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1. Data **pre-processing**
2. Interpreting responses to **time-lagged** processes
3. Interpreting responses to **periodic** processes



1. Data pre-processing

- Gap filling
- Resampling
- Detrending

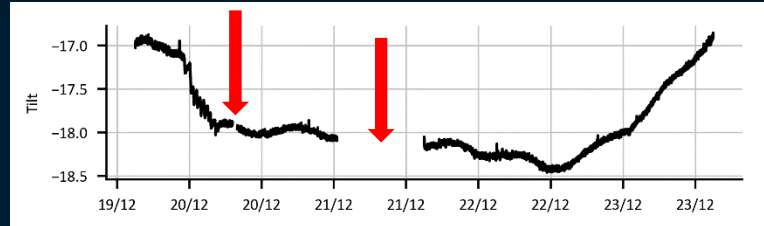
1. Data pre-processing

- **Gap filling**
- Resampling
- Detrending

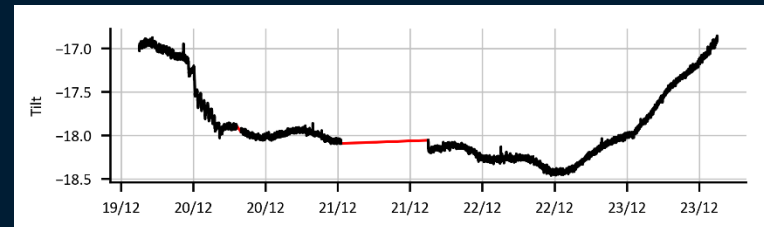


Tiltmeter measurement site, Bowen Basin, Australia

Input data with gaps...



...and after gap filling by linear interpolation



Other interpolants also available:

- Polynomial, piecewise polynomial
- Spline, cubic spline
- Quadratic

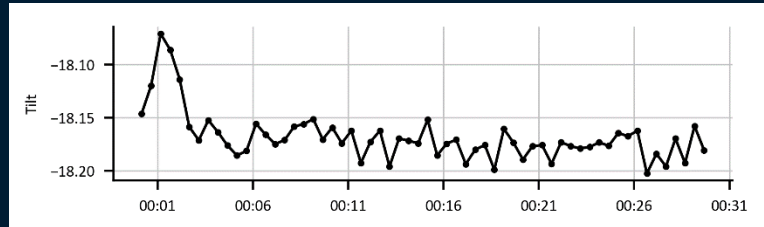
1. Data pre-processing

- Gap filling
- **Resampling**
- Detrending

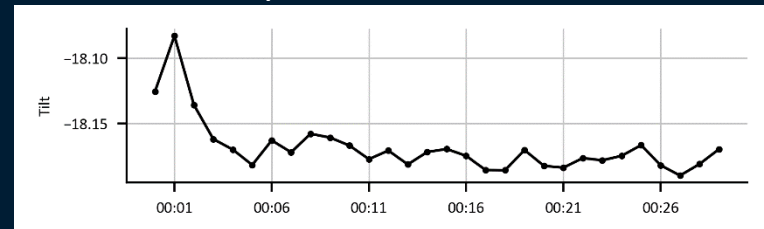


Tiltmeter measurement site, Bowen Basin, Australia

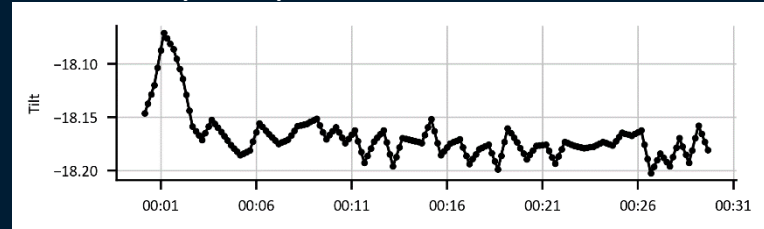
Input at 30 second resolution...



...downsampled to 1 minute resolution...



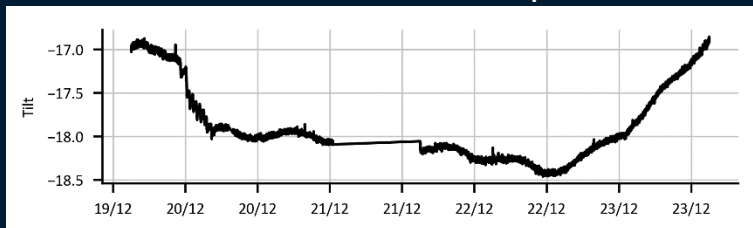
...or upsampled to 10 second resolution



1. Data pre-processing

- Gap filling
- Resampling
- **Detrending**

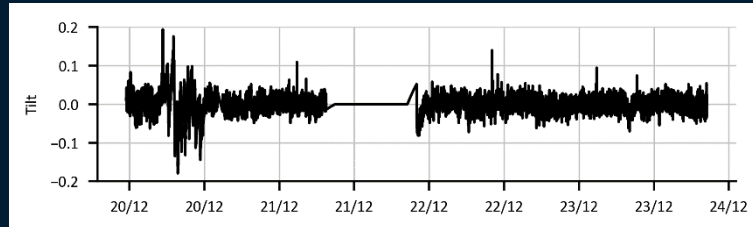
Input dataset...



...a fitted moving average function...



...and the result after subtraction



Tiltmeter measurement site, Bowen Basin, Australia

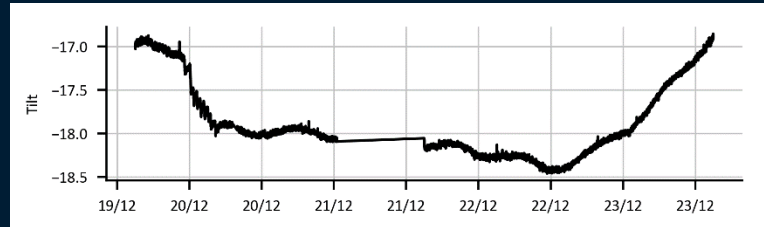
1. Data pre-processing

- Gap filling
- Resampling
- **Detrending**

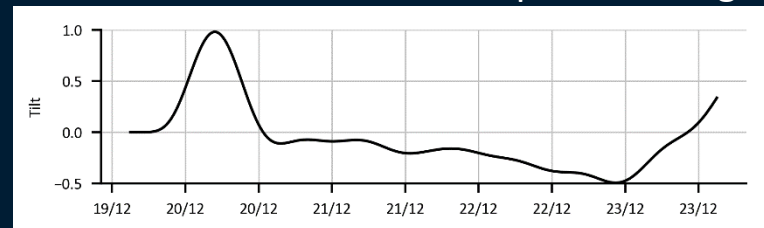


Tiltmeter measurement site, Bowen Basin, Australia

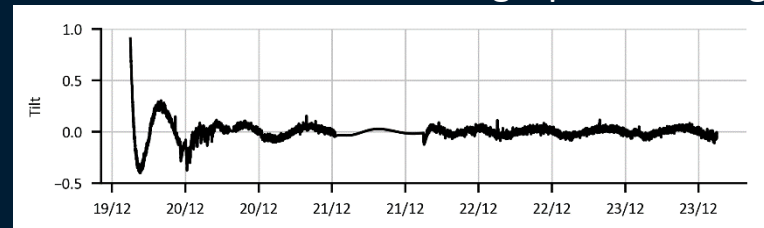
Input dataset...



...the result of low-pass filtering...



...or the result of high-pass filtering

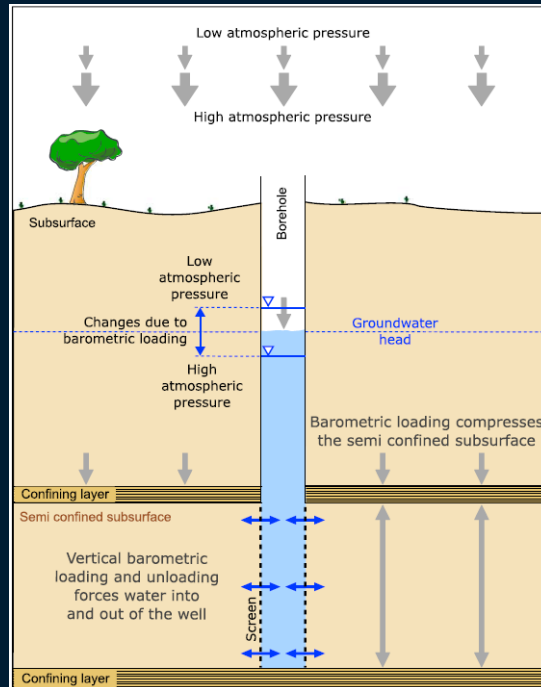




2. Interpreting responses to time-lagged processes

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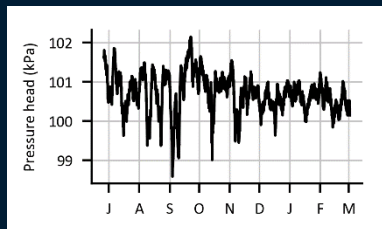
Barometric pressure influences



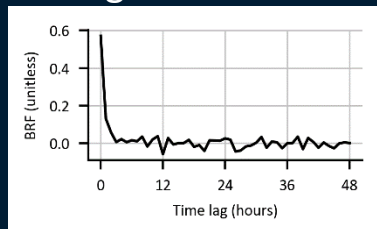
2. Interpreting responses to time-lagged processes

- **Regression deconvolution** (Rasmussen and Crawford, 1997)

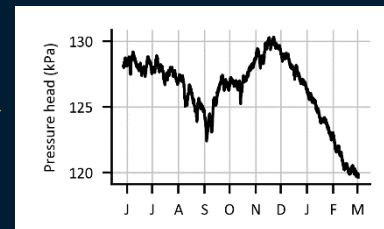
Barometric pressure



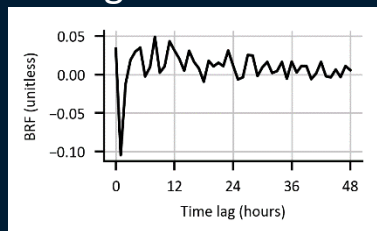
Mixing model #1



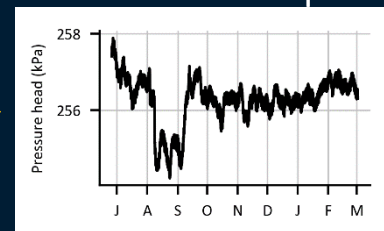
Unconfined aquifer



Mixing model #2



Confined aquifer

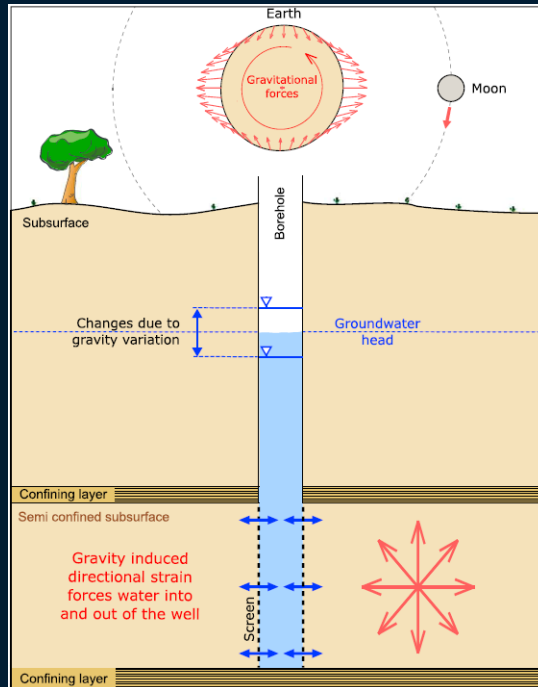




3. Interpreting responses to periodic processes

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Earth tide influences





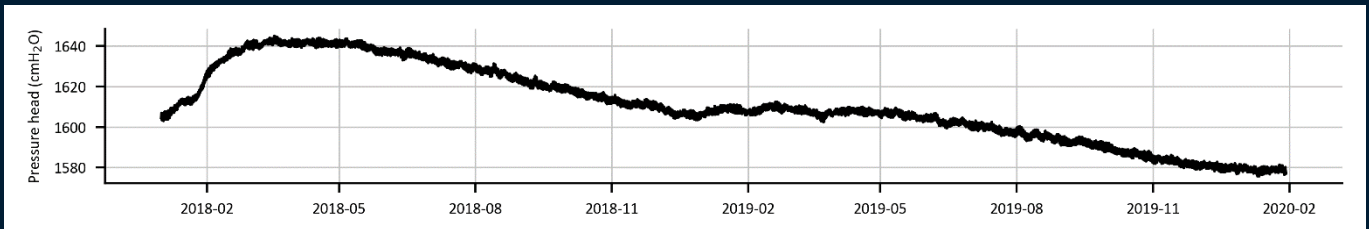
3. Interpreting responses to periodic processes

- Fourier transform
- Periodograms
- Harmonic least squares

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- Fourier transform
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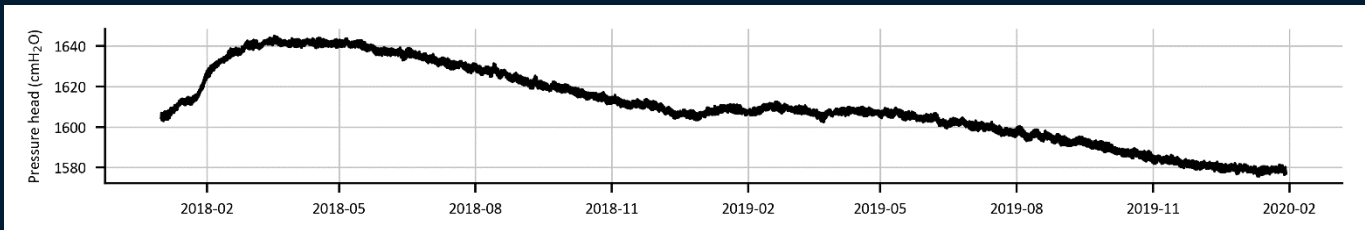
Input dataset: groundwater pressures



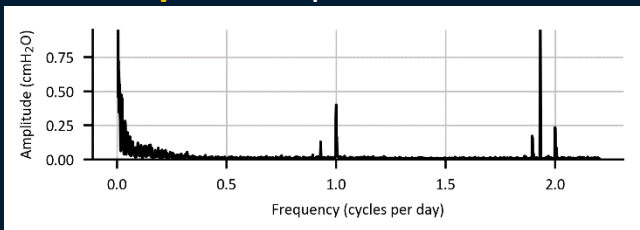
3. Interpreting responses to periodic processes

- **Fourier transform**
- Periodograms
- Harmonic least squares

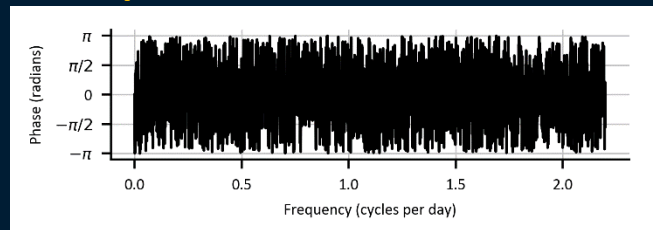
Input dataset: groundwater pressures



...the **amplitude** spectrum...



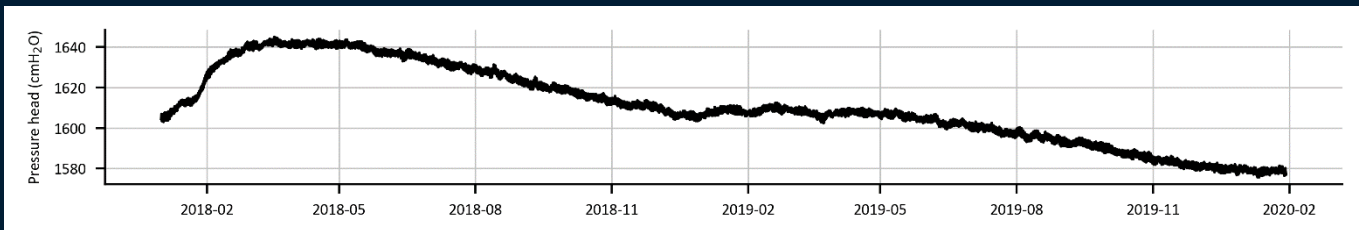
...and **phase** values



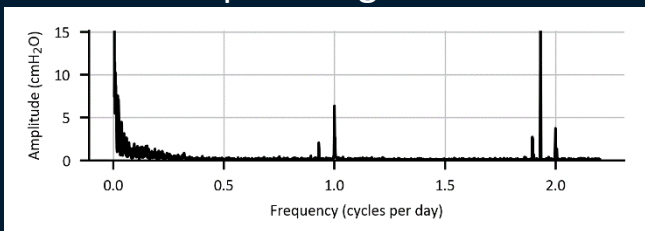
3. Interpreting responses to periodic processes

- Fourier transform
- **Periodograms**
- Harmonic least squares

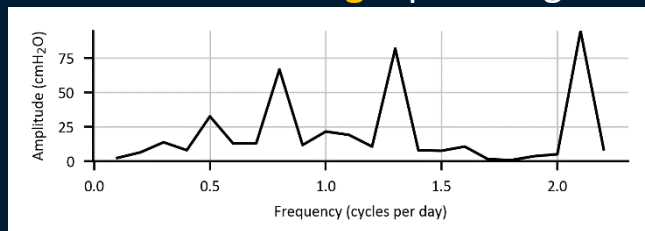
Input dataset: groundwater pressures



...the **Welch** periodogram...

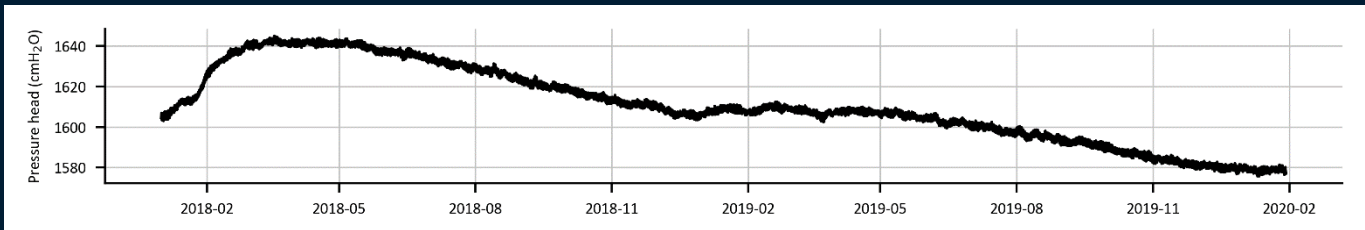


...or the **Lomb-Scargle** periodogram

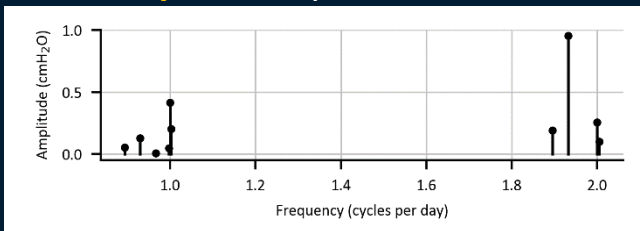


3. Interpreting responses to periodic processes

- Fourier transform
- Periodograms
- **Harmonic least squares** (Schweizer et al. 2020)



...the **amplitude** spectrum...



...and **phase** values

