	44.46730	11.559656	-38.00158	69.45428	-27.90822
2.752	46.39296	78.02152	35.46662	2.680893	42.55491	14.812380	-21.37423	40.25012	-16.11181
2.368	46.61613	75.91153	35.48409	2.737778	40.42743	16.333139	-18.40591	34.99575	-13.71847
5.440	42.52721	75.85063	35.54325	3.083441	40.30739	6.708274	-55.11512	98.17215	-39.88237
4.800	48.76404	78.50579	35.24490	3.284458	43.26089	7.970434	-45.12171	84.21208	-36.92614
Duration (ms)	F-maxE (kHz)	maxFreq (kHz)	minFreq (kHz)	midOffset (kHz)	Bandwidth (kHz)	Slope (kHz/ms)	curvePosStart	curveNeg	curvePosEnd

10 acoustic parameters

- Minimum and maximum frequency
- Frequency at maximum amplitude
- Slope, bandwidth and duration
- Curve position start / end

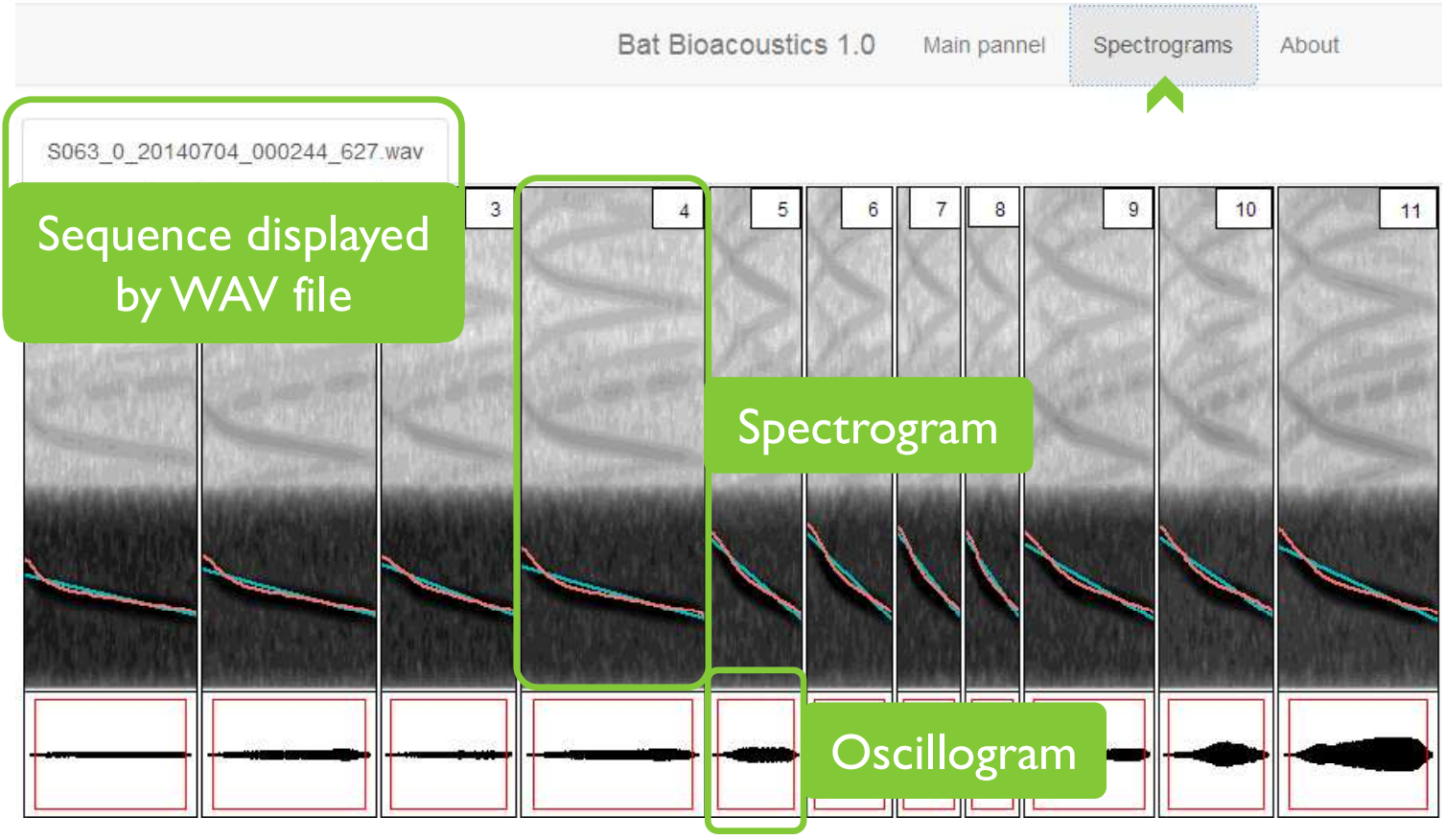
User interface

curvePosStart	curveNeg	curvePosEnd	Harmonic distortion (dB)	SNR (dB)	Smoothness
-55.92200	89.32894	-33.40694	-45.28055	11.57585	4.123777
-58.34600	91.73773	-31.90290	-49.49392	15.92709	3.487076
-37.84152	65.51522	-27.67370	-46.98209	13.38540	3.086313
-77.27869	123.95405	-44.90662	-55.92048	16.87081	3.960482
-31.47841	58.16713	-24.49339	-61.90101	19.70366	3.783142
-38.00158	69.45428	-27.90822	-52.17169	18.82276	3.726117
-21.37423	40.25012	-16.11181	-45.21671	16.53766	3.241323
-18.40591	34.99575	-13.71847	-44.06961	16.64150	2.740370
-55.11512	98.17215	-39.88237	-53.39814	18.40498	4.289909
-45.12171	84.21208	-36.92614	-66.19836	21.20654	4.561208
curvePosStart	curveNeg	curvePosEnd	Harmonic distortion (dB)	SNR (dB)	Smoothness

Signal quality

- Signal to noise ratio
- Harmonic distortion
- Smoothness

User interface



The good and the bad

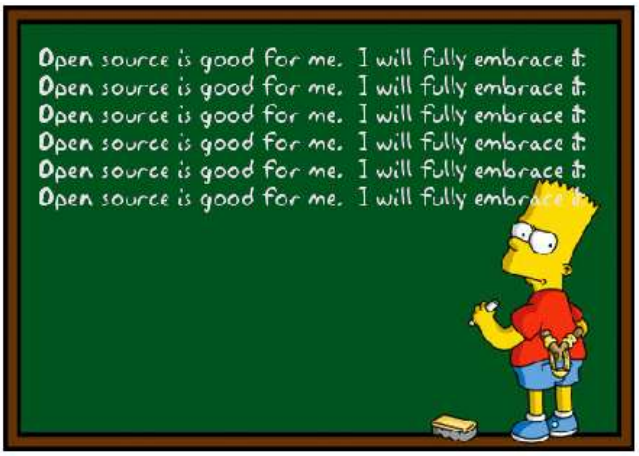
The good and the bad

Main disadvantage of using R

~ 5x slower than original C++ code

So why R ?

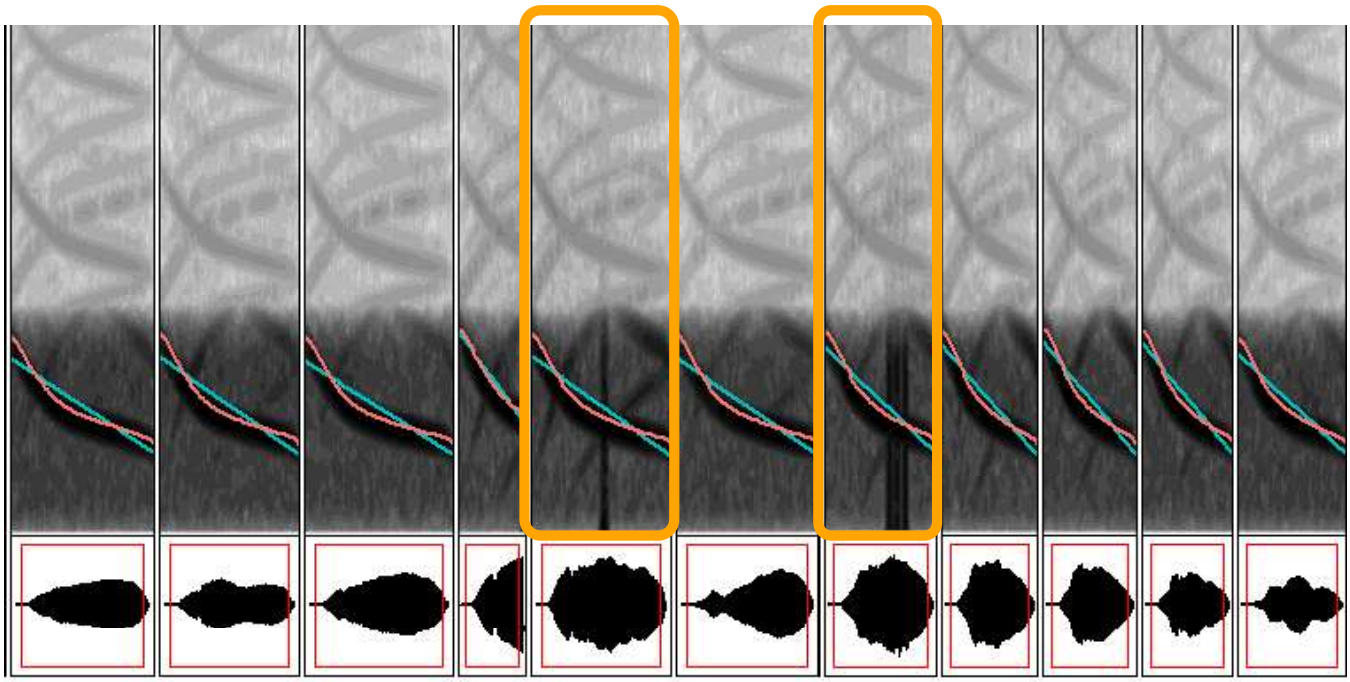
Free, maintained, portable
Widely used by scientists
Statistical packages



R implementation

Adaptable to specific needs
Encourage peer review

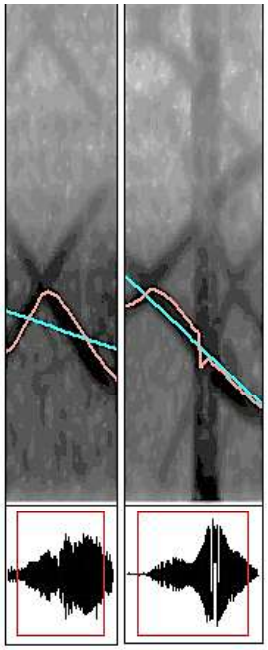
The good and the bad



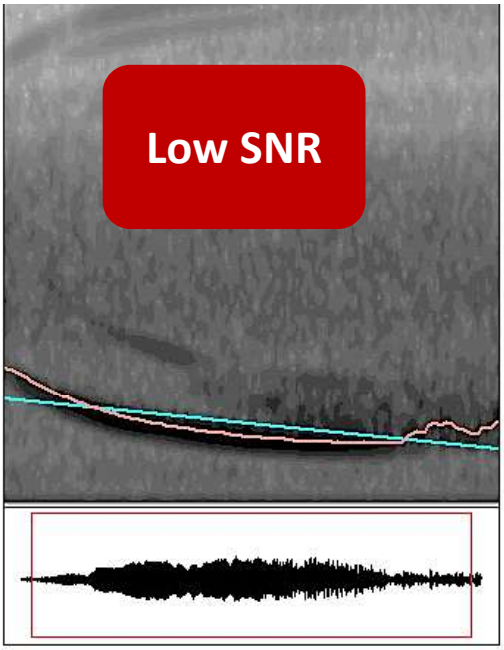
Performs well in noisy files and with moderately clipped calls (Scott, 2012)

The good and the bad

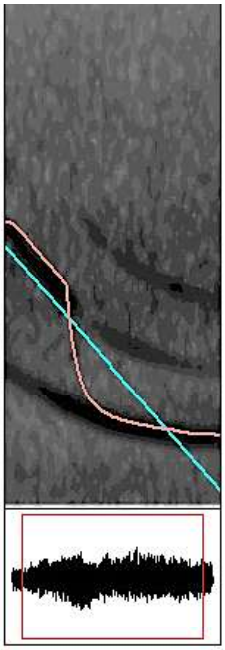
Clipping



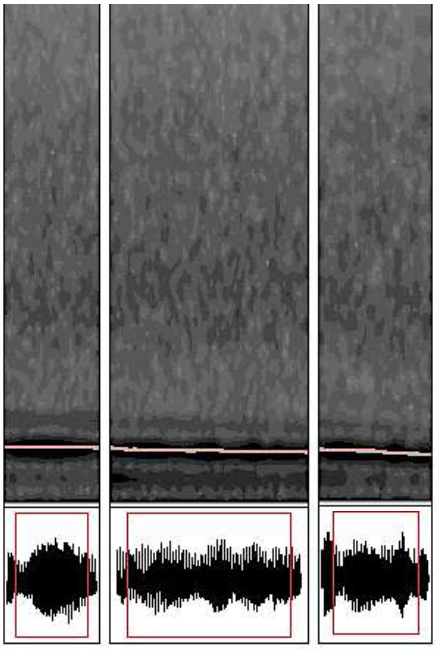
Echo / noise



Harmonic jump



Signal cuts

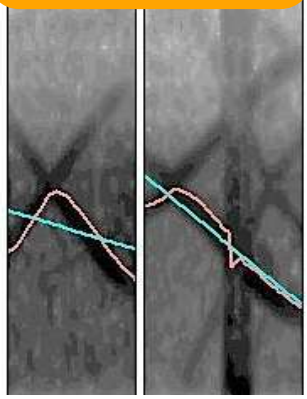


Further development

Further development

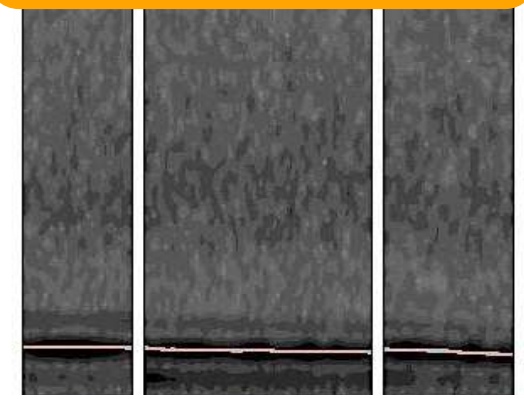
Clipping

Amplitude threshold



Signal cuts

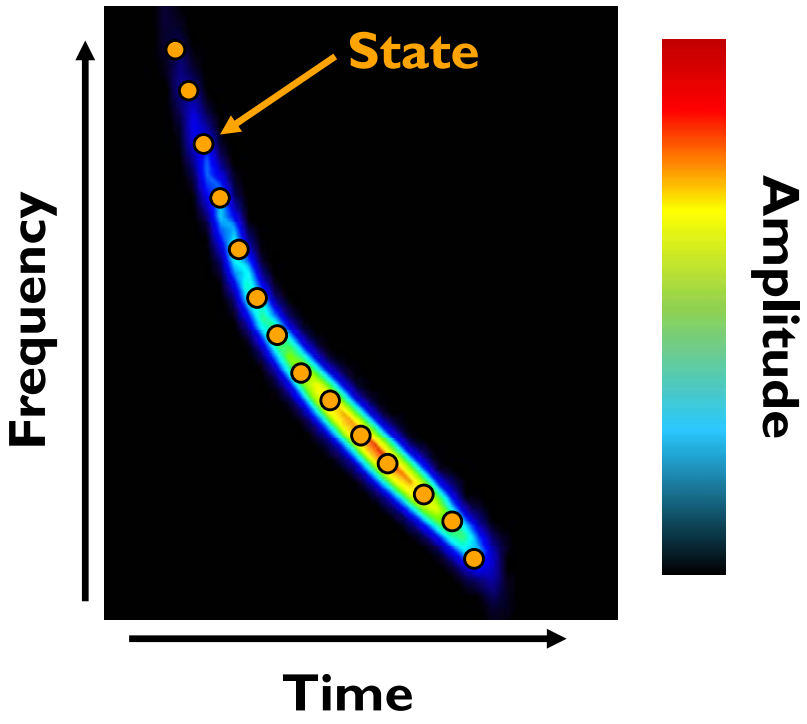
Minimum time interval between calls



Build filters (remove clipped signals and signal cuts)

Further development

Hidden Markov Models
(Agranat 2013, Aide 2013)



Add new extraction procedure based on ROI (Aide 2013, Scott 2014)

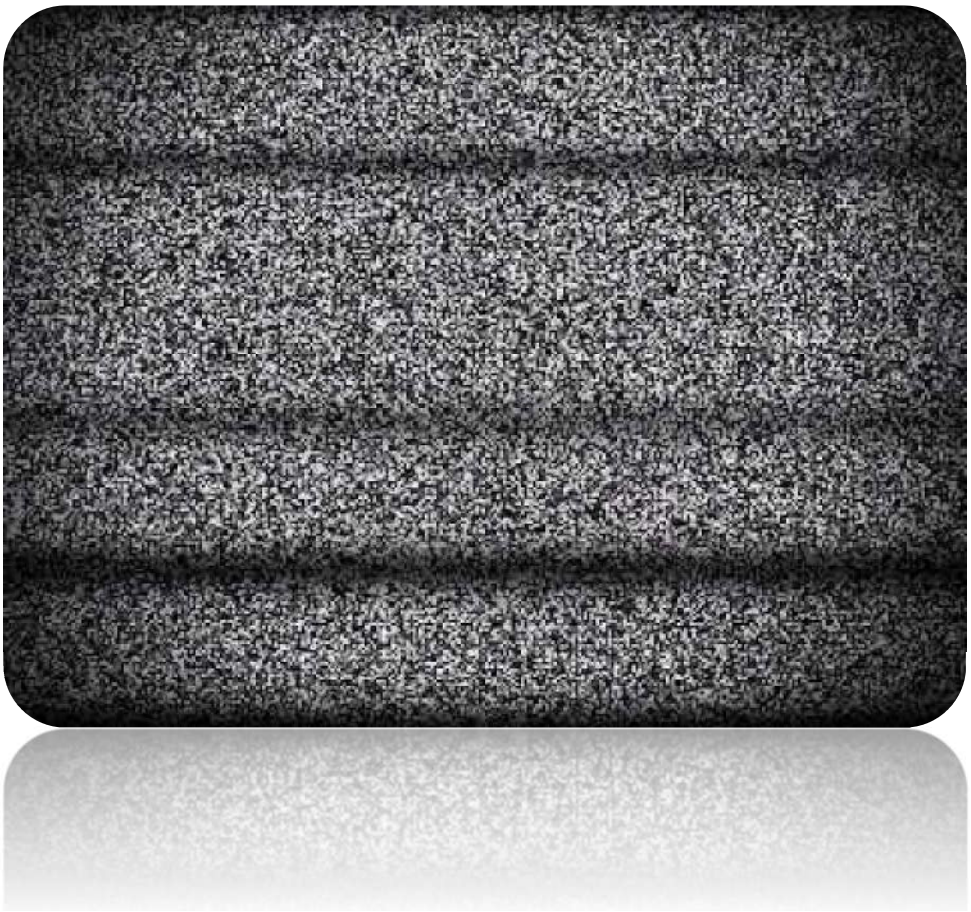
Sequence (state) of frequencies and amplitude parameters (Scott 2014)

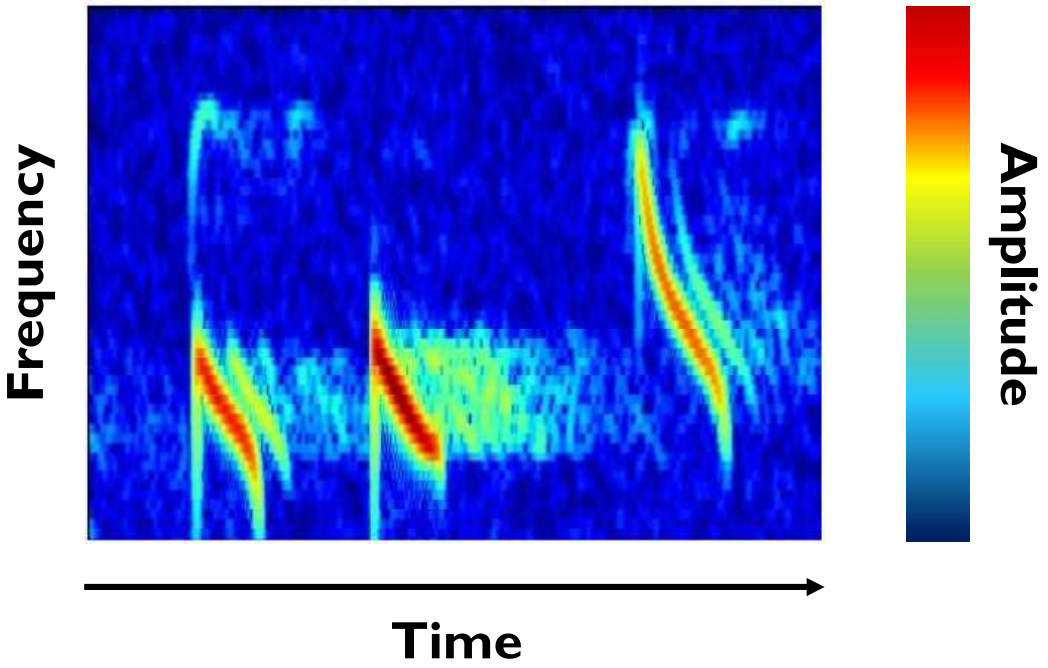
What can you do ?

Peer review
Create a network
Reference calls
$$

Use it !
Share it !
Improve it !
Fund it !

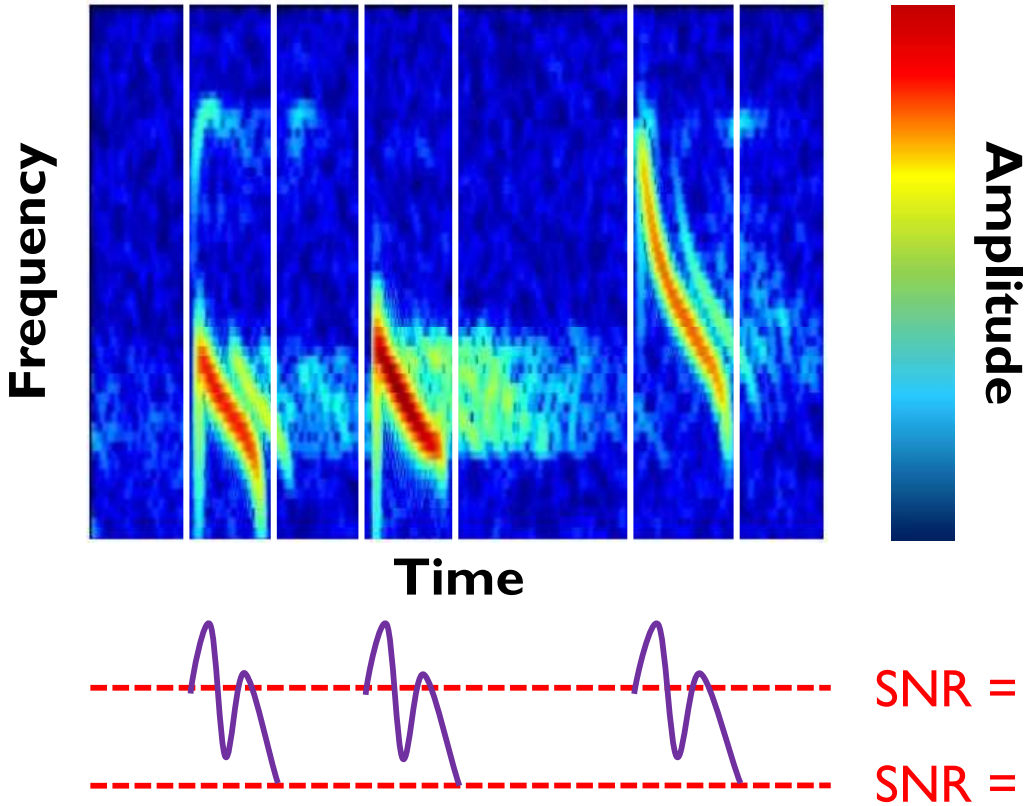
END





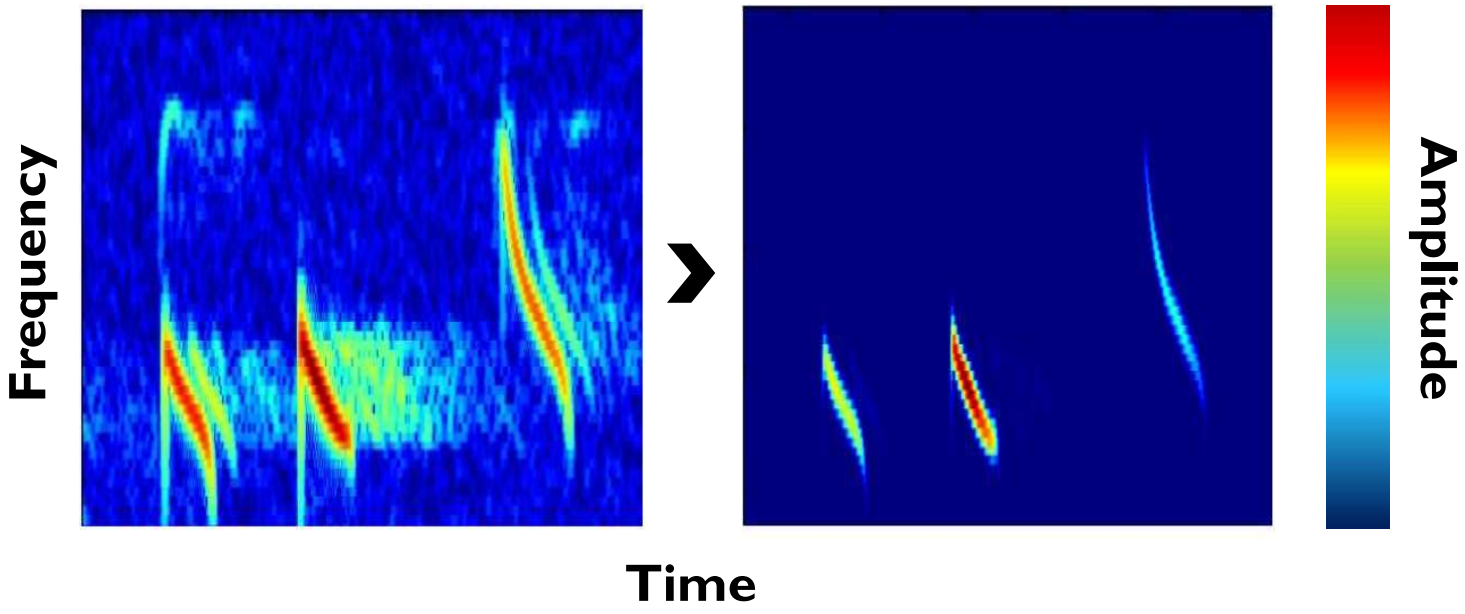
1. Frequency / time spectrum using overlapping FFT windows

Extraction



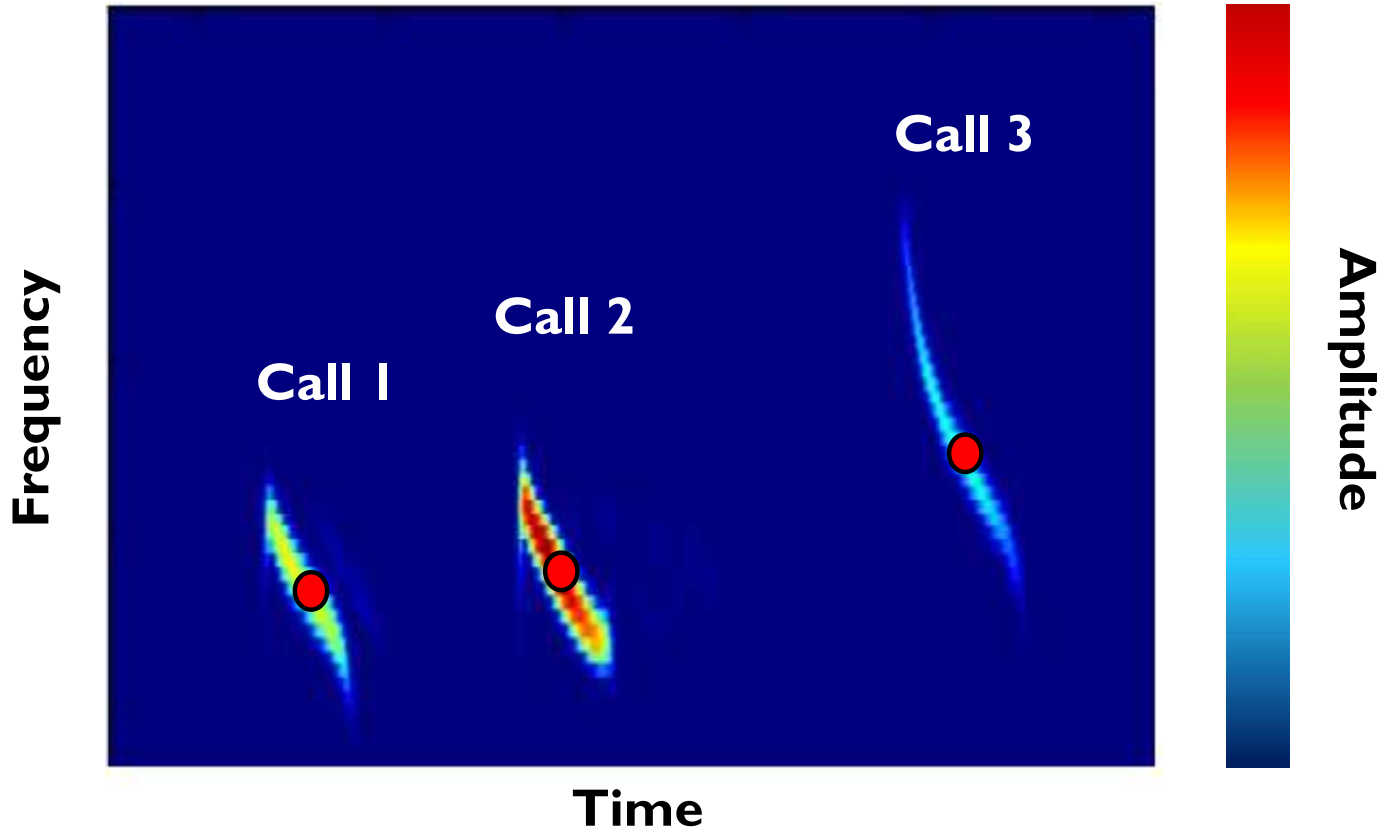
2. Identify regions with calls using Signal to Noise Ratio (SNR)

Extraction



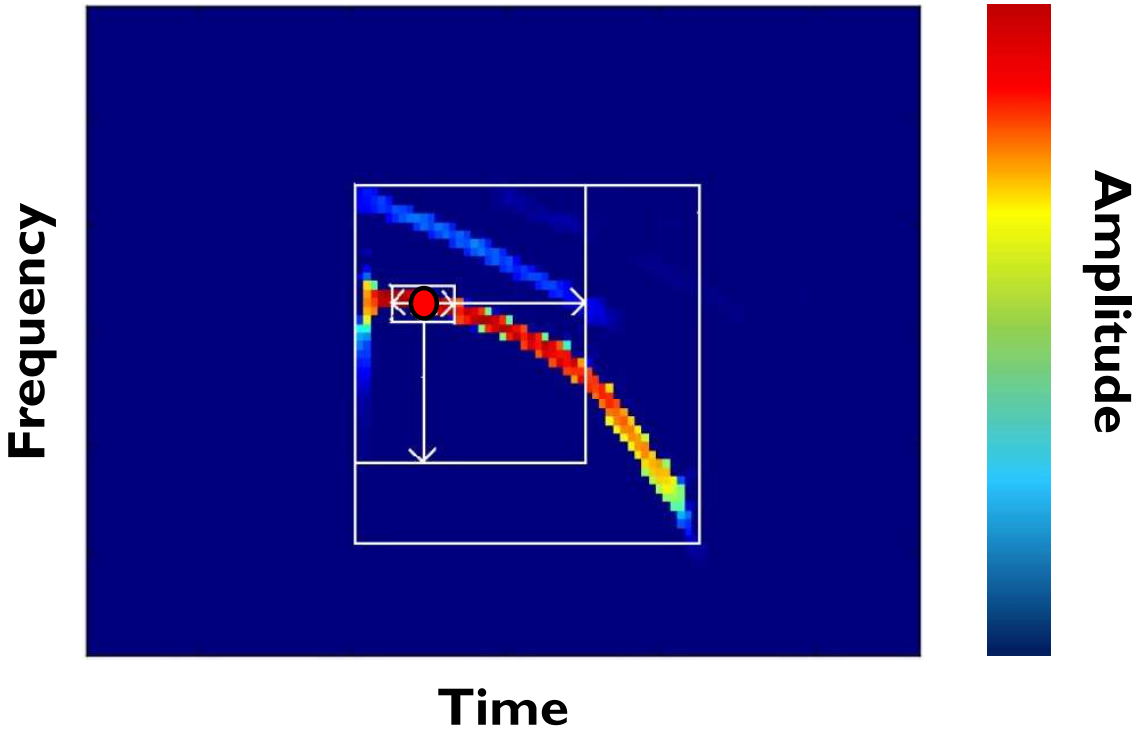
3. Background noise: spectral mean subtraction (Skowronski & Fenton, 2009)

Extraction

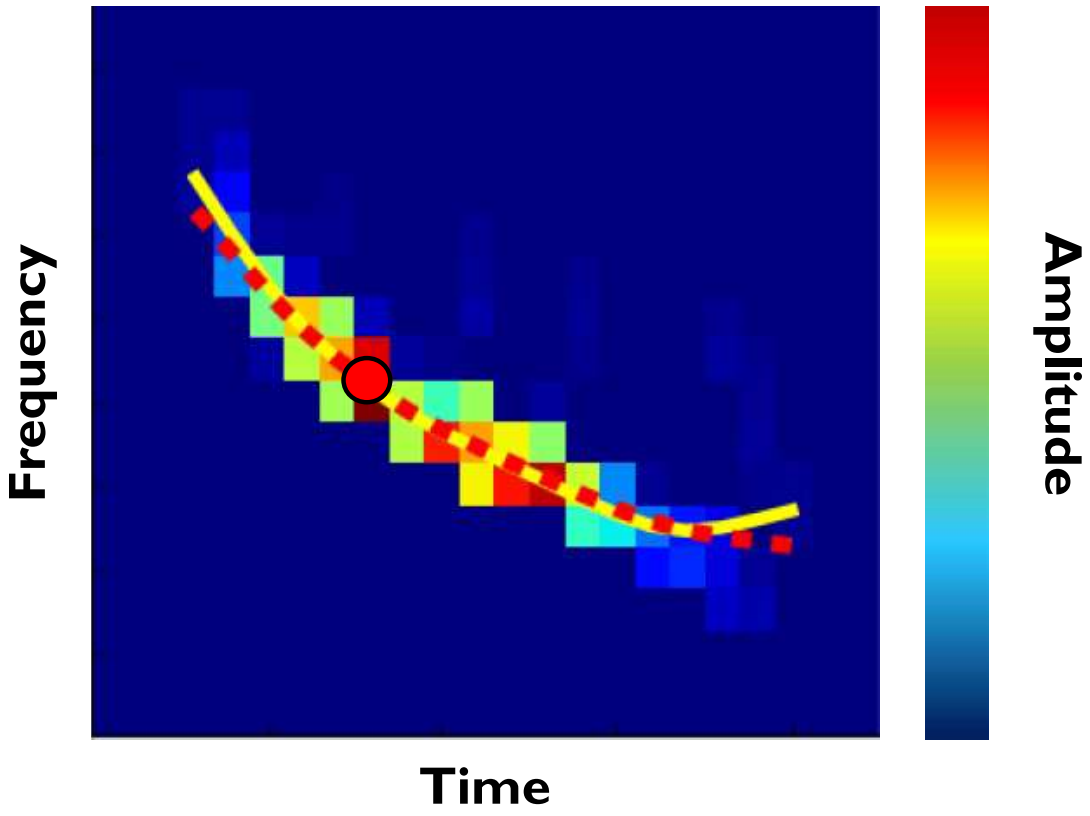


4. Spectral peak tracker to identify call centroids based on max. energy

Extraction

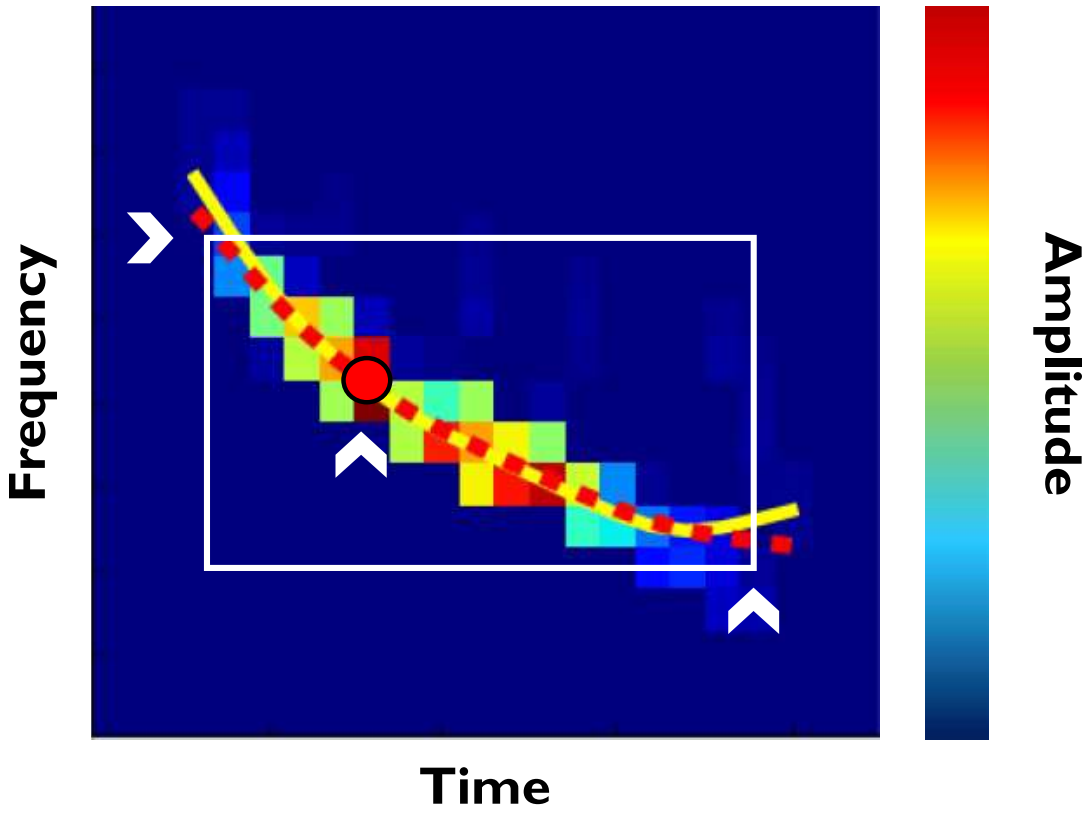


5. Identifies call contour (left & right) based on SNR



6. Applies a Kalman filter for smoothing (Scott, 2012)

Extraction



7. Then extracts call parameters for classification