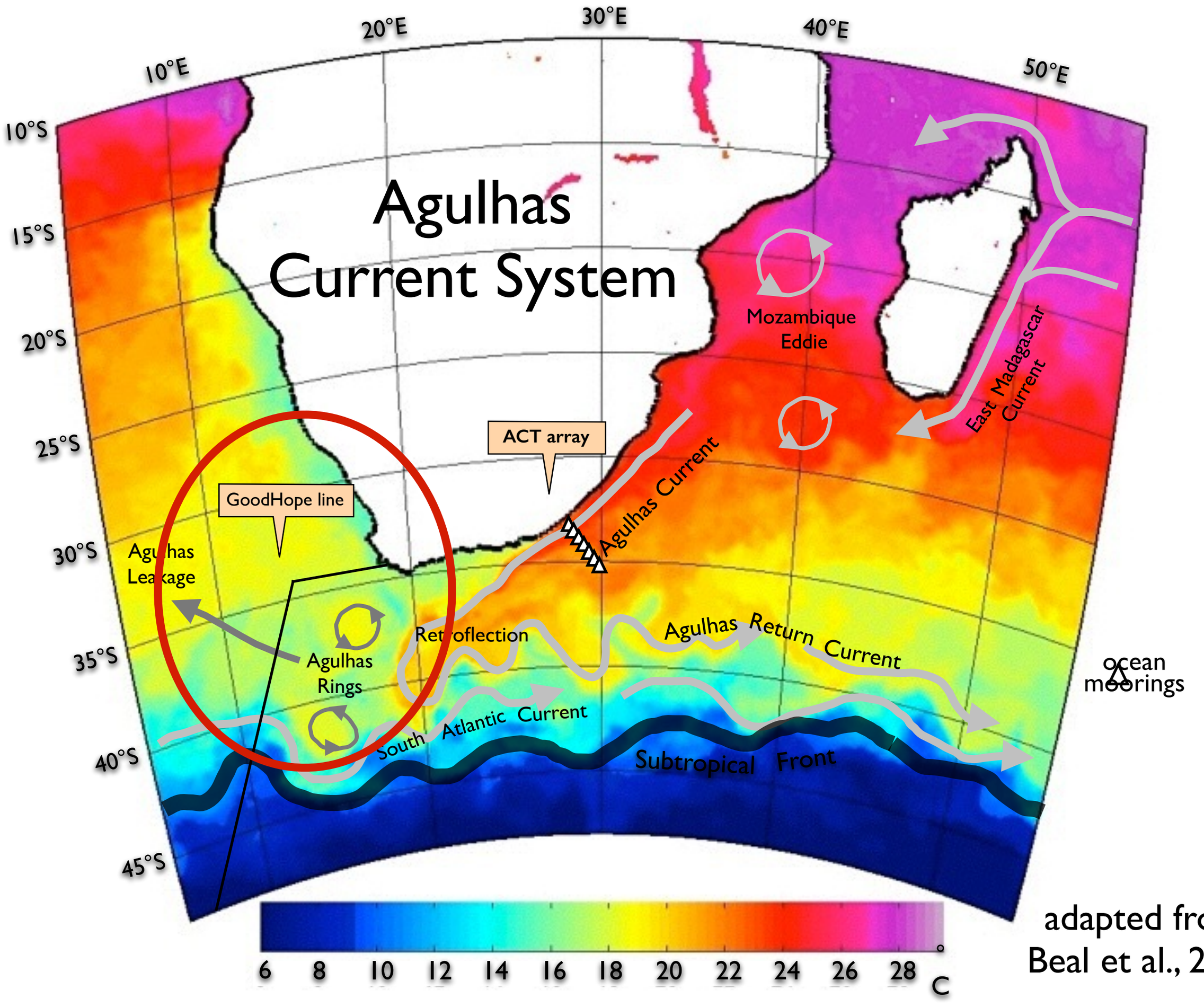
Spectrum analysis of Agulhas Current and Agulhas Leakage timeseries

Yu Cheng



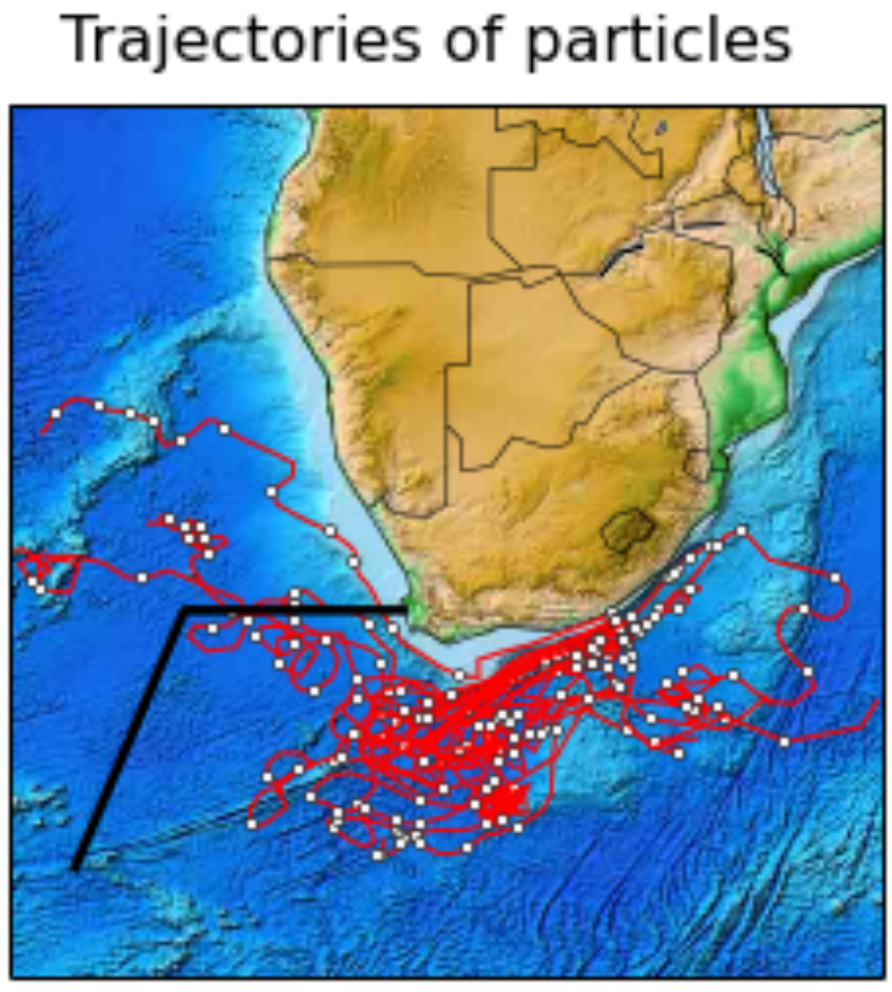
adapted from
Beal et al., 2011

DATA

- Two timeseries: (1) Eulerian Agulhas Current transport across the ACT section (2) Lagrangian Agulhas Leakage transport estimated using CMS

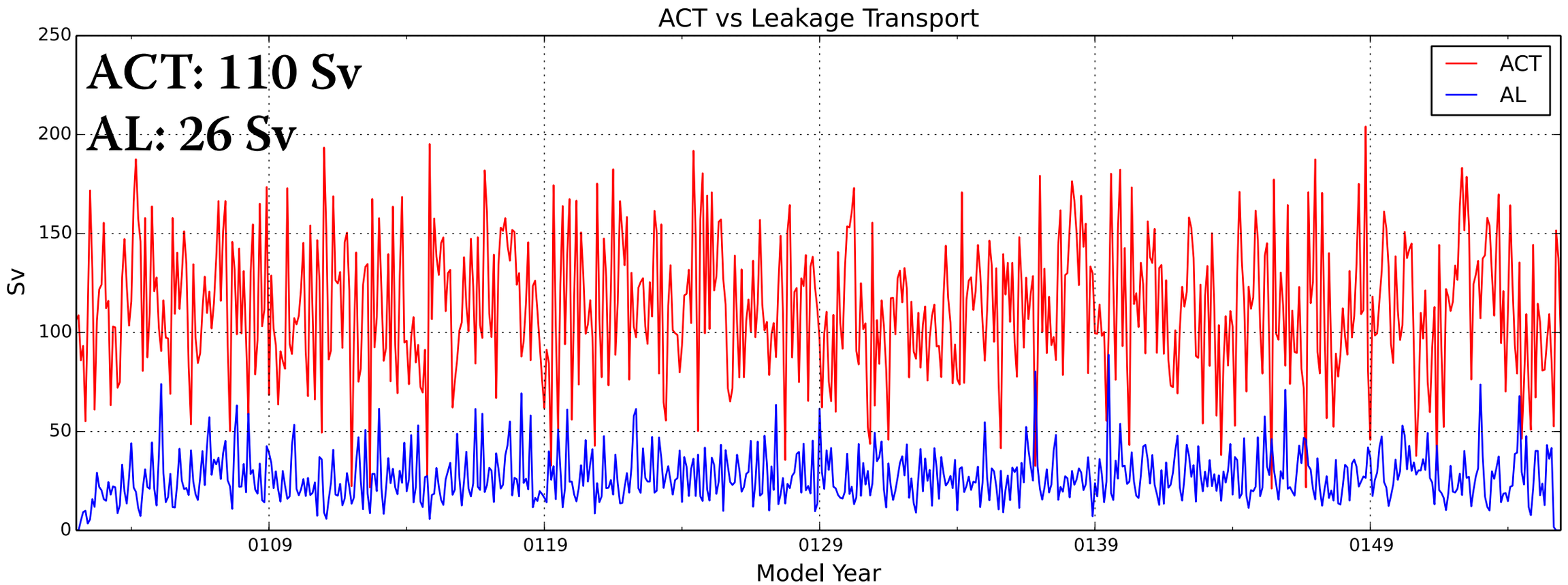
- HighRes CCSM4 control run with 0.1deg horizontal resolution

- Data from model year 104-153 are used (first and last 2 years are cut-off to avoid ramp-up time in Leakage-TS)



Questions

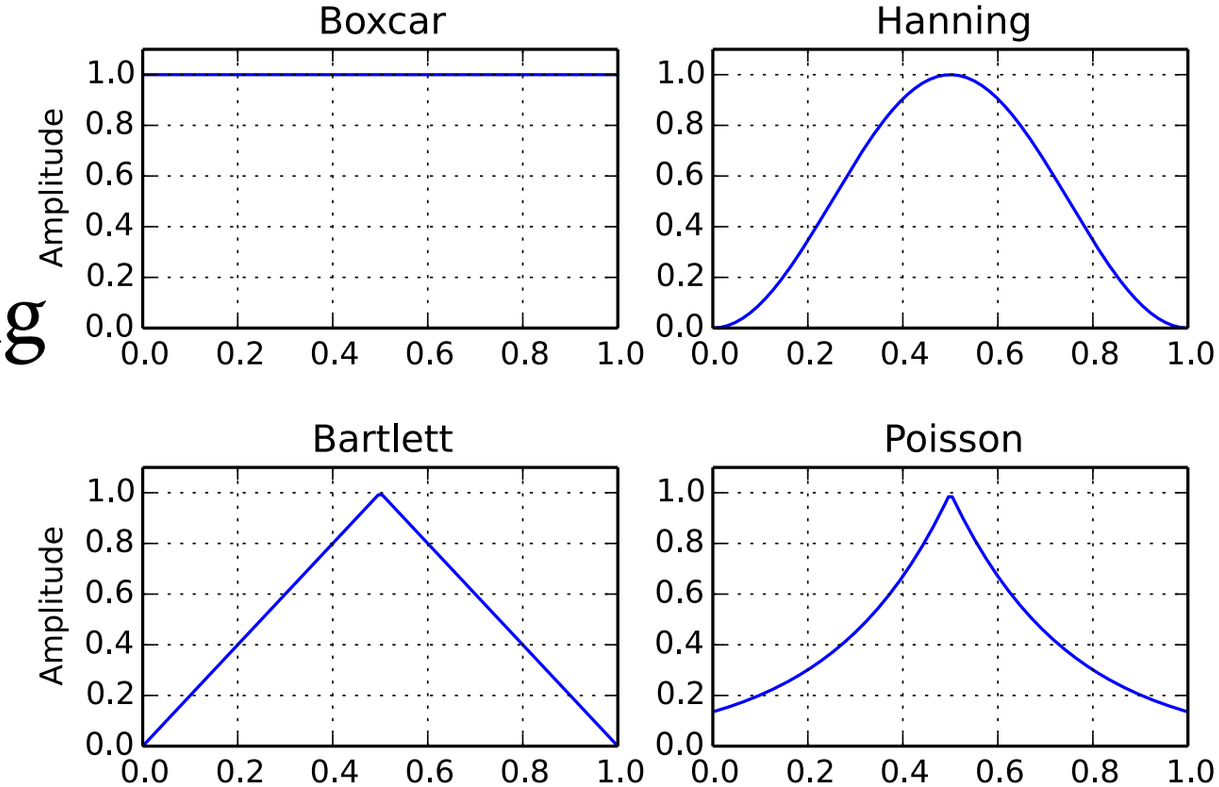
- Are there any dominant periods in Agulhas Current (ACT) and Agulhas Leakage (AL) timeseires?
- Is there any upstream control of AC on AL?



Power Spectral Density

- FFT Periodogram (boxcar window)
- Windowing (Tapering)
- Welch & Multi-tapering
- PSD: (Lec.12)

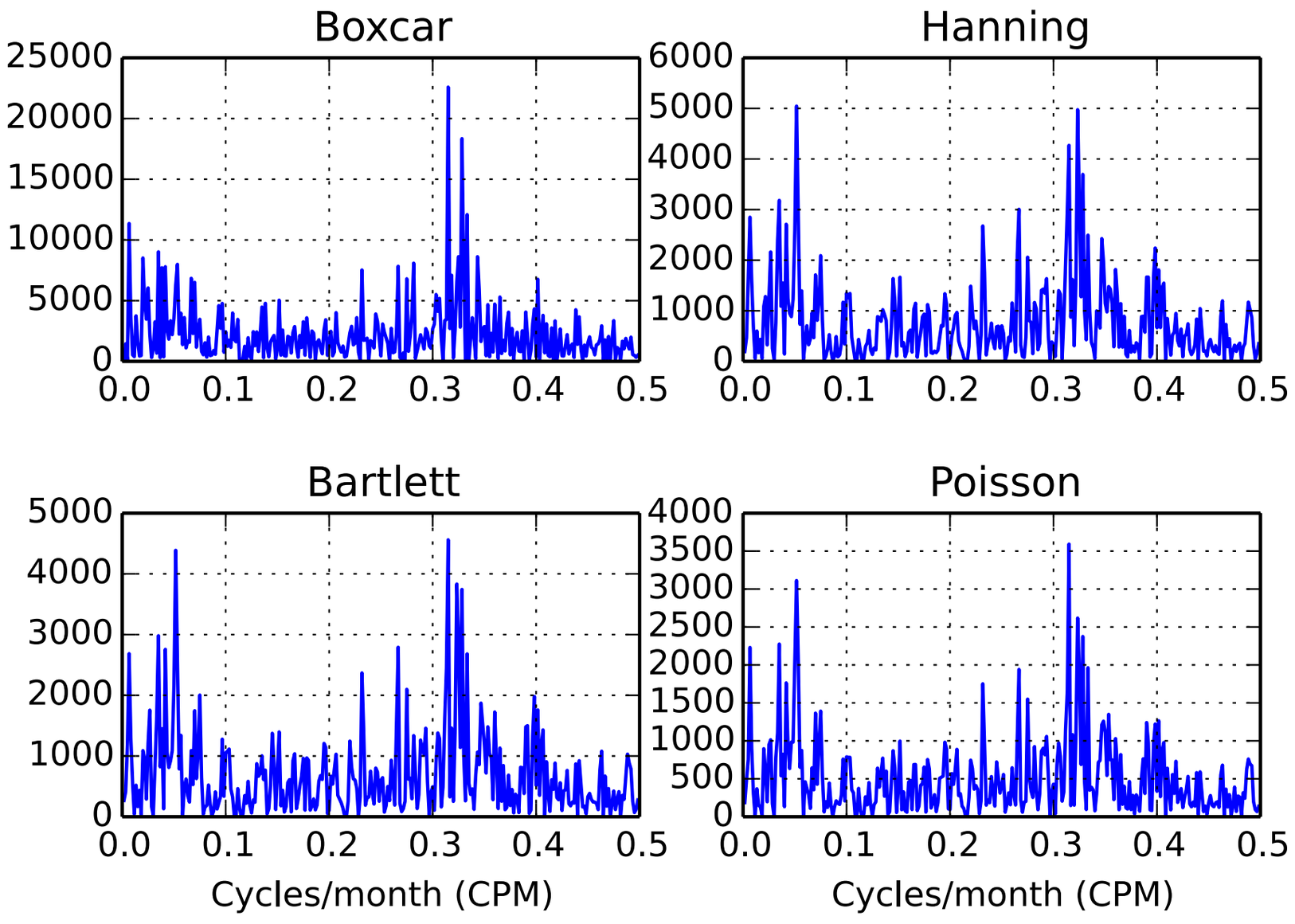
$$s^2(f) = \frac{2}{T} \left|\tilde{d}(f)\right|^2$$



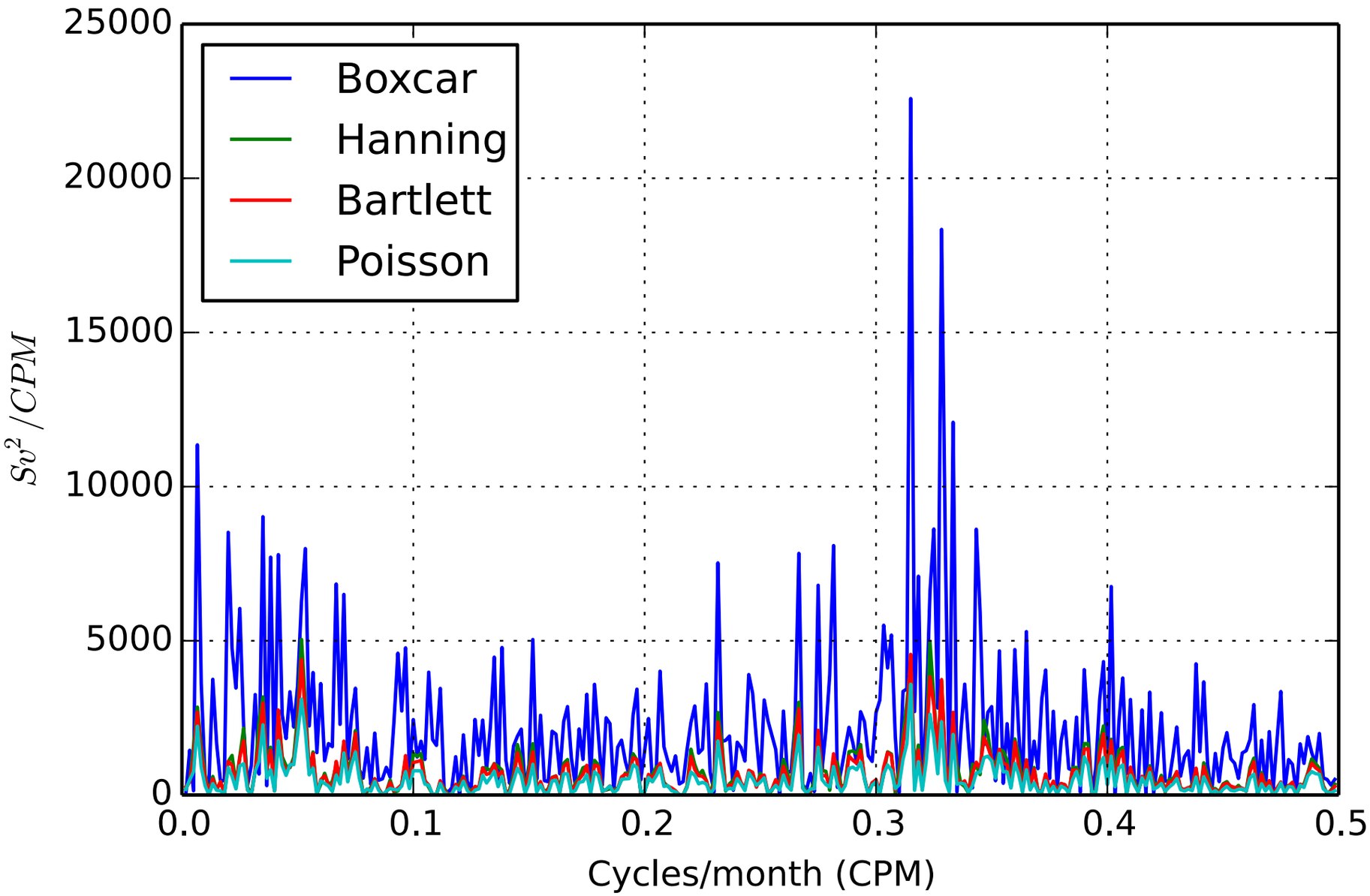
Windowing

- Assumption: stationary time series
- In Practice, we always have to deal with finite-length time-series: estimation of indefinitely-long physical processes.
- Concept: short piece is just the indefinitely-long TS times a window function W(t)
- Object: to avoid biases of spectrum estimation, and sidelobes introduced by the window-function, trading off power (Lec. 20)

Windowing

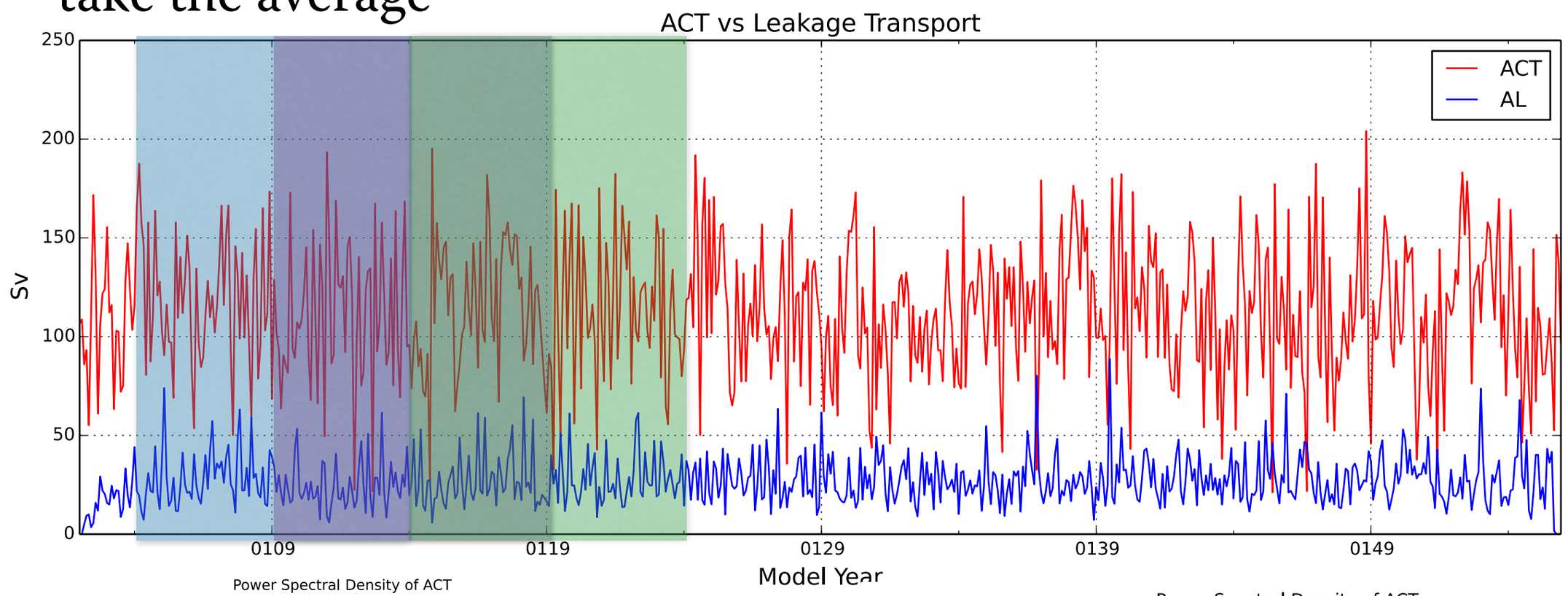

Boxcar
Hanning
Bartlett
Poisson
25000
20000
15000
10000
5000
0
6000
5000
4000
3000
2000
1000
0
4000
3500
3000
2500
2000
1500
1000
500
0.0
0.1
0.2
0.3
0.4
0.5
Cycles/month (CPM)

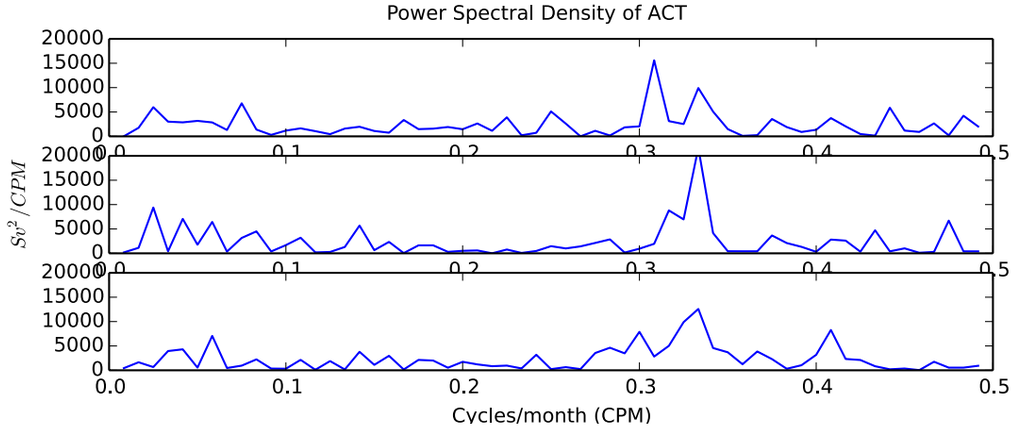
Windowing

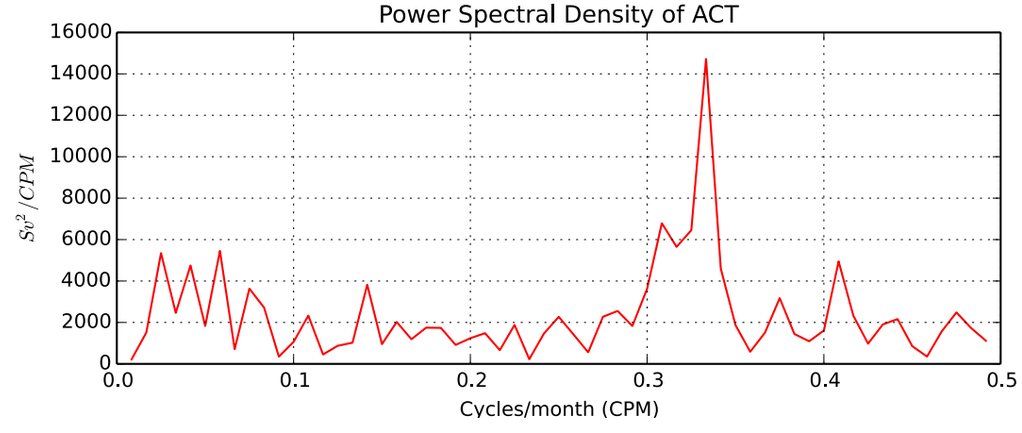

Boxcar
Hanning
Bartlett
Poisson
25000
20000
15000
10000
5000
0
Sv^2/CPM
0.0
0.1
0.2
0.3
0.4
0.5
Cycles/month (CPM)

Welch & Multitaper

- Welch's method: Divide the original TS into several overlapping segments, perform periodogram estimates of each segment, and take the average

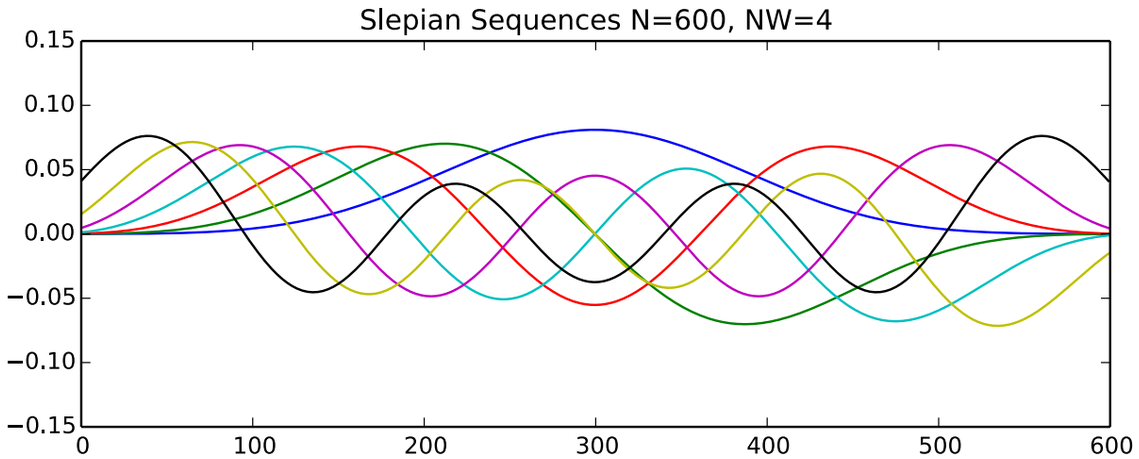


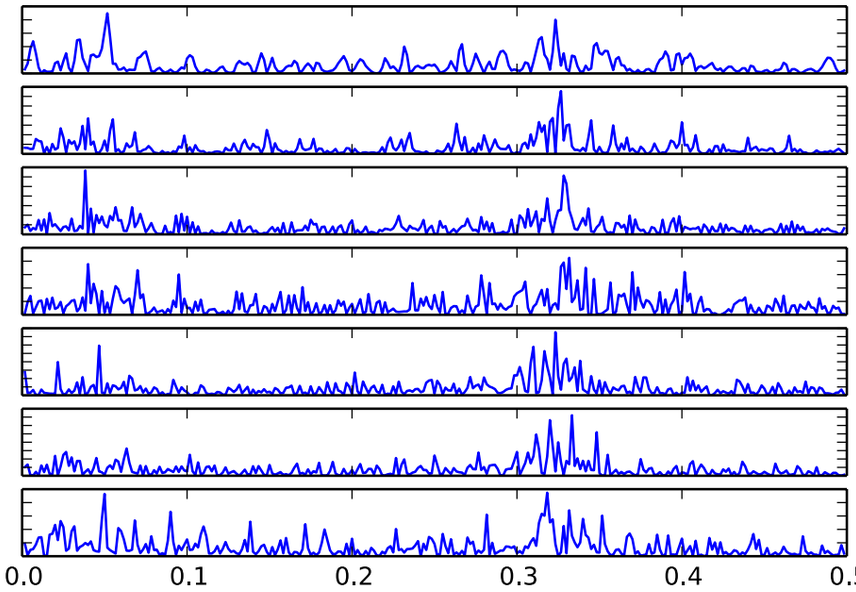


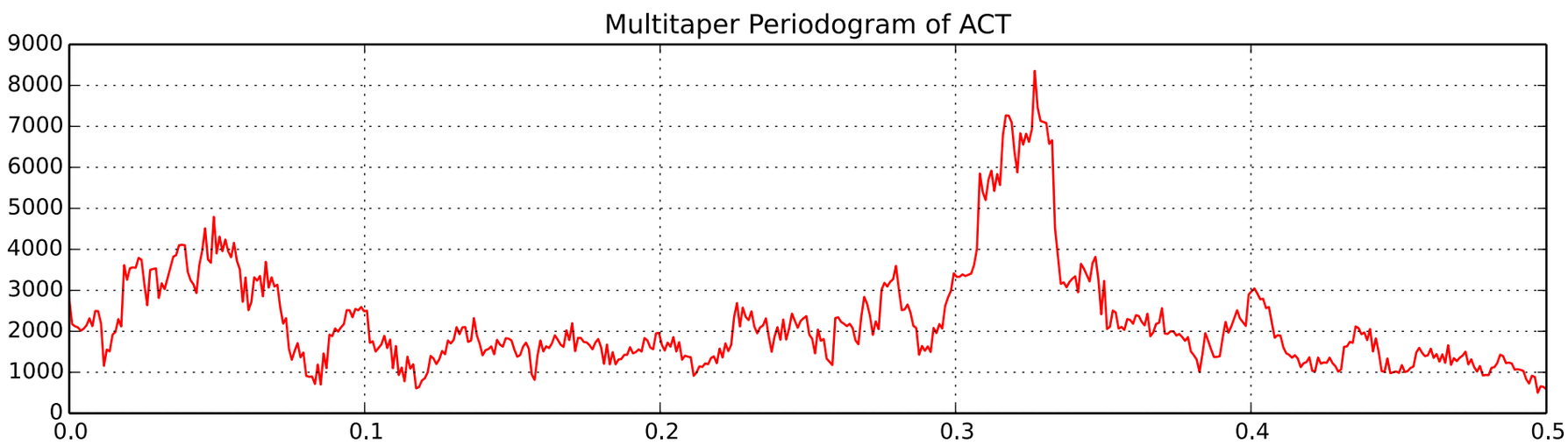


Welch & Multitaper

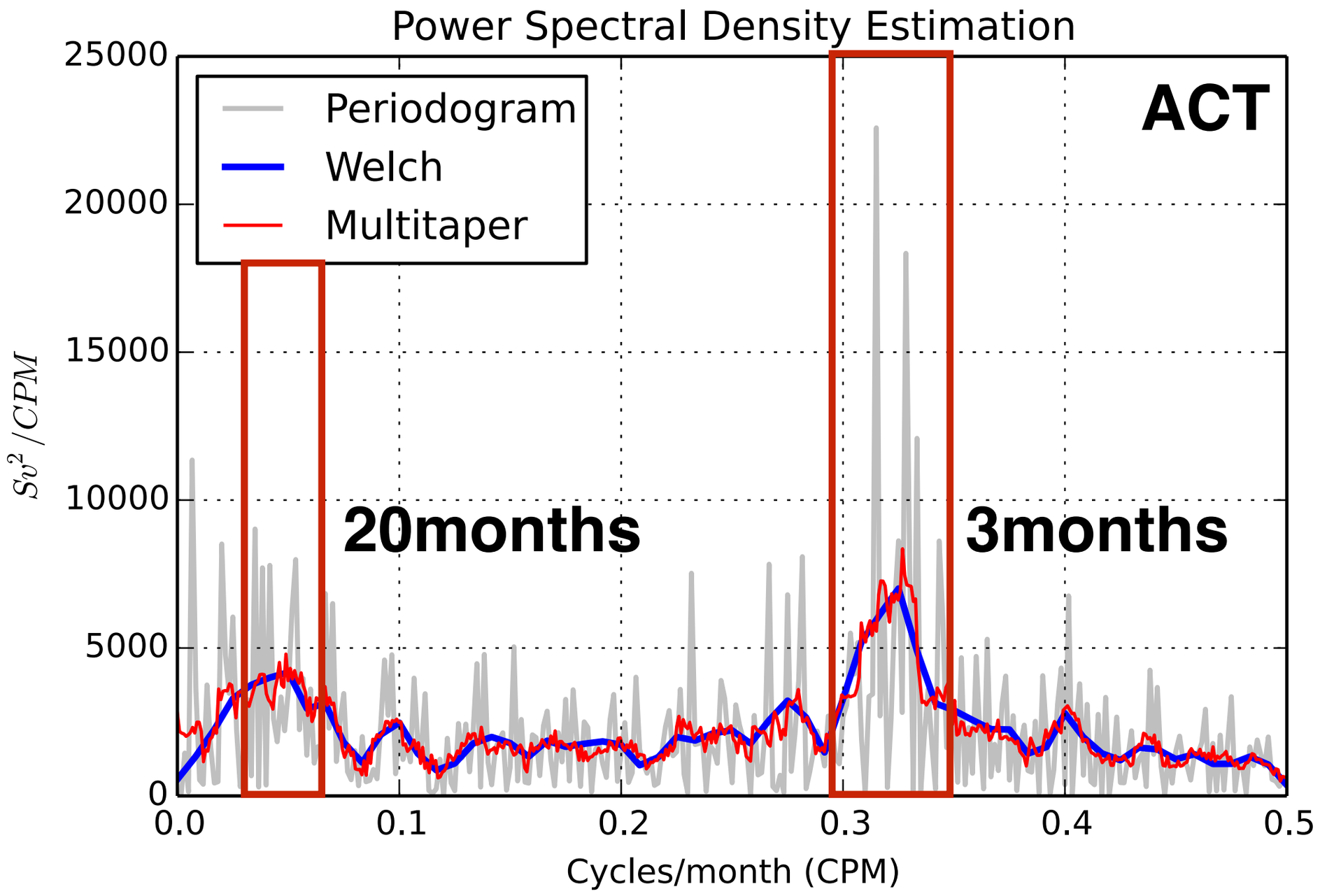
- Multi-taper: Use multiple “optimal” windowing functions to compute PSD respectively, and take the average



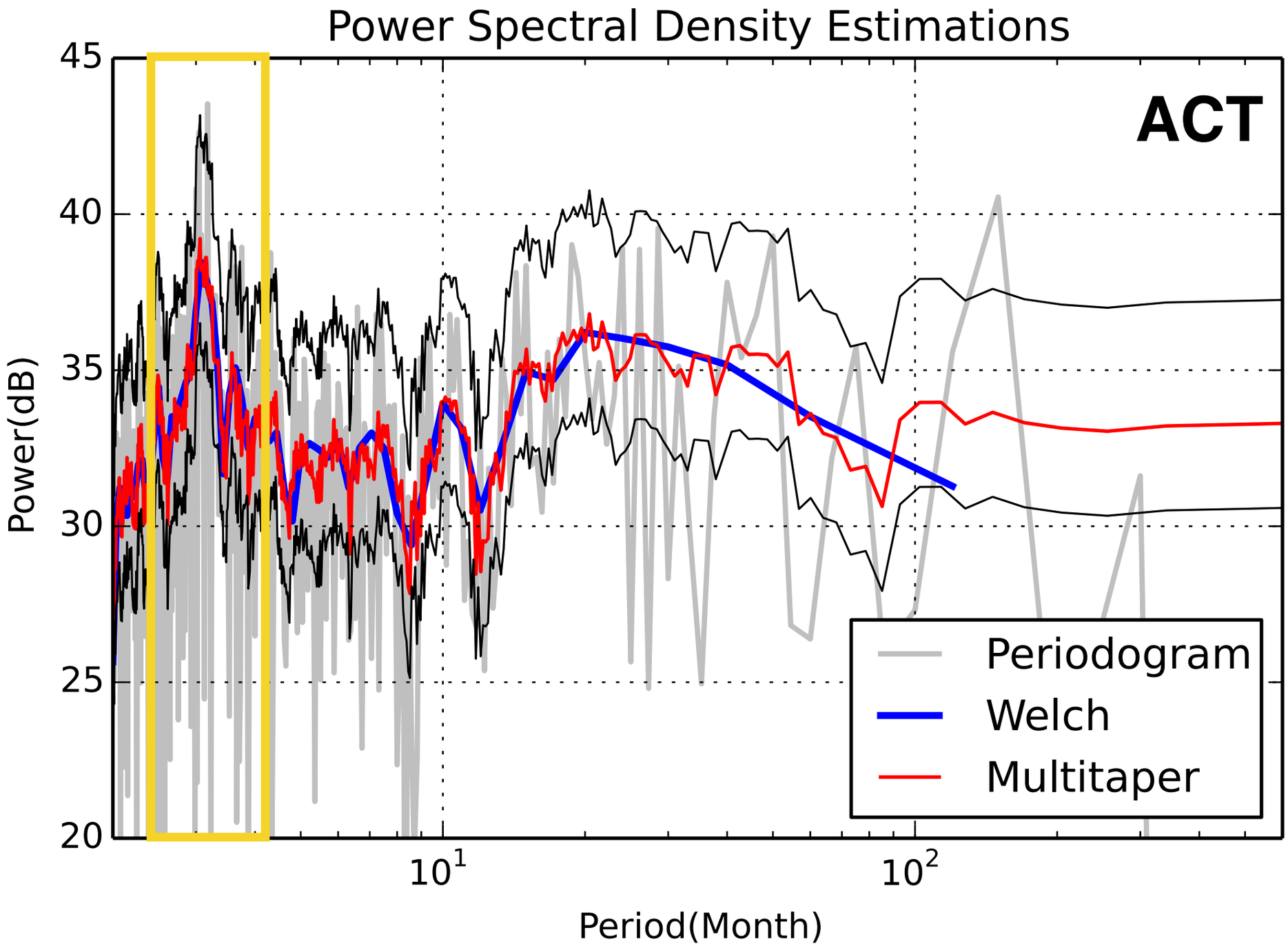




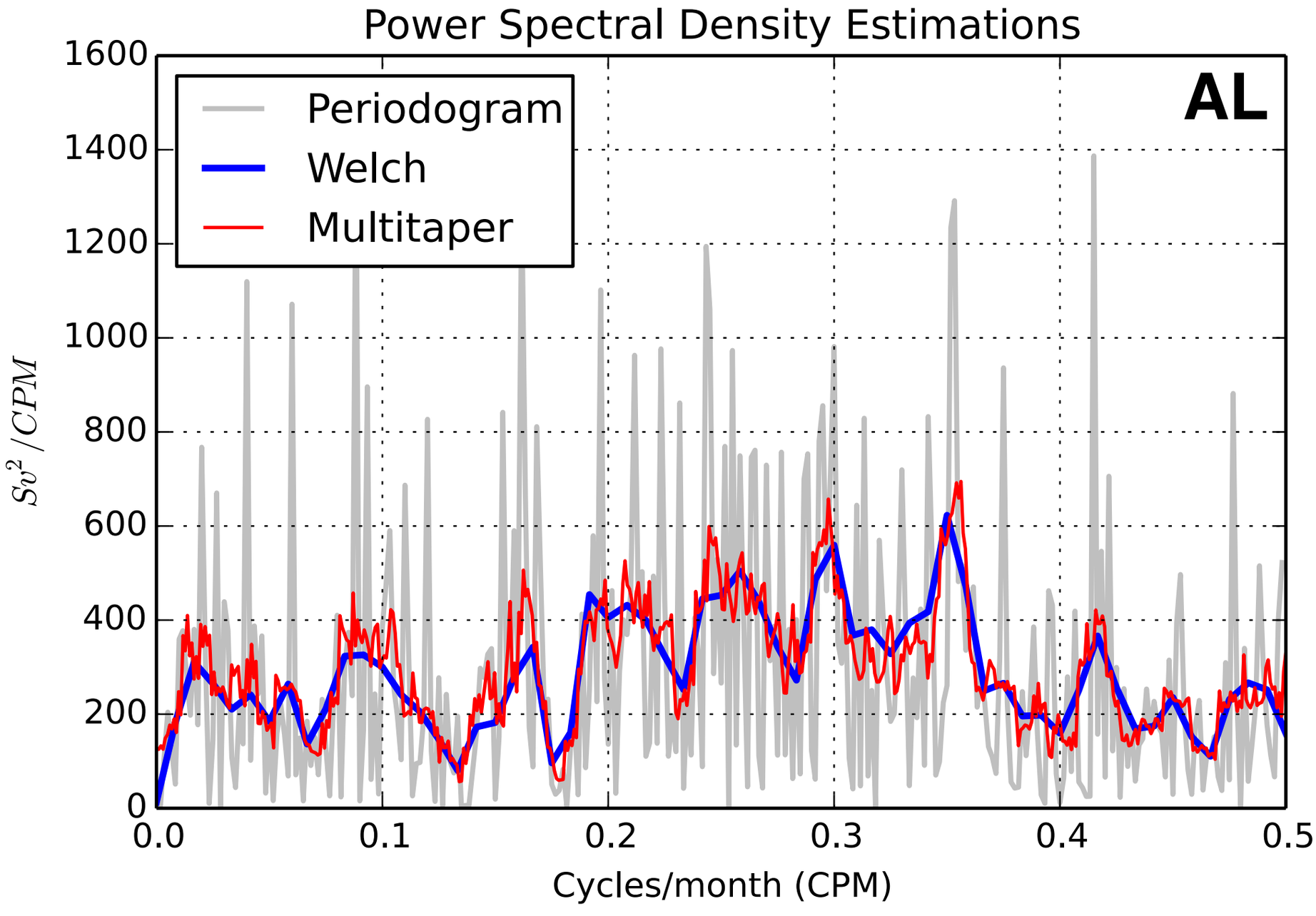
Results


Power Spectral Density Estimation
ACT
Periodogram
Welch
Multitaper
20months
3months
Sv^2/CPM
25000
20000
15000
10000
5000
0
0.0
0.1
0.2
0.3
0.4
0.5
Cycles/month (CPM)

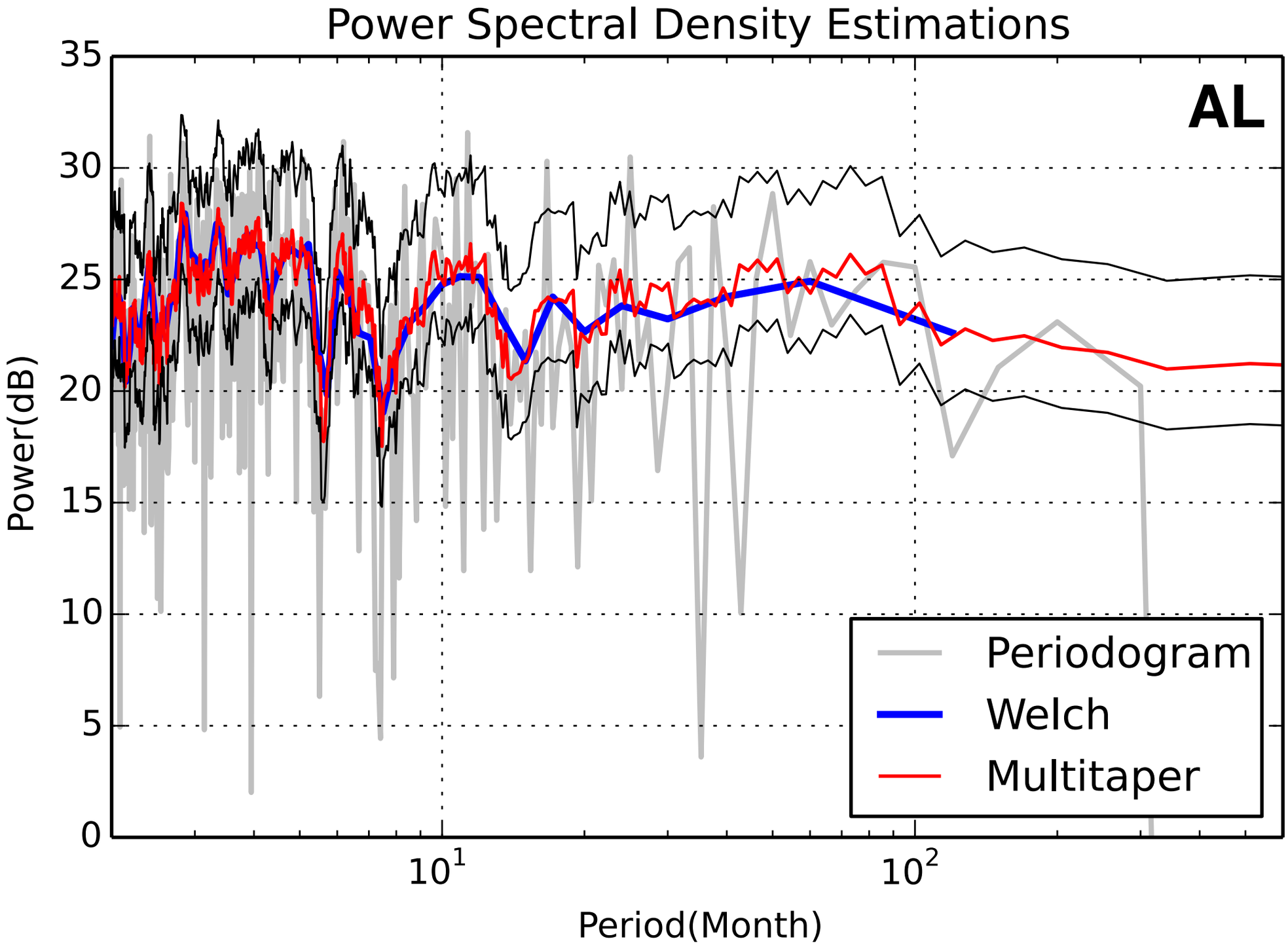
Results


Power Spectral Density Estimations
ACT
Power(dB)
45
40
35
30
25
20
10^1
10^2
Period(Month)
Periodogram
Welch
Multitaper

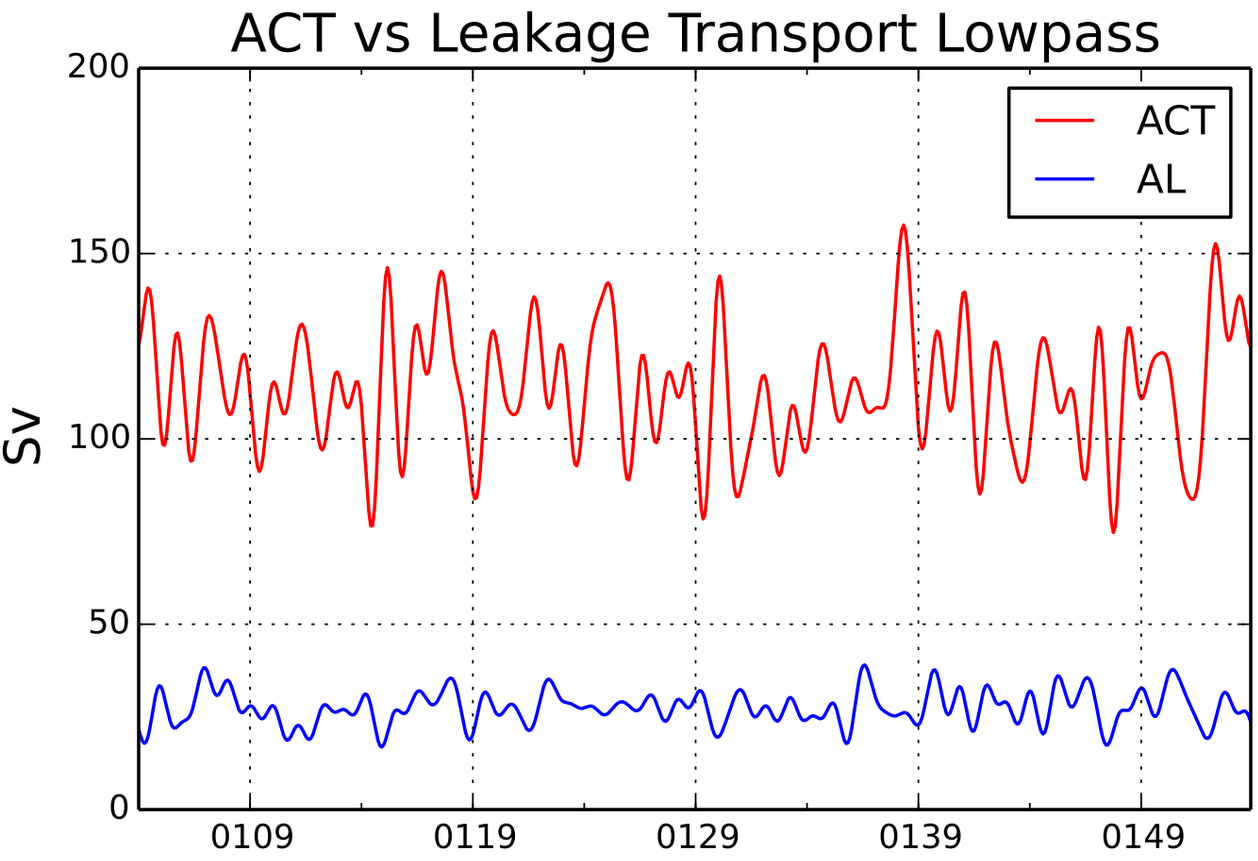
Results

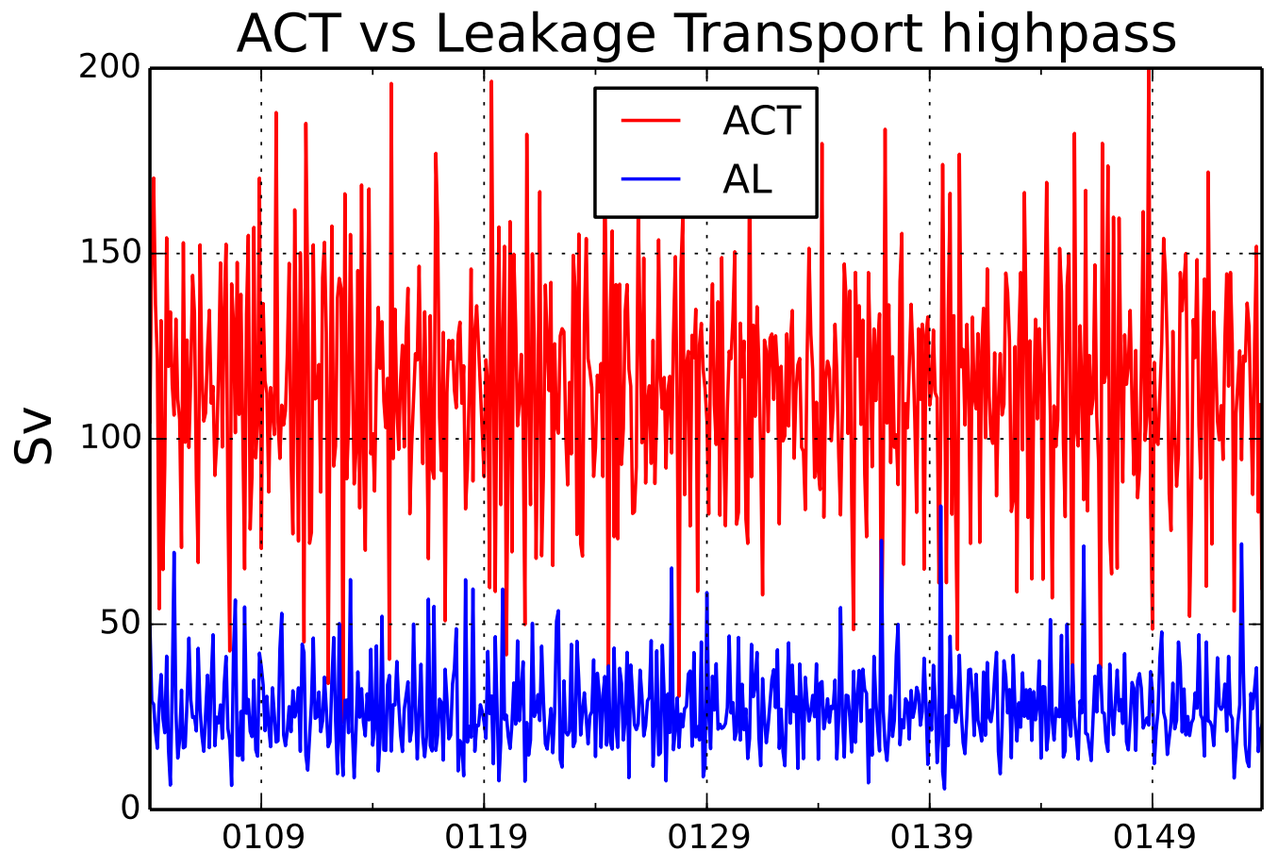

Power Spectral Density Estimations
AL
Periodogram
Welch
Multitaper
Sv^2 /CPM
Cycles/month (CPM)
0
200
400
600
800
1000
1200
1400
1600
0.0
0.1
0.2
0.3
0.4
0.5

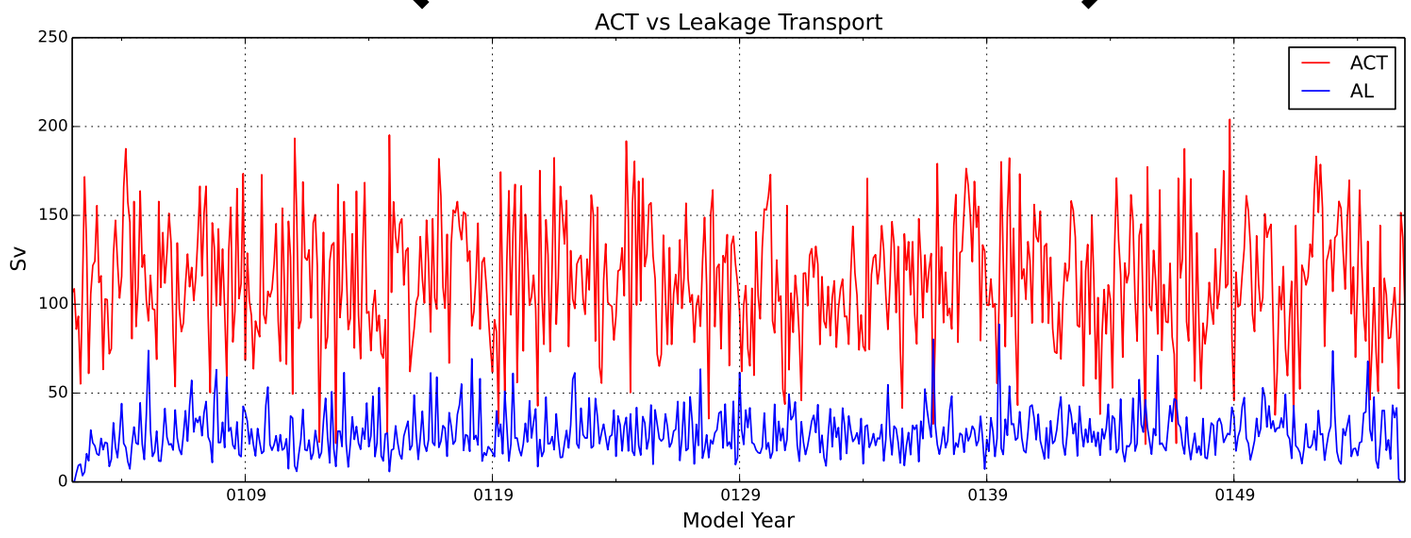
Results


Power Spectral Density Estimations
AL
Power(dB)
35
30
25
20
15
10
5
0
10^1
10^2
Period(Month)
Periodogram
Welch
Multitaper

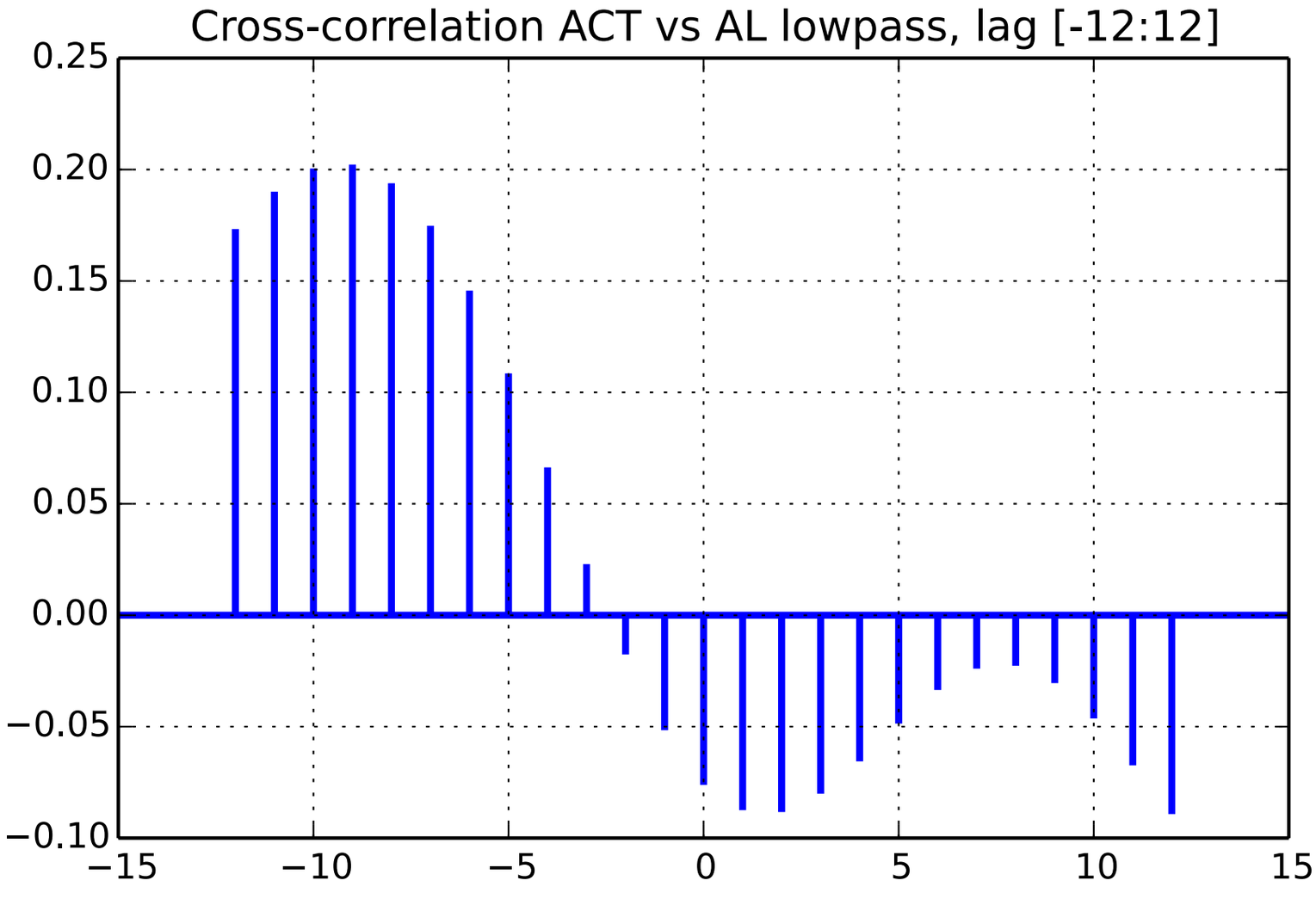
Filtering


ACT vs Leakage Transport Lowpass
ACT
AL
Sv
200
150
100
50
0
0109
0119
0129
0139
0149
Model Year


ACT vs Leakage Transport highpass
ACT
AL
Sv
200
150
100
50
0
0109
0119
0129
0139
0149
Model Year


ACT vs Leakage Transport
ACT
AL
Sv
250
200
150
100
50
0
0109
0119
0129
0139
0149
Model Year

Cross-correlation



Lowpass

Maximum corr.

r=0.21 (lag=-9)

significant

Summary

- The FFT with Boxcar window is the most basic way to estimate Power Spectrum Density for a finite-length data, Welch's or Multitaper methods are two other approaches to reduce biases.

- The power spectrum of both AL and AC have no significant peaks, very much like the spectrum of White-noise.

- The maximum correlation (r=0.21) between AC and AL occurs, when AC leads AL by 9 months. It is about the time a virtual float needs to travel between ACT to GoodHope line.