LIÈGE université
GIGA institute
CYCLOTRON RESEARCH CENTRE
IN VIVO IMAGING

ACTIGRAPHY DATA ANALYSIS AND VISUALISATION

PYACTIGRAPHY

WEBINAR SERIES FOR OPEN SOURCE SOFTWARE & ALGORITHM DEVELOPER'S

IN THE PHYSICAL BEHAVIOUR RESEARCH FIELD

FEBRUARY 2021

Grégory Hammad, Ir, PhD
Sleep and Chronobiology research group

CONTEXT: RESEARCH LAB ACTIVITIES

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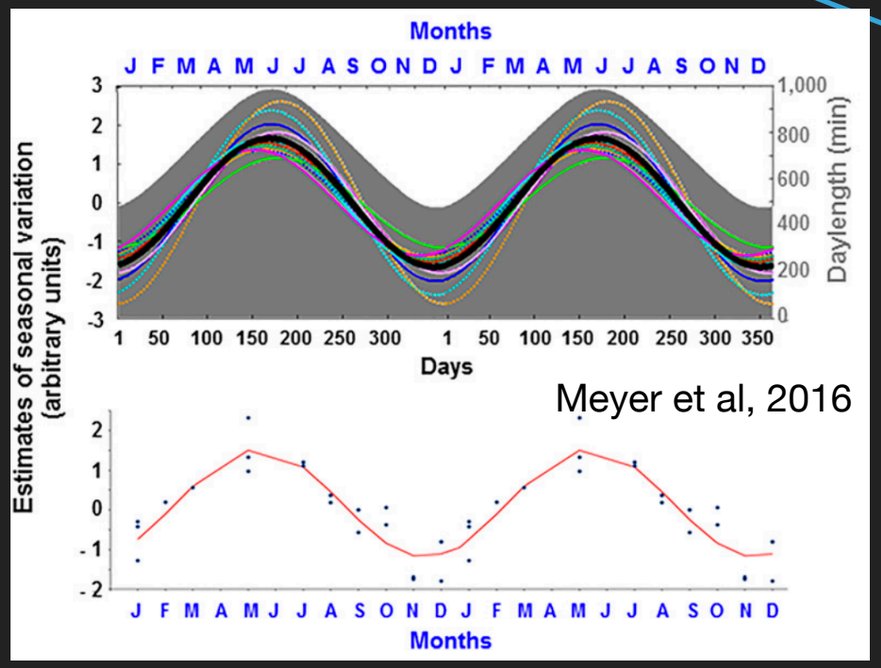

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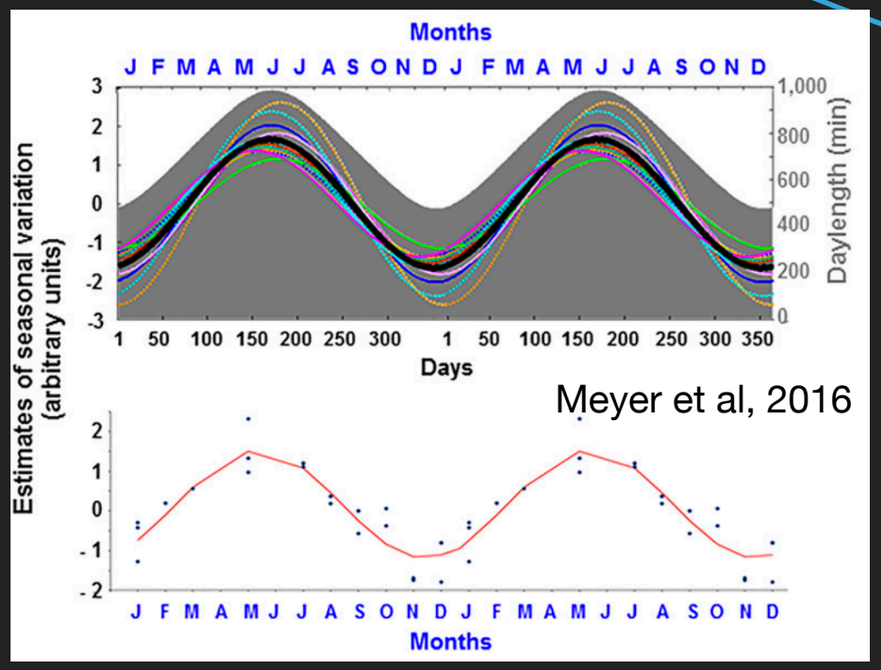

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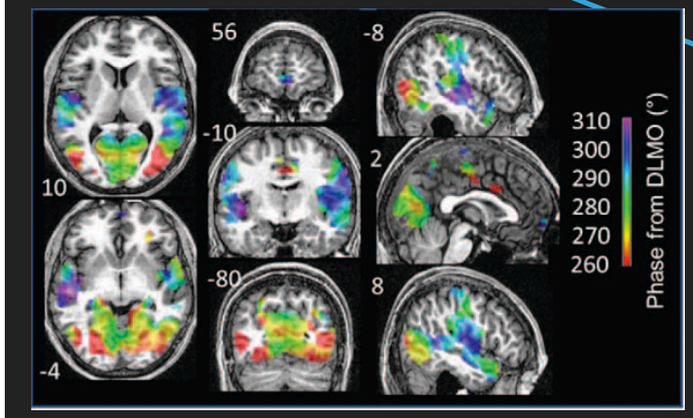

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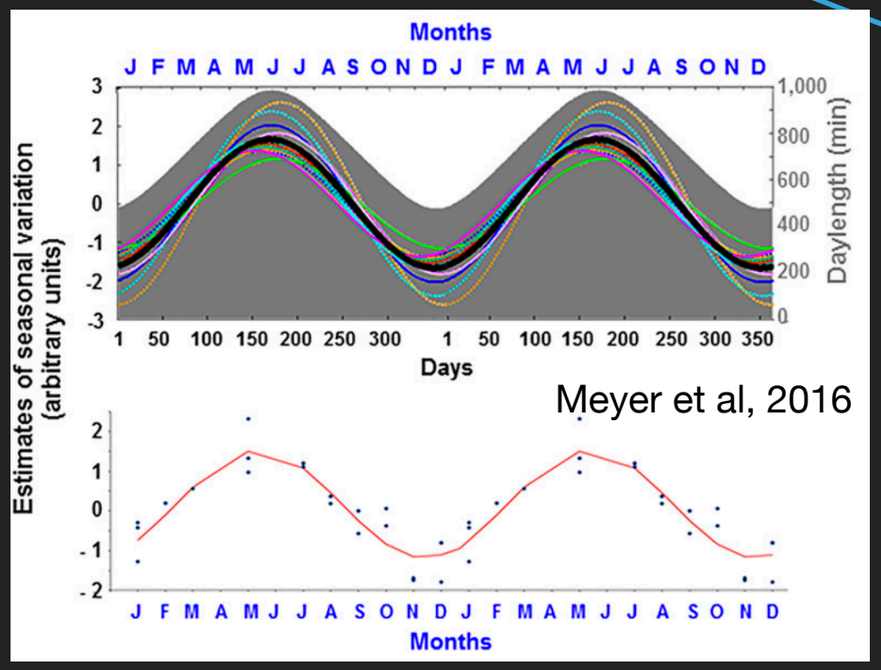

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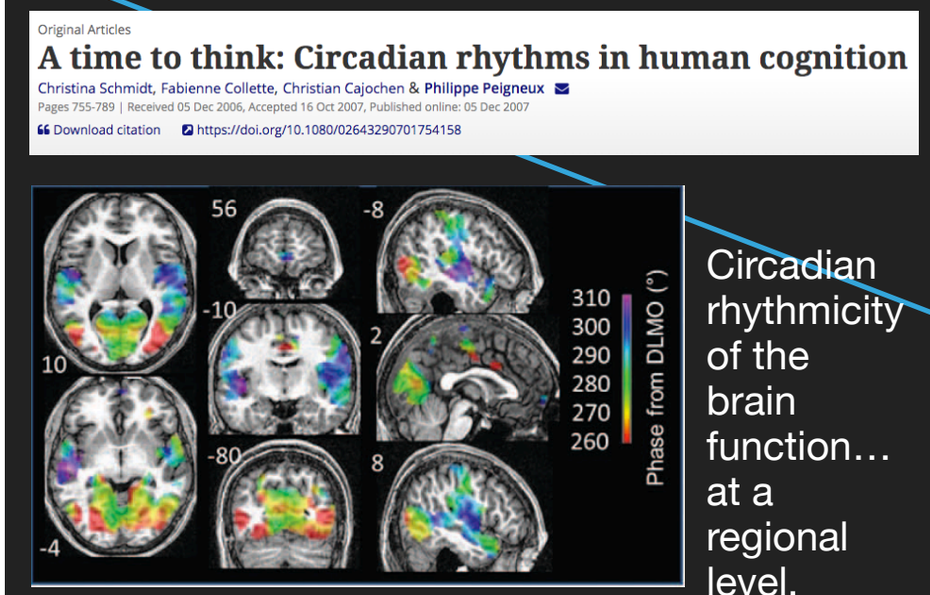

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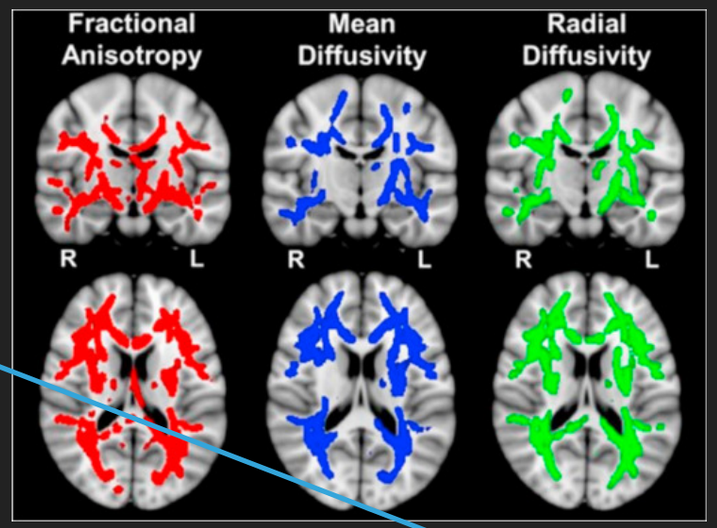

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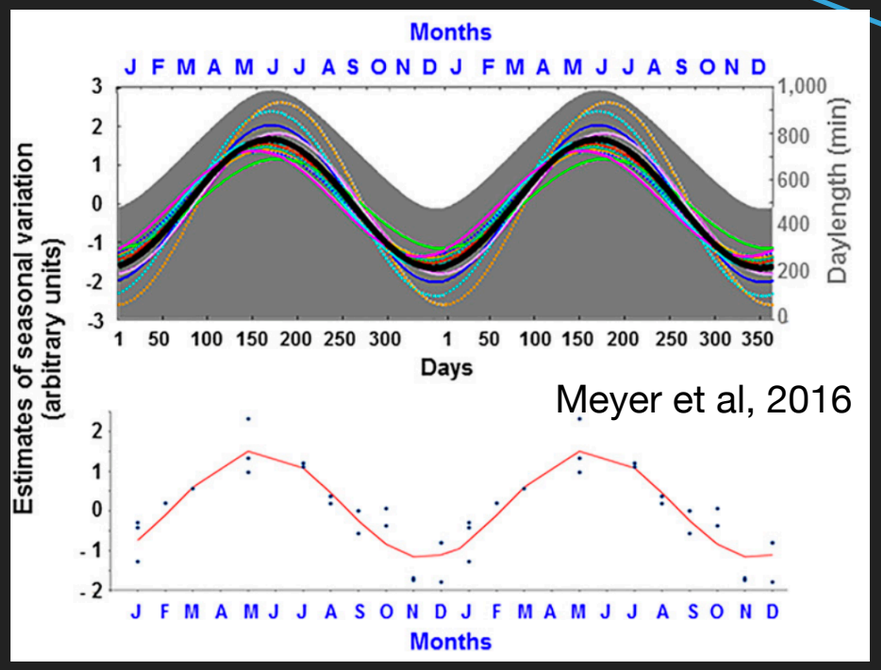

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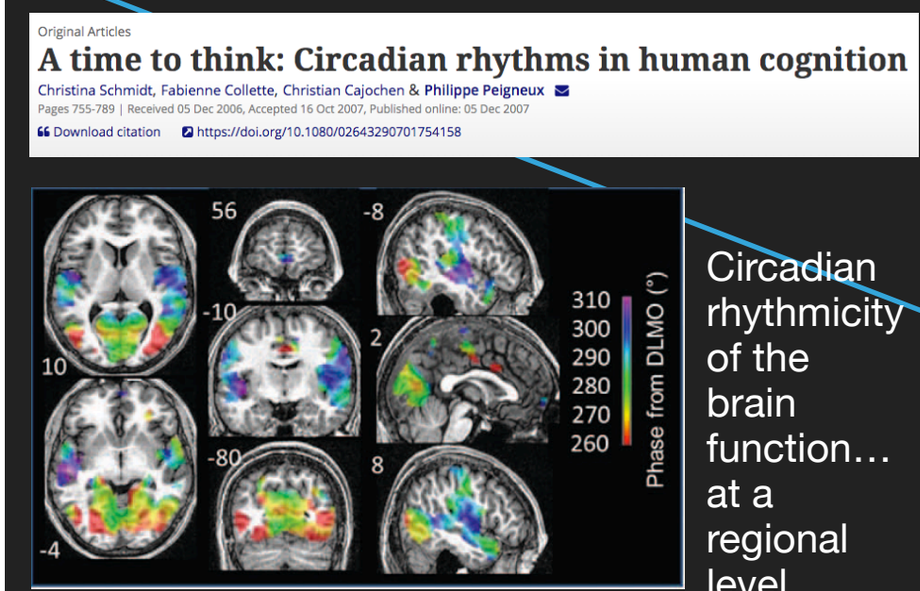

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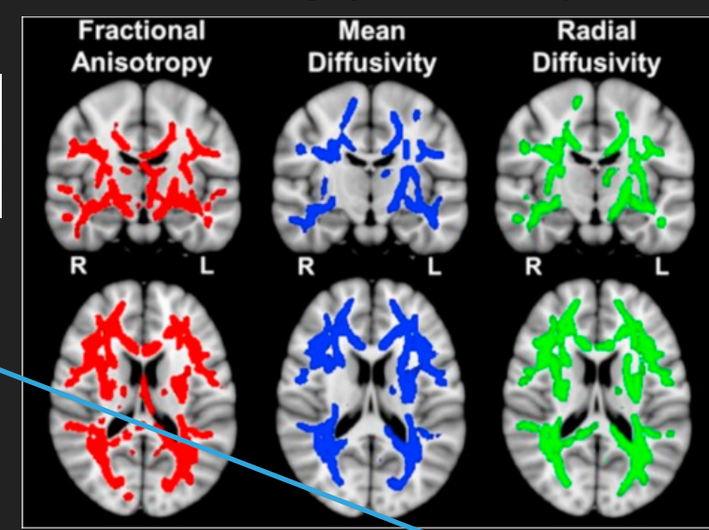

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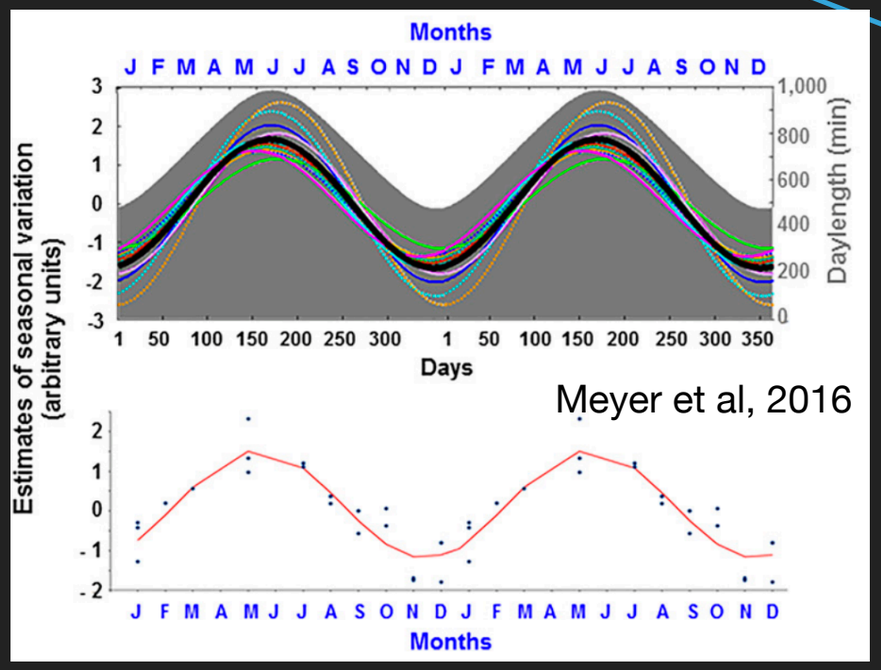

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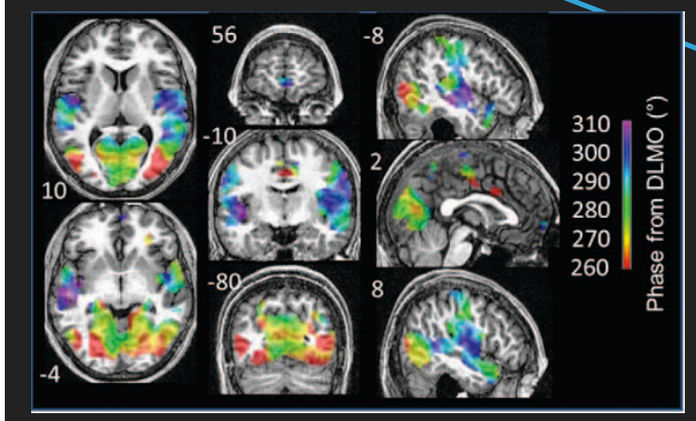

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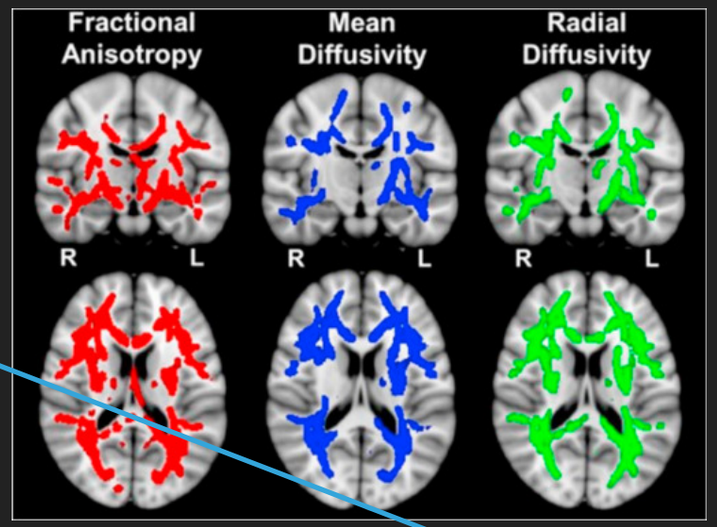

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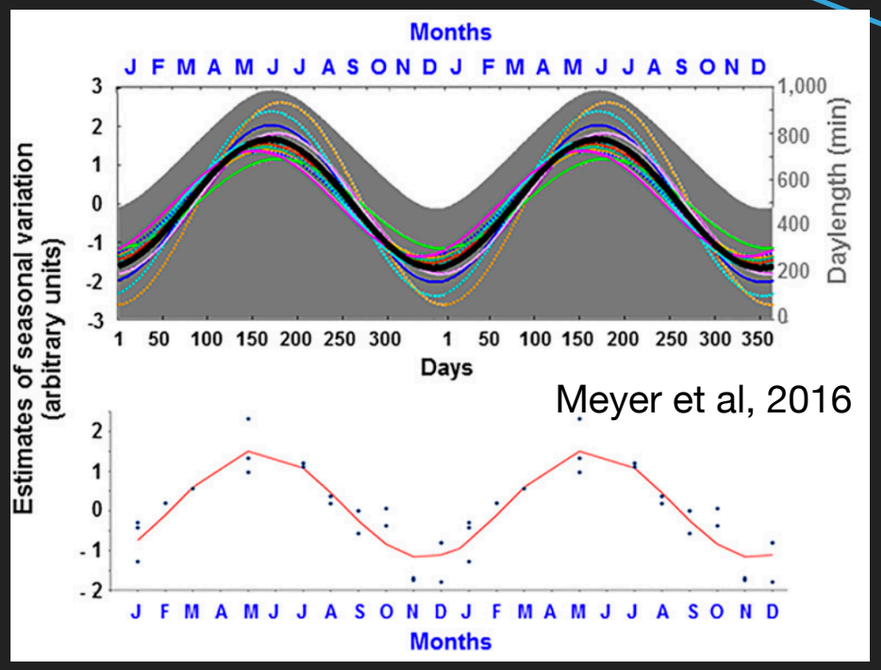

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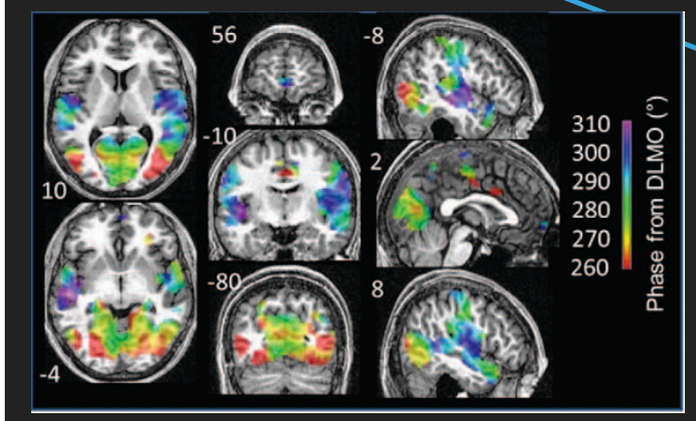

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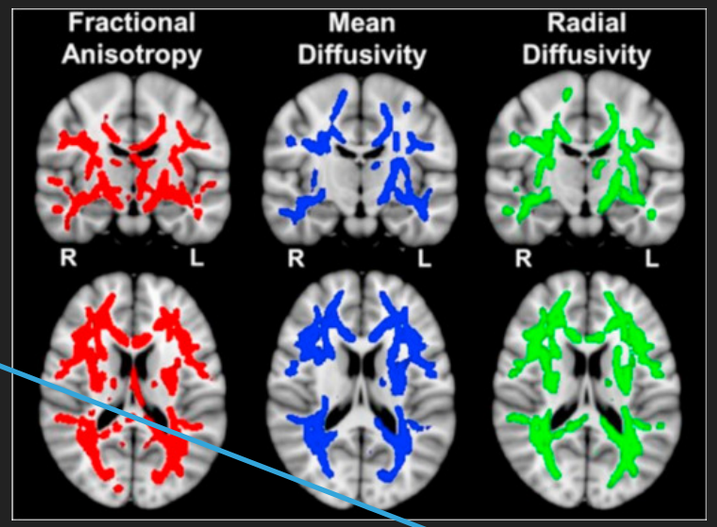

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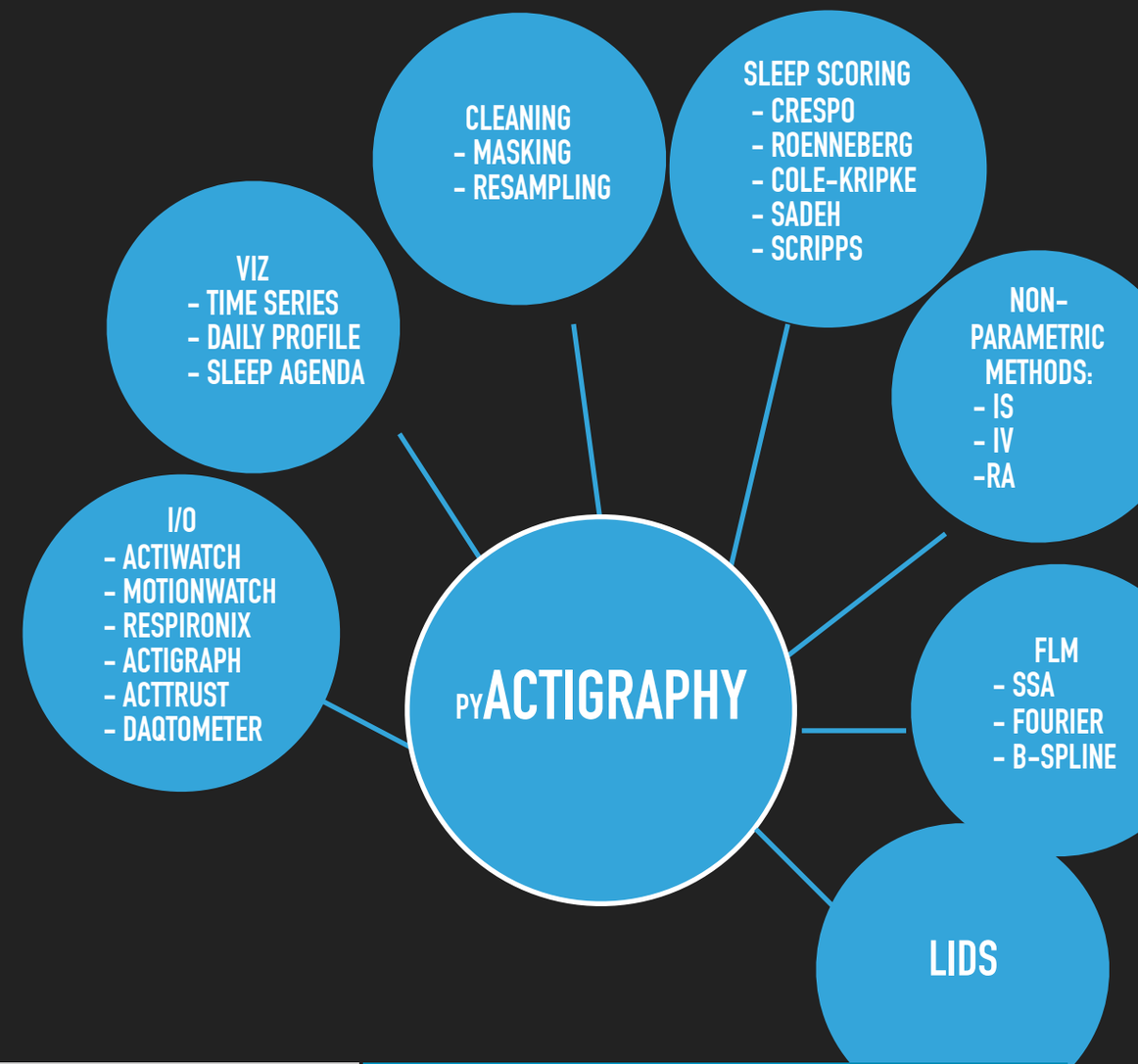
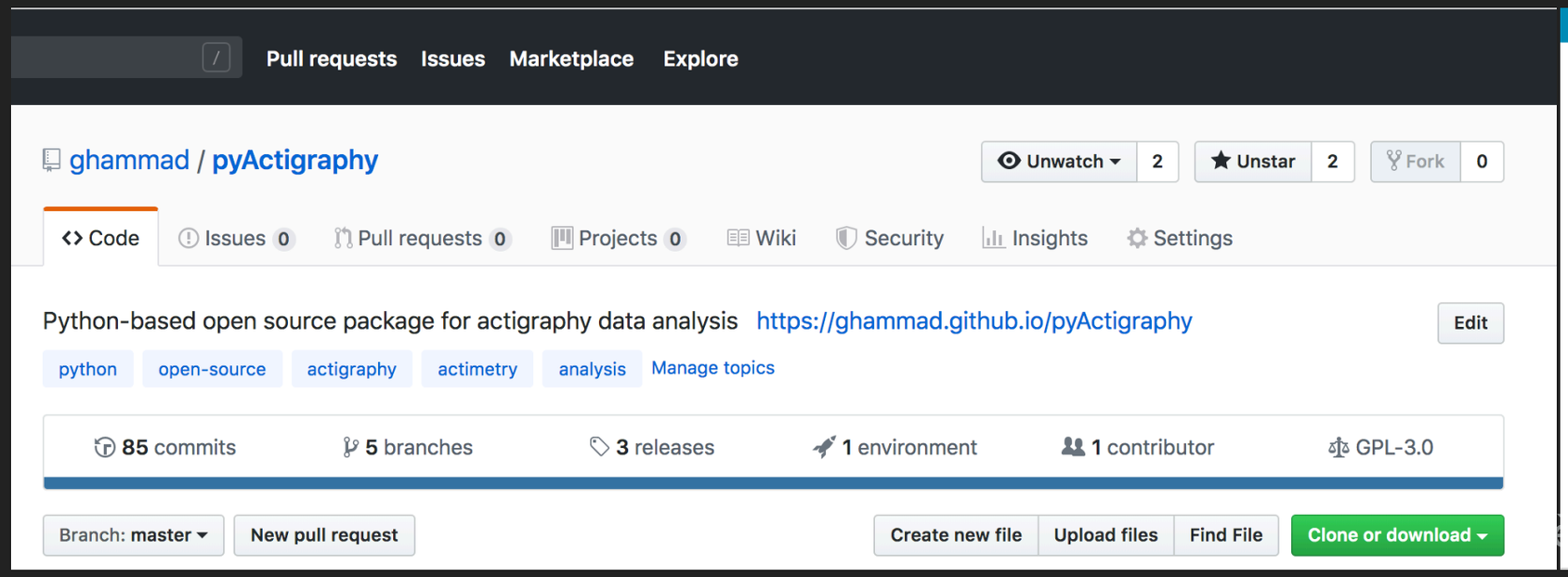
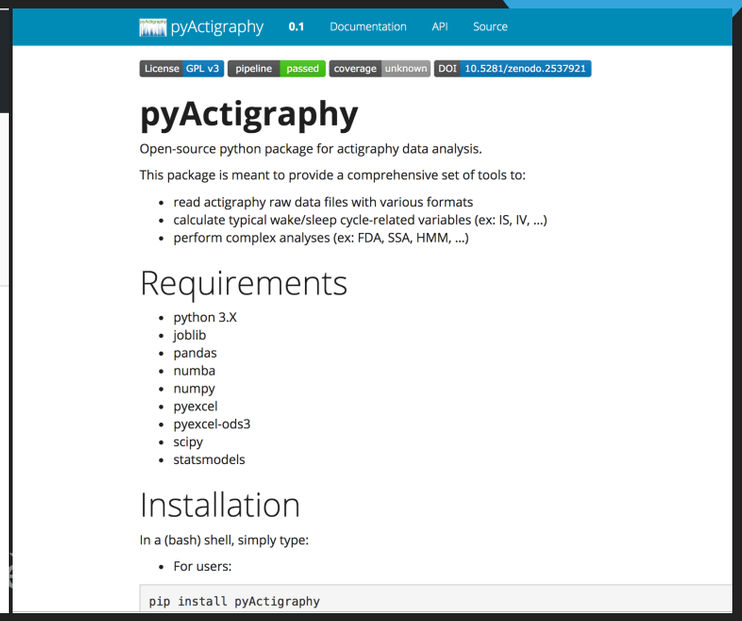
This motivated the development of an open-source toolbox !

pyACTIGRAPHY

- Overview:
  - python package, available on PyPI
  - source code hosted on GitHub
  - open source, released under GPL-3
  - unit test suite (~50 tests)
  - online documentation and tutorials







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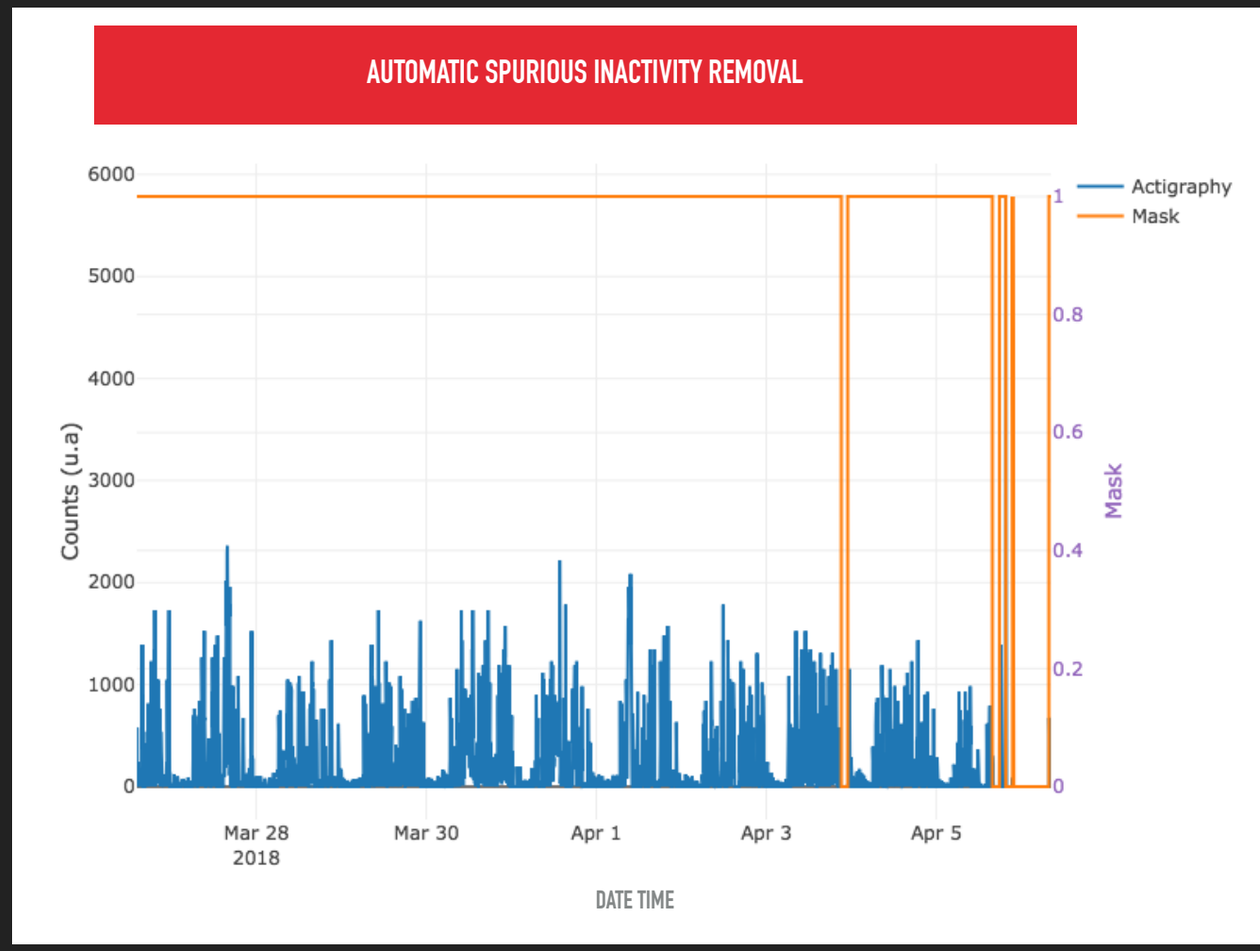

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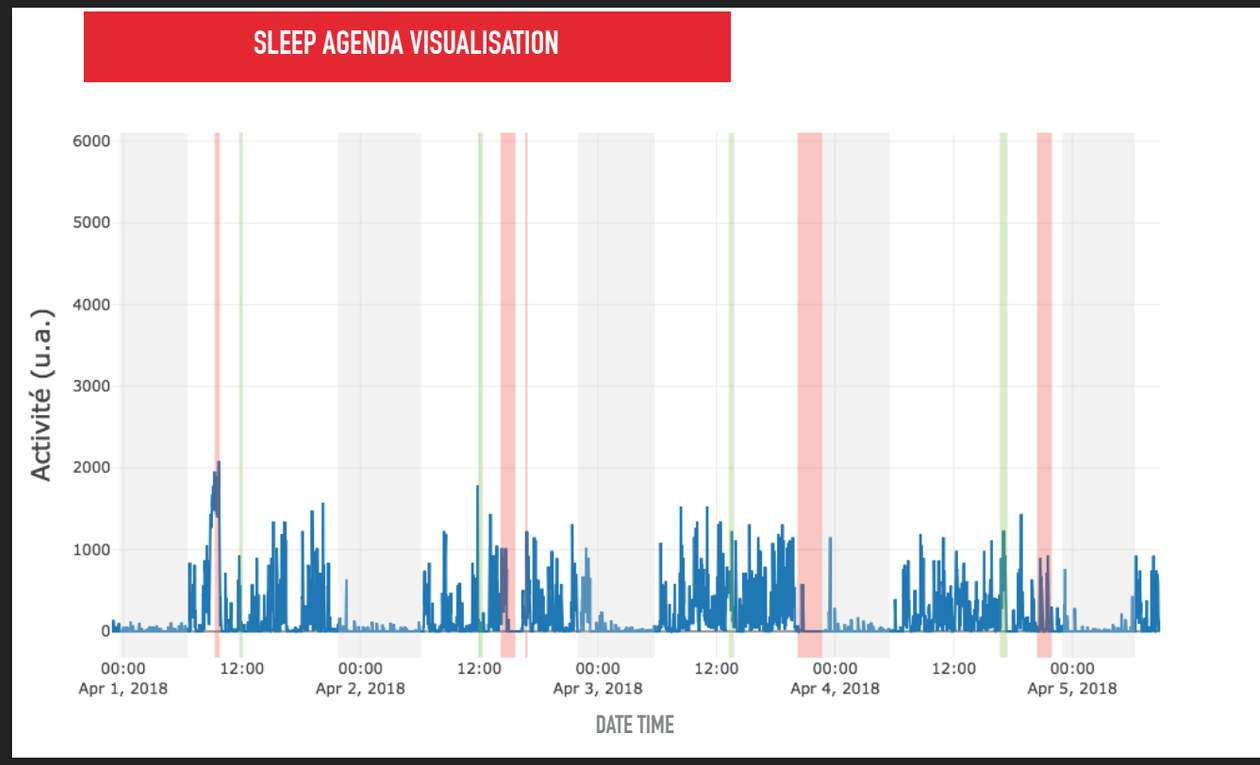

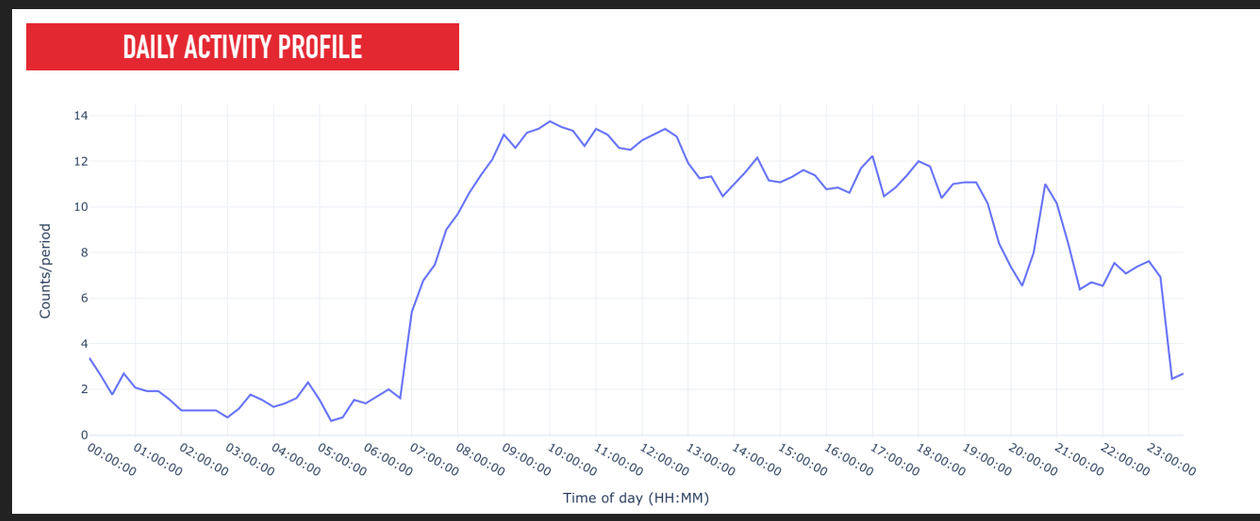

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- Signal filtering and smoothing:
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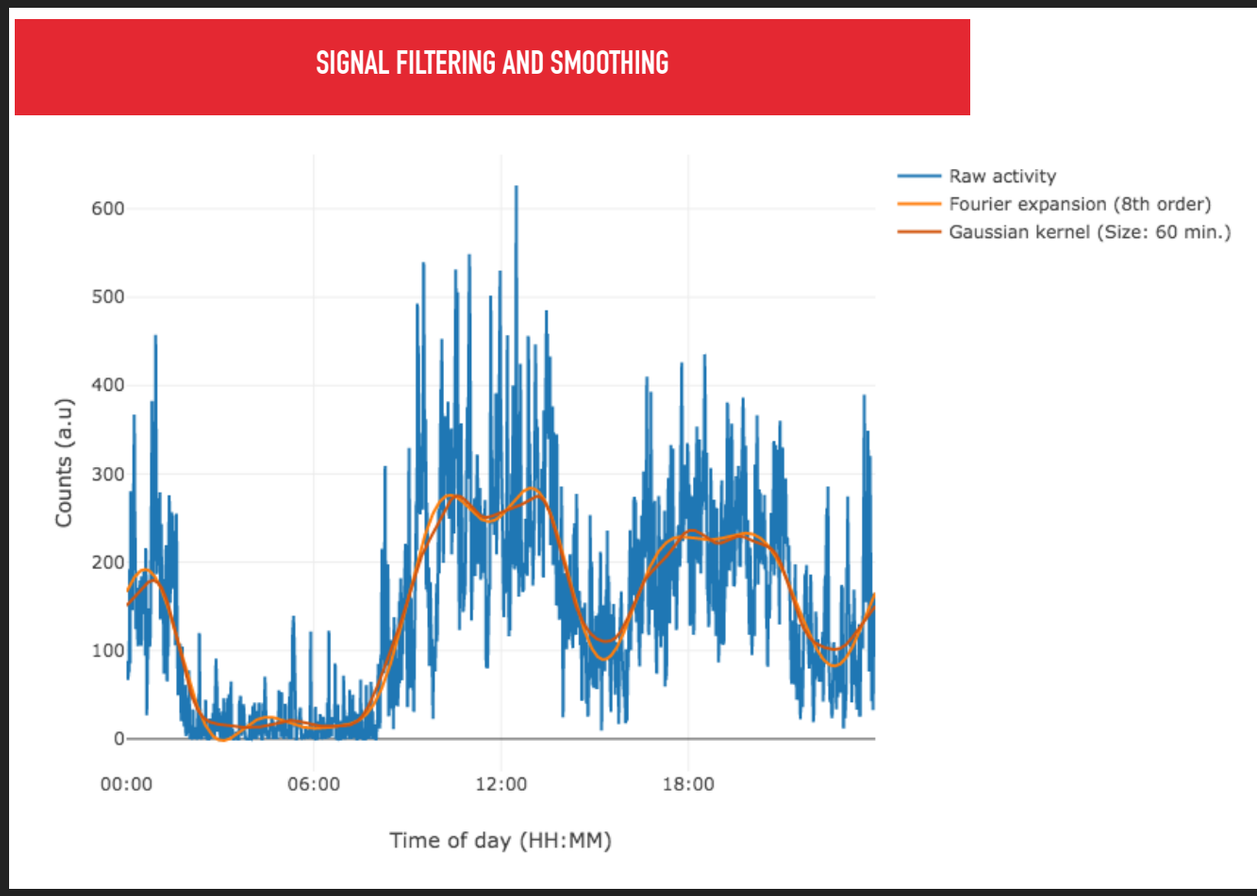

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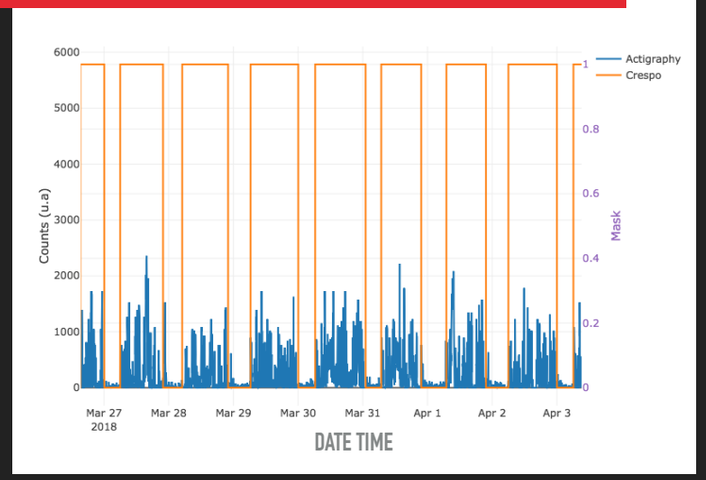

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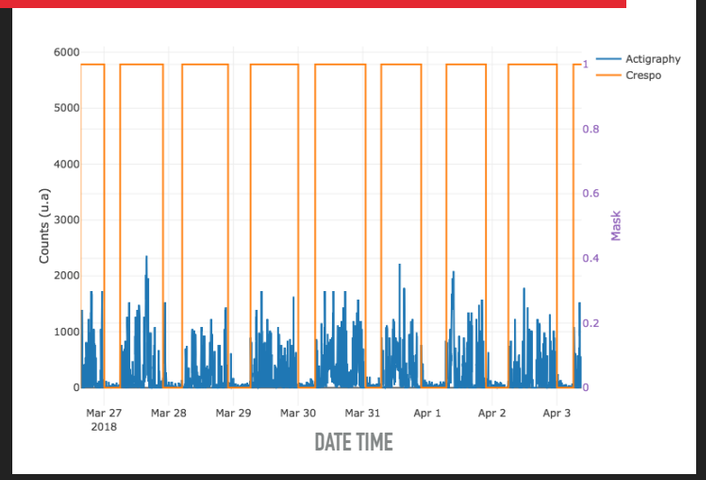
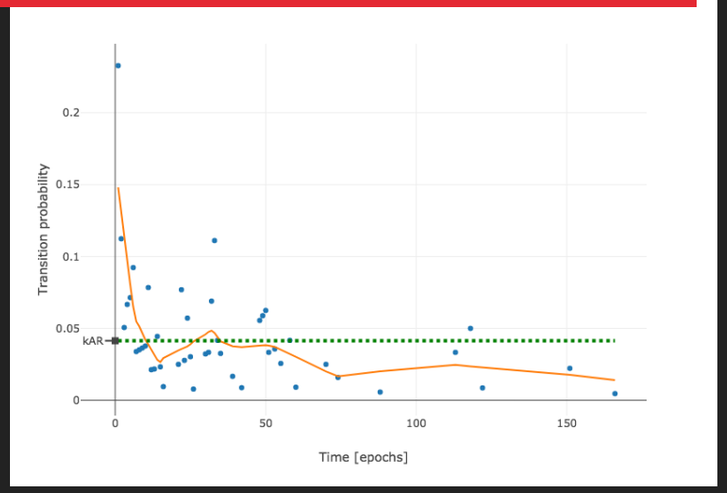


STATE TRANSITION PROBABILITY (k_{AR}, k_{RA}) LIM ET AL., 2011



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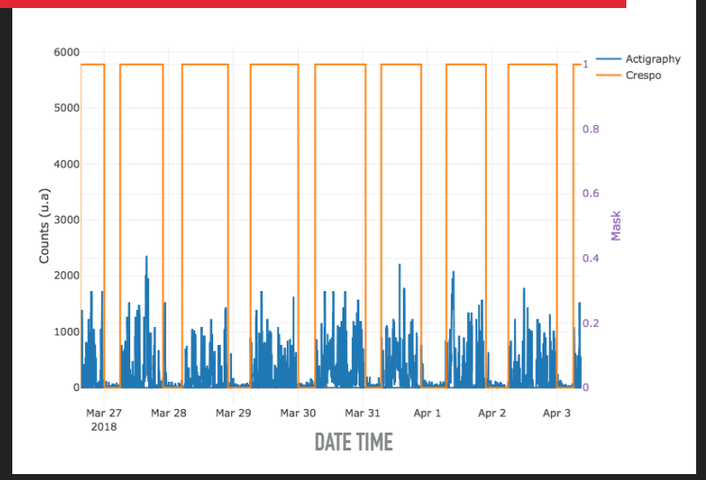

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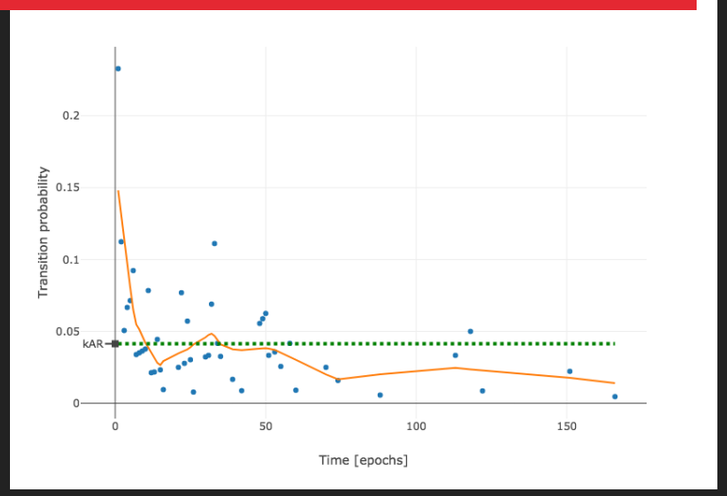
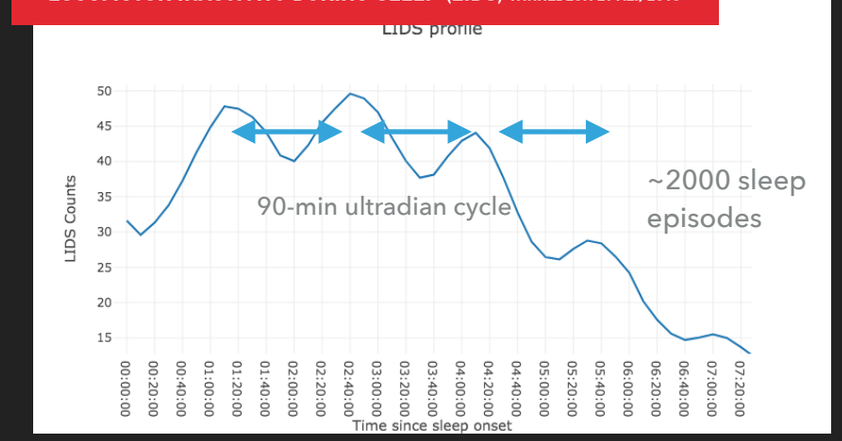


LOCOMOTOR INACTIVITY DURING SLEEP (LIDS) WINNEBECK ET AL., 2018



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- Actigraphy signal decomposition (SSA): inspect circadian/ultradian components separately!

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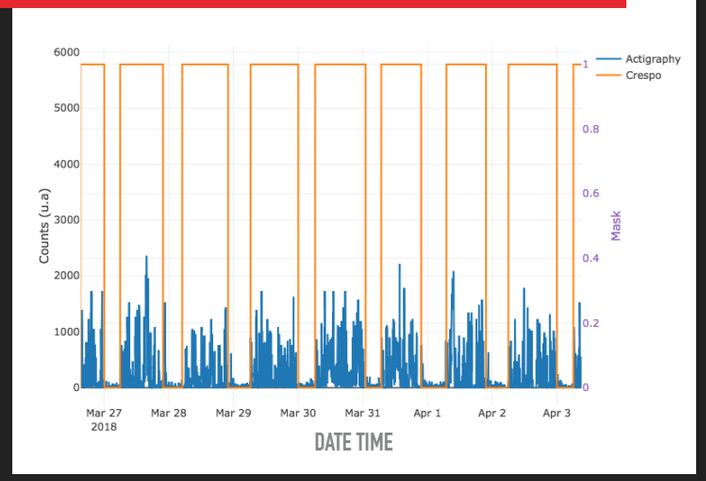

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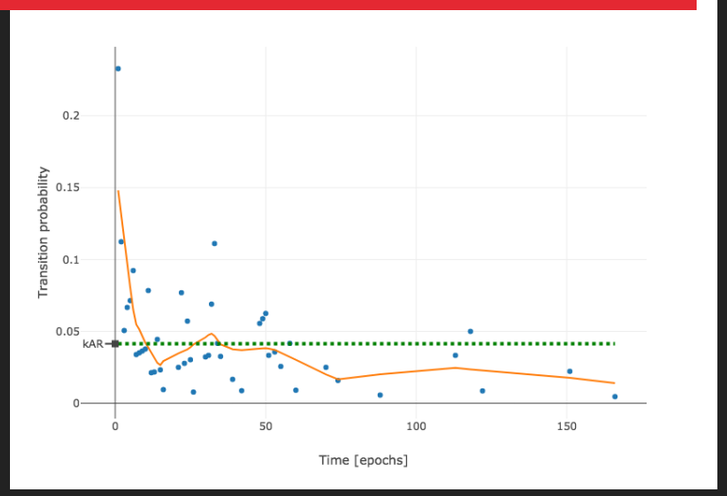

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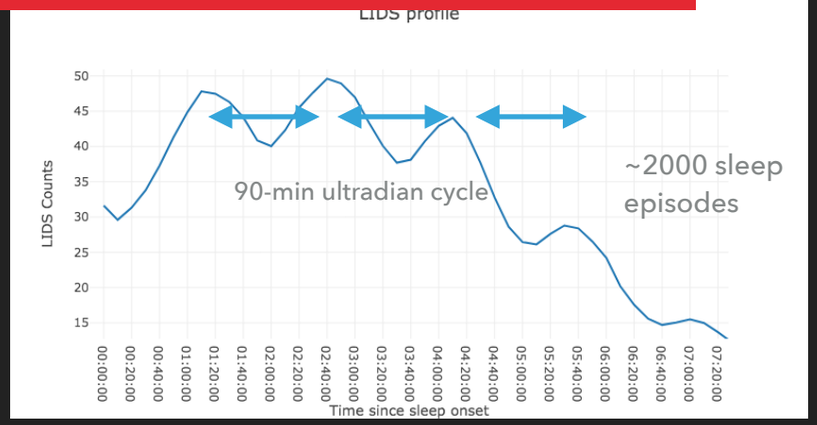
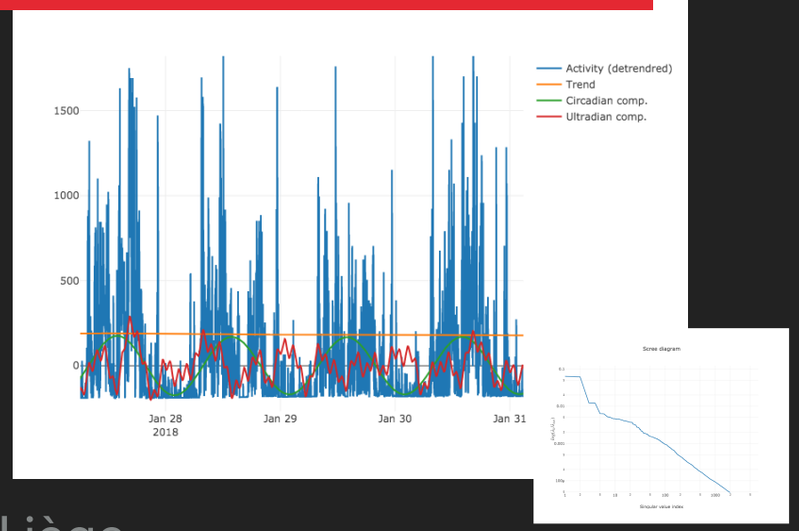


SINGULAR SPECTRUM ANALYSIS (SSA) GOLYANDINA AND ZHIGLJAVSKY, 2013



PYACTIGRAPHY

pyACTIGRAPHY

- Learn how to use it: tutorials

pyActigraphy 0.2 Documentation API Source Search

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  - 1.1 Changing the resampling frequency
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pyActigraphy 0.2 Documentation API Site Search

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In [5]: layout = go.Layout(title="Actigraphy data", xaxis=dict(title="Date time"), yaxis=dict(title="Counts/period"), showlegend=Fals
In [6]: go.Figure(data=go.Scatter(x=raw.data.index.astype(str), y=raw.data), layout=layout)
```

pyActigraphy 0.2 Documentation API Source Search

Sleep fragmentation via state transition probability

"Quantification of the Fragmentation of Rest-Activity Patterns in Elderly Individuals Using a State Transition Analysis"

Andrew S.P. Lim, MD, Lei Yu, PhD, Madalena D. Costa, PhD, Aron S. Buchman, MD, David A. Bennett, MD, Sue E. Leurgans, PhD, (

Sleep, Volume 34, Issue 11, 1 November 2011, Pages 1569–1581, https://doi.org/10.5665/sleep.1400

```
In [1]: import pyActigraphy
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Quantify the Rest-to-activity transition probability

help(raw.kRA)

Rest to activity (kRA)

pyActigraphy 0.2 Documentation API Site Search

Automatic detection of rest/activity periods with pyActigraphy

The **pyActigraphy** package implements several rest/activity detection algorithms.

Broadly speaking, they can be divided in two categories:

- Epoch-by-epoch rest/activity scoring (inspired by PSG):
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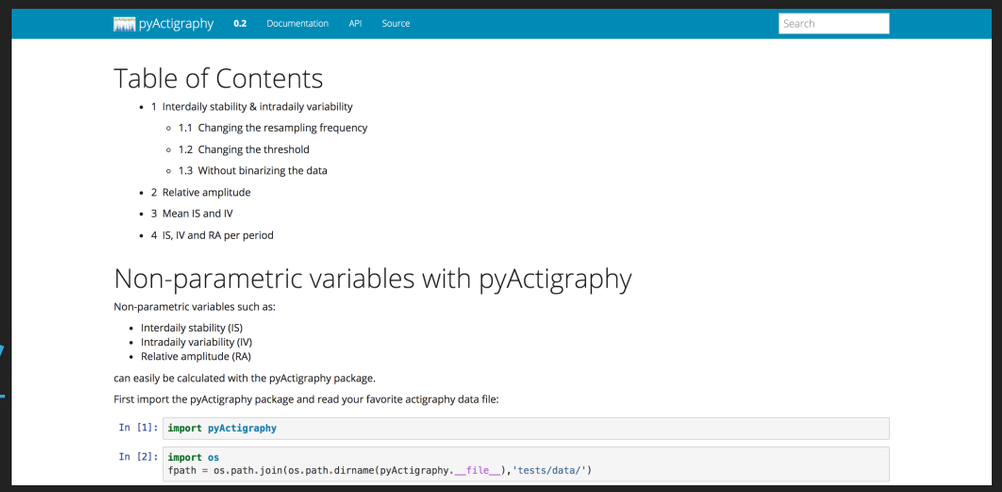

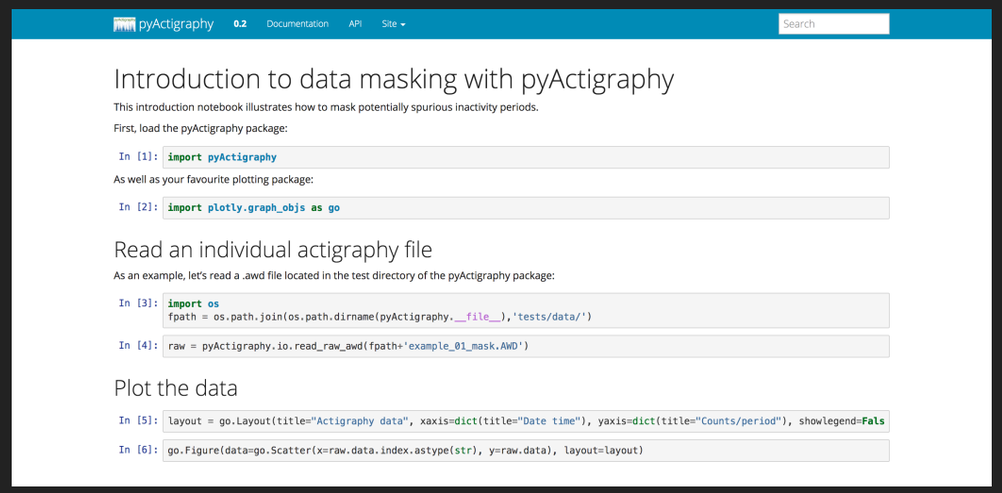

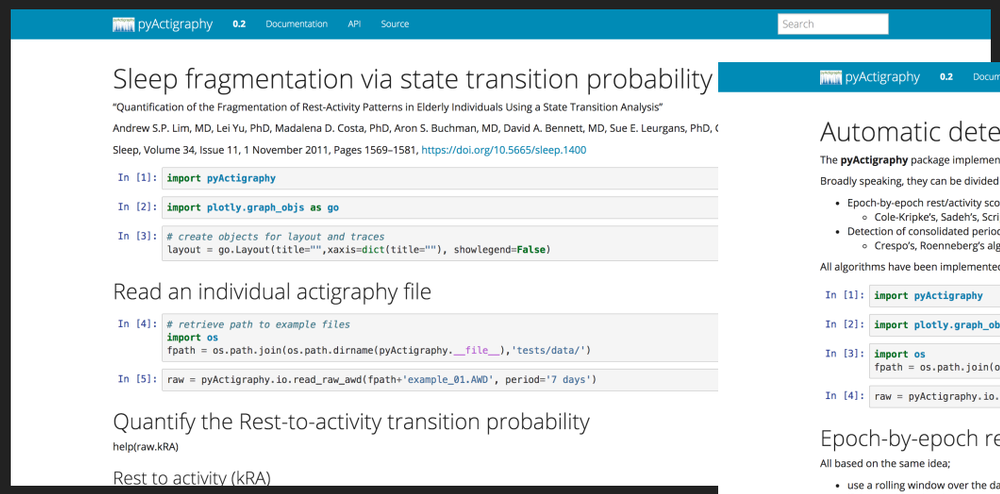

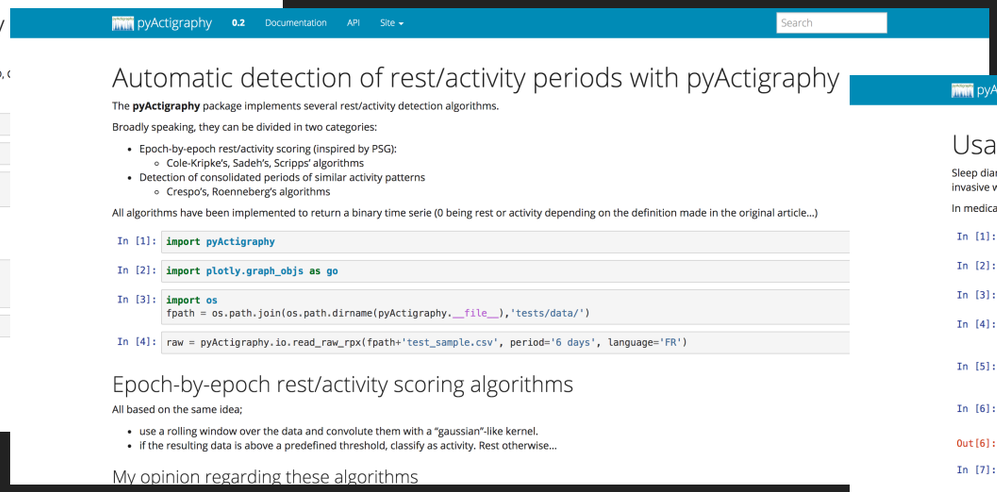

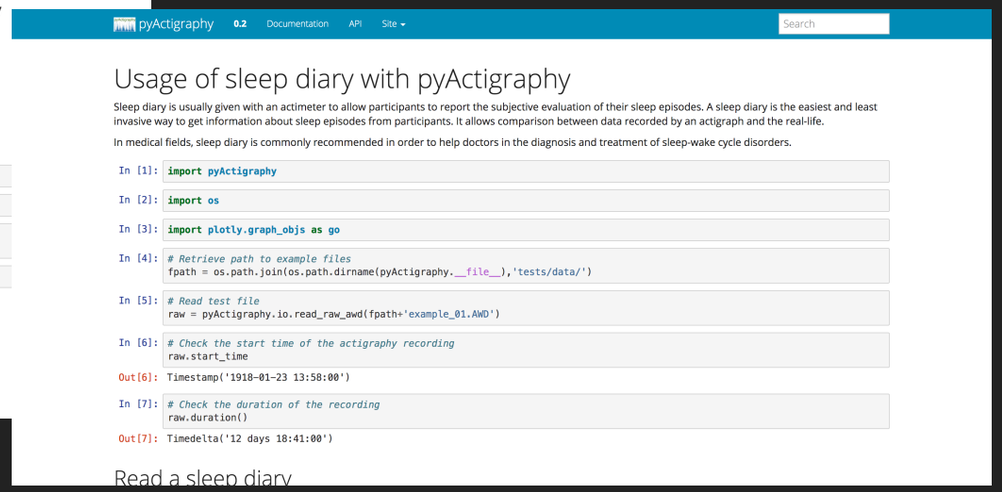

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pyActigraphy 0.2 Documentation API Source Search

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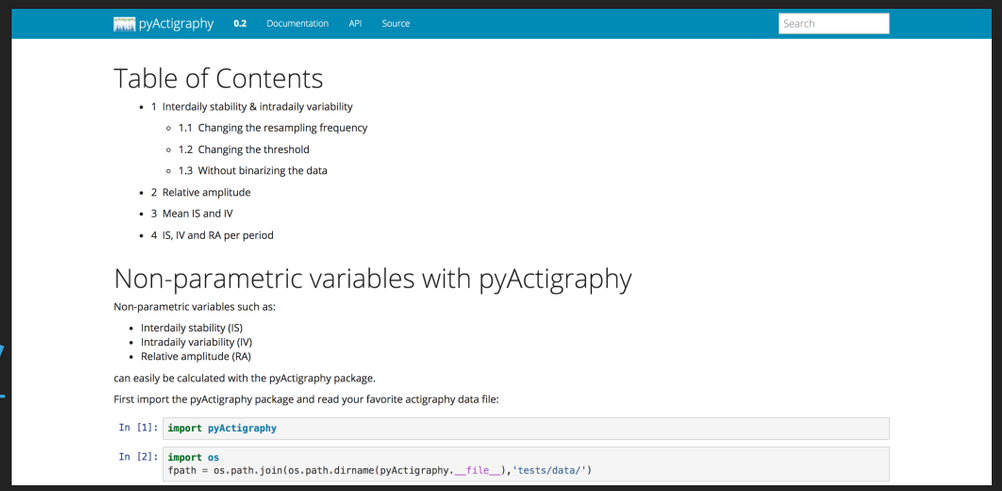

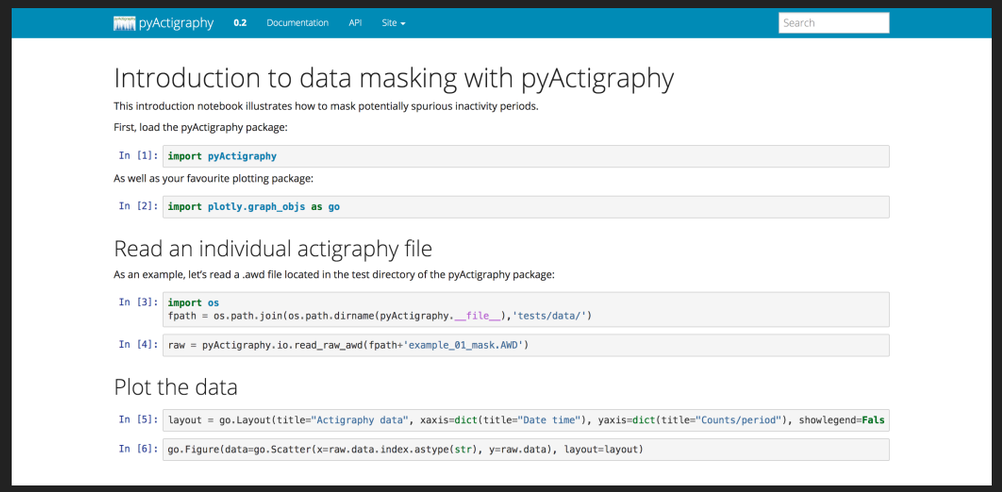

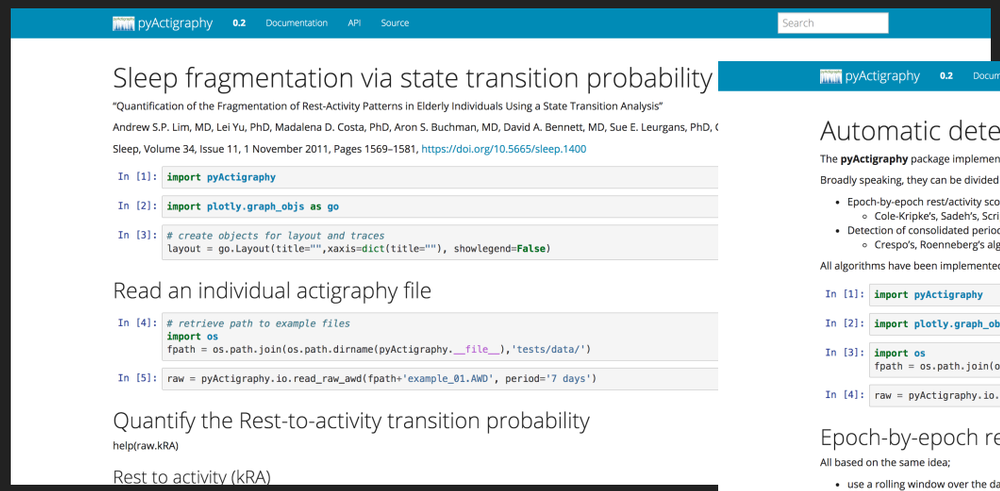

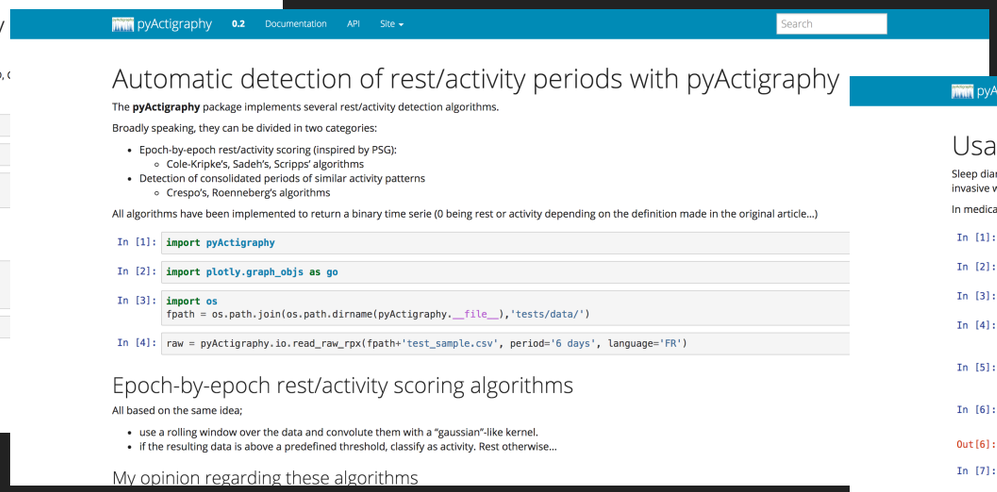

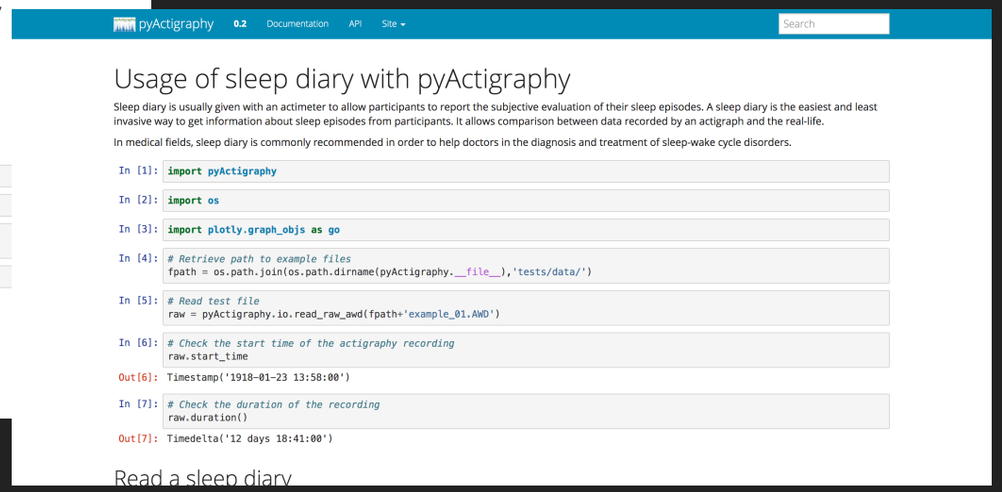

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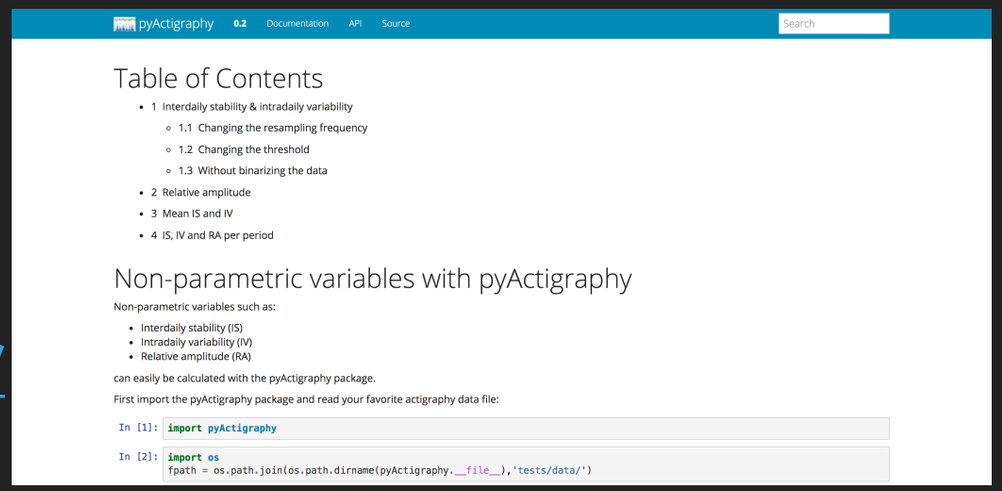

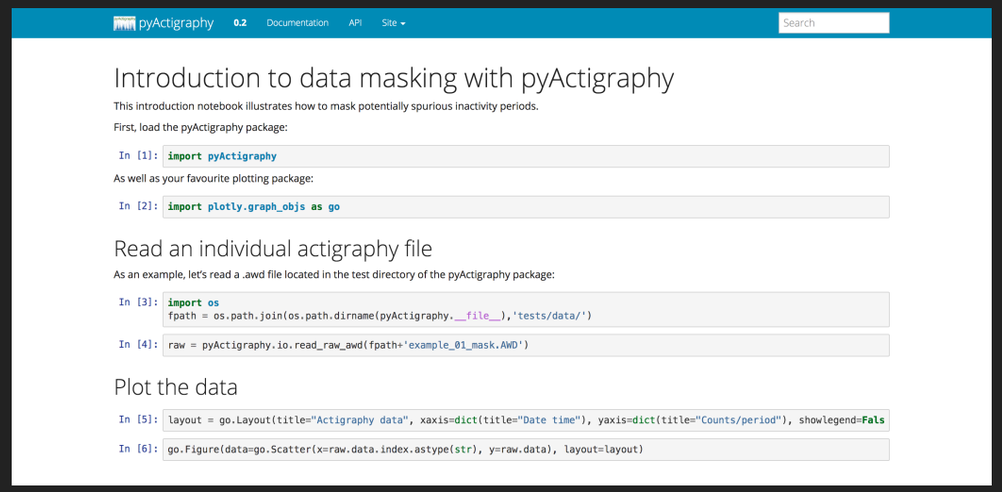

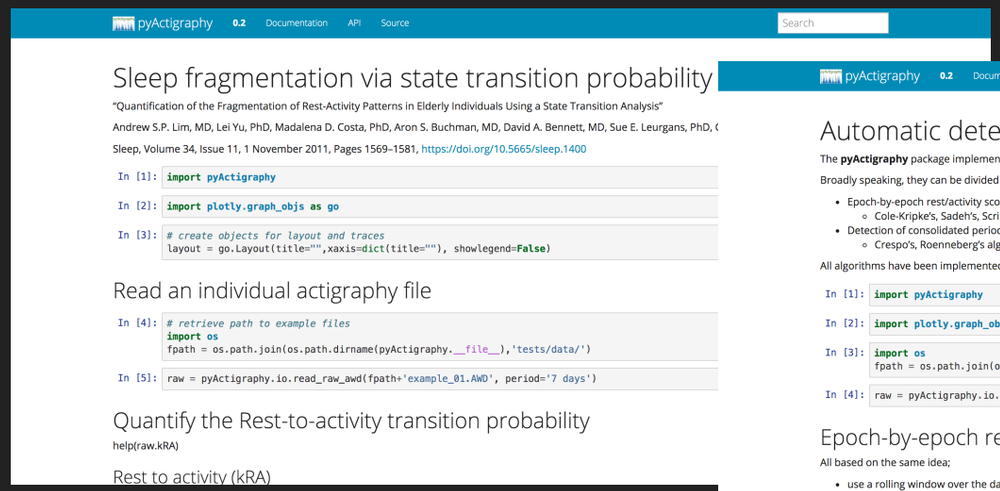

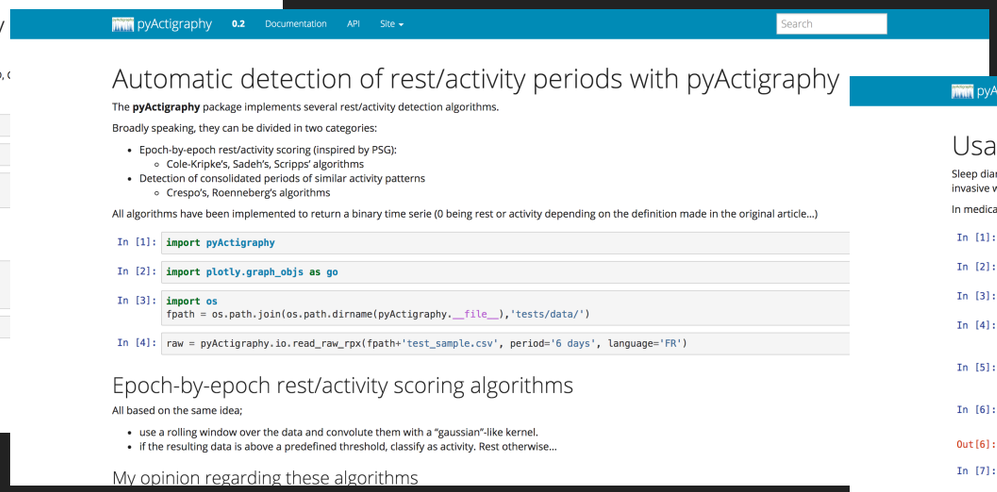

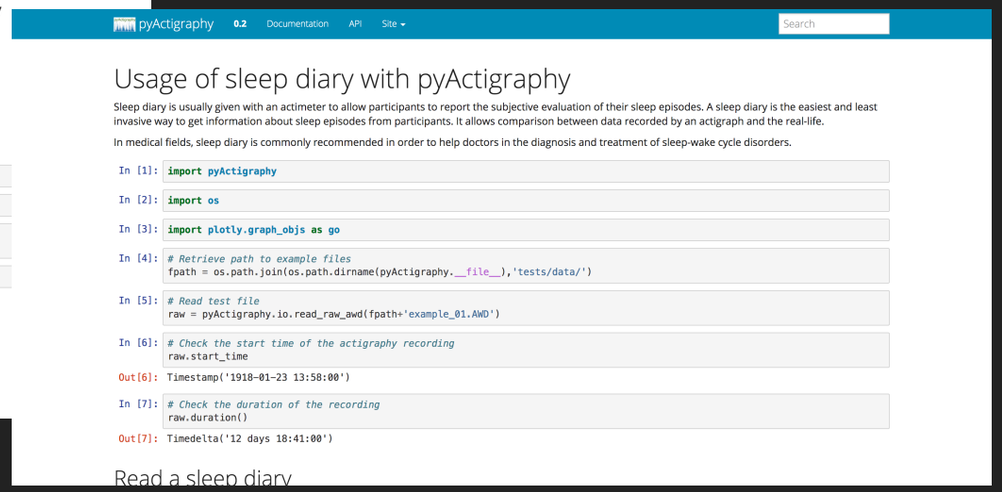

IMPLEMENTATION DETAILS: UNIT TESTS

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```
40  def test_kra_sequences():
41
42      assert seq.kRA(0) == pytest.approx(seq_prob, rel=0.01)
43
44
45  def test_kra_logit():
46
47      assert seq.kRA(0, logit=True) == pytest.approx(1.0, rel=0.04)
48
49
50  def test_kar_sequences():
51
52      assert seq.kAR(0) == pytest.approx(0, abs=0.02)
53
```

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- Unit test:
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IMPLEMENTATION DETAILS: UNIT TESTS

- Unit test:
  - test if function output is conform to expectations
- Implemented using [pytest]
- Integrated in the Github CI/CD pipeline:
  - Run automatically when modifications are pushed on Github.

```
========================================================================== test session starts ==========================================================================
platform darwin -- Python 3.7.0, pytest-3.8.0, py-1.6.0, pluggy-0.7.1 -- /Users/ghammad/.virtualenvs/pyActigraphy/bin/python
cachedir: .pytest_cache
rootdir: /Users/ghammad/Work/CRC/pyActigraphy, inifile:
collected 51 items

pyActigraphy/tests/test_agd.py::test_instance_agd PASSED                                                                                                    [  1%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_name PASSED                                                                                               [  3%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_uuid PASSED                                                                                               [  5%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_start_time PASSED                                                                                         [  7%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_frequency_header PASSED                                                                                   [  9%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_data PASSED                                                                                               [ 11%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_data_frequency PASSED                                                                                     [ 13%]
pyActigraphy/tests/test_atr.py::test_instance_atr PASSED                                                                                                     [ 15%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_name PASSED                                                                                                [ 17%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_uuid PASSED                                                                                                [ 19%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_start_time PASSED                                                                                          [ 21%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_data PASSED                                                                                                [ 23%]
pyActigraphy/tests/test_awd.py::test_instance_awd PASSED                                                                                                     [ 25%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_name PASSED                                                                                                [ 27%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_uuid PASSED                                                                                                [ 29%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_start_time PASSED                                                                                          [ 31%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_data PASSED                                                                                                [ 33%]
pyActigraphy/tests/test_dqt.py::test_instance_dqt PASSED                                                                                                     [ 35%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_name PASSED                                                                                                [ 37%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_uuid PASSED                                                                                                [ 39%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_start_time PASSED                                                                                          [ 41%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_duration PASSED                                                                                            [ 43%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_length PASSED                                                                                              [ 45%]
pyActigraphy/tests/test_kra.py::test_kra_sequences PASSED                                                                                                    [ 47%]
pyActigraphy/tests/test_kra.py::test_kra_logit PASSED                                                                                                        [ 49%]
pyActigraphy/tests/test_kra.py::test_kar_sequences PASSED                                                                                                    [ 50%]
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    def IS(self, freq='1H', binarize=True, threshold=4):
        r"""Interdaily stability

        The Interdaily stability (IS) quantifies the repeatibilty of the
        daily rest-activity pattern over each day contained in the activity
        recording.

        Parameters
        ----------
        freq: str, optional
            Data resampling `frequency string
            <https://pandas.pydata.org/pandas-docs/stable/timeseries.html>`_.
            Default is '1H'.
        binarize: bool, optional
            If set to True, the data are binarized.
            Default is True.
        threshold: int, optional
            If binarize is set to True, data above this threshold are set to 1
            and to 0 otherwise.
            Default is 4.

        Returns
        -------
        is: float


        Notes
        -----

        This variable is defined in ref [1]_:

        .. math::

            IS = \frac{d^{24h}}{d^{1h}}

        with:
```

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838
839         Returns
840         -------
841         is: float
842
843
844         Notes
845         -----
846
847         This variable is defined in ref [1]_:
848
849         .. math::
850
851             IS = \frac{d^{24h}}{d^{1h}}
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853         with:
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pyActigraphy 1.0 Tutorials API Source Search

pyActigraphy.metrics.MetricsMixin.IS

MetricsMixin. **IS** (*freq='1H', binarize=True, threshold=4*) [source]

Interdaily stability

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Parameters:
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- **threshold** (*int, optional*) – If binarize is set to True, data above this threshold are set to 1 and to 0 otherwise. Default is 4.

Returns: **is**

Return type: float

Notes

This variable is defined in ref [1]:

$$IS = \frac{d^{24h}}{d^{1h}}$$

with:

$$d^{1h} = \sum_{i}^{n} \frac{(x_i - \bar{x})^2}{n}$$

where x_i is the number of active (counts higher than a predefined threshold) minutes during the ith period, $\bar{x}$ is the mean of all data and n is the number of periods covered by the actigraphy data and with:

$$d^{24h} = \sum_{i}^{p} \frac{(\bar{x}_{h,i} - \bar{x})^2}{p}$$

where $\bar{x}^{h,i}$ is the average number of active minutes over the ith period and p is the number of periods per day. The average runs over all the days.

For the record, tt is the 24h value from the chi-square periodogram (Sokolove and Bushel1 1978).

References

[1] Witting W., Kwa I.H., Eikelenboom P., Mirmiran M., Swaab D.F. Alterations in the circadian rest–activity rhythm in aging and Alzheimer's disease. Biol Psychiatry. 1990;27:563–572.

Examples

```
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>>> rawAWD.IS()
0.690017591303102 7
>>> rawAWD.IS(freq='30min', binarize=True, threshold=4)
0.6245582891144925
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0.5257020914453097
```

IMPLEMENTATION DETAILS: TUTORIALS

- Jupyter notebooks
  - included in the package itself
  - converted to HTML pages during the build of the documentation

pyActigraphy 1.0 Tutorials API Source Search

Introduction to data masking with pyActigraphy

This introduction notebook illustrates how to mask potentially spurious inactivity periods.

First, load the pyActigraphy package:

In [1]:
```
import pyActigraphy
```

```
/usr/local/lib/python3.7/site-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Us
  import pandas.util.testing as tm
```

As well as your favourite plotting package:

In [2]:
```
import plotly.graph_objs as go
```

Read an individual actigraphy file

As an example, let's read a .awd file located in the test directory of the pyActigraphy package:

In [3]:
```
import os
fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
```

In [4]:
```
raw = pyActigraphy.io.read_raw_awd(fpath+'example_01_mask.AWD')
```

Plot the data

In [5]:
```
layout = go.Layout(title="Actigraphy data", xaxis=dict(title="Date time"), yaxis=dict(title="Counts/period"), showlegend=Fals
```

In [6]:
```
go.Figure(data=go.Scatter(x=raw.data.index.astype(str), y=raw.data), layout=layout)
```

PYACTIGRAPHY

LIVE DEMO

PYACTIGRAPHY

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  - Paper in prep.

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  - Use software's DOI

Publication date:
August 27, 2019

DOI:
DOI 10.5281/zenodo.3379063

Keyword(s):
actigraphy actimetry analysis open-source python

Grants:
European Commission:
- COGNAP - To nap or not to nap? Why napping habits interfere with cognitive fitness in ageing (757763)

Related identifiers:
Supplement to https://github.com/ghammad/pyActigraphy/tree/v0.2

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PYACTIGRAPHY V2.0?

- v1.0: release available, paper on the way.
- v2.0:
  - Engage with other developers
  - Develop readers for raw data accelerometers (Axivity, GeneActive, Actigraph, etc)
  - Develop building blocks for complete analysis pipelines:
    - "A la Scikit learn"

TEAM WORK

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THANK YOU ALL!

Special thanks to:

- Eva Winnebeck (Institute of Medical Psychology, München) for advices, data&code sharing on the LIDS
- Andrew Lim (Sunnybrook Research Institute, Toronto) for sharing his code on state-transition probability

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THANK YOU

PS: Don’t hesitate to contact me if you want a software demo.

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